Modern Concepts and Practices of Organic Farming for Safe Secured and Sustainable Food Production

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FOREWORD

Organic farming aims to largely exclude or avoid synthetics in agriculture and relies mostly with on-farm inputs for nutrient and insect-disease management of crops. Around 112.2 million ha in 181 countries is under organic agriculture which includes both cultivated (69.8 million ha; 1.4% of total agricultural land) and wild harvest (42.4 million ha) during 2017-18. Market size during 2017 was 97 billion USD. Although 181 countries produce organic foods, but markets are concentrated in European Union and North America (32 countries) and 90% of international trade is these two regions. The sector is growing at 12% compounded annual growth rate. In India, emerging from 42,000 ha under certified organic farming in 2003-04, the organic agricultural area has grown many folds and by March 2019, India has brought 3.566 m ha under organic production in which 56% area is of cultivated agricultural lands. Currently only 1.3% of net cultivable area is under certified organic production systems and as per targets , government is aiming for 4% in 2025 considering the growth rate of this sector. During 2018-19 , India exported 6,14,089 t of produces worth Rs 5,151 crores. Among the states, 59% of cultivated farm area under organic production is shared by 3 states namely Madhya Pradesh (35 % of total cultivated farm area under organic agriculture in India), Maharashtra (13%) and Rajasthan (11%) shares higher area. Currently, India ranks 8th in terms of cultivable land under organic certification. Around 8.35 lakh producers are engaged in the country in various forms. Sikkim state has been declared as organic state from

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January 2016 and has highest net sown area (100%) under organic certification. It is expected that the domestic market will be the main growth driver in next 5 years.

The rate at which the organic farming sector grows needs to be supported with advancement in technologies, knowledge sharing, human resource and policy. Therefore , the book on "Modern Concepts and Practices of Organic Farming for safe, secured and sustainable food production" has been prepared based on the lectures and experiences of ICAR sponsored summer school by ICAR-Indian Institute of Farming Systems Research, Modipuram and would help to share the knowledge among various stakeholders. The book covers major aspects such as concepts, theoretical and practical information on Organic Farming. I congratulate the editors in bringing out the publication.

K. Alagusundaram

PREFACE

India has traditionally been a country of organic agriculture, but the growth of modern scientific, input intensive agriculture has pushed it to an edge. But with increasing awareness about the safety and quality of foods and long-term sustainability of the agricultural system, the organic farming has emerged as an alternative system of farming which not only addresses the quality and sustainability concerns but also ensures a debt-free, profitable livelihood option. Organic agriculture is an ideal option for addressing the distresses of farmers. Majority of farming community of our country lies under small and marginal category and has limited resources which bar them from affording expensive farm inputs. Thus, low-cost crop production technologies like organic farming may be a boon to these resource-poor farmers. India is home to 30 per cent of the total organic producers in the world but accounts for just 2.59 per cent (1.5 million hectares) of the total organic cultivation area of 57.8 million hectares, according to the World of Organic Agriculture 2018 report. In this context, organic agriculture can be seen as revolutionary efforts to create sustainable development. There are however large differences between the challenges connected to its execution by the resource-poor farmers and consumers in low-income countries. Organic manure influences soil productivity in agricultural and horticultural crops through their effects on soil physical, chemical and biological properties. However, organic farming is not new and indeed a healthy change because it enriches the daily nutritional requirement by diversifying the cropping systems by including high-value crops.

This book on "Modern Concepts and Practices of Organic Farming for safe, secured and sustainable food production" is thus intended as a resource to help researchers, policymakers, conservationists, entrepreneurs, farmers and rural and urban community groups to move the ball toward a more sustainable future. Organic farming approach needs to be adaptive and is better achieved through education and understanding than with simple recommendations.

To share the knowledge on organic farming, an ICAR sponsored summer school on "Modern Concepts and Practices of Organic Farming for safe, secured and sustainable food production" was organized by ICAR-Indian Institute of Farming Systems Research (ICAR-IIFSR), Modipuram during 14th July to 03rd August 2017. The book is a compilation based on the lectures delivered by experts from different parts of the country including ICAR-IIFSR, Modipuram.

The Editorial Board constituted for the book would like to acknowledge all the eminent resource persons, and also gratefully acknowledged Indian Council of Agriculture Research (ICAR) for financial support.

Hope the compiled lectures will be useful to all those interested in promoting organic farming in India.

Editors

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Chapter 1

MODERN AGRONOMIC TOOLS FOR ORGANIC CROP PRODUCTION

S. Bhaskar and P.C. Ghasal

1.1 INTRODUCTION

Different parts of India have developed their own local or regional systems for ecological agriculture that are now gathered in one umbrella term 'Jaivik Krishi' or 'Jaivik Kheti'. India has a sizable cropped area in different states, which is more prone to weather vagaries; especially those located in rainfed, dryland and hilly areas. Increasing the agricultural productivity and income of the farmers as well as sustaining soil resource in these agricultural systems has always been a challenging task for researchers and policy planners. At first instance, minimal agricultural inputs use area which need to be targeted for organic production by devising proper strategies and identifying niche crops (crops which yield higher under organic production systems and have adequate market demand).

1.2 NUTRIENT MANAGEMENT IN ORGANIC FARMING

The management of nutrient in organic farming system is a challenge as the use of inorganic fertilizer which feed the plant directly and are thought to bypass the natural processes of the soil, is not permitted. Effective nutrient management is essential in organic farming systems. Nutrient supply to crop plants is supported through recycling, the management of biologically related processes such as nitrogen fixation and the limited use of unrefined, slowly soluble off- farm materials that decompose in the same way as soil minerals or organic matter. Nutrient sources commonly used for organic farming are green manure, farm yard manure (FYM), vermicompost (VC), compost, enriched compost, bio-gas slurry, non-edible oil cakes, poultry manure, Azolla, biofertilizer, biodynamic compost and Panchgavya.

1.2.1 Green Manure

The crops to be taken for green manuring should be fast growing, rich in nutrient like legumes, resistant to biotic and abiotic stresses, has smoothening effect against weeds and with more foliage. Crops that are commonly used for green manuring are *Sesbania aculeata* (suitable for rice-wheat, 55 days old crop producing 17-30 tonnes green matter per ha), *Sesbania speciosa (*suitable for wet lands, when raised on field borders along the bunds, 90 day old crop contributes 2-4 tonnes green matter per ha) and *Crotolaria juncea* (suited to almost all parts of country and adds 15-25 tonnes fresh biomass in 50-60 days). They can be grown together with crops or alone. Because the C:N ratio of green manure crops increases as they age, it is generally recommended that green manure crops be harvested or incorporated into the soil when close to full bloom (but prior to seed set) to assure a C:N ratio of 22:1 or less so that net mineralization occurs. The 60-day-old crop can contribute approximately 100 kg N/ha, 25-30 kg P_2O_5/ha and 75 kg K_2O/ha and these can meet the requirement of organic rice crop (Chandra, 2005).

1.2.2 Farm Yard Manure (FYM)

Farm yard manure is partially decomposed dung, urine, bedding and straw. The nutrients from urine become readily available. Dung contains about 0.50 per cent of the nitrogen, 0.15 percent of potash and almost all of the phosphorus that is excreted by animals. FYM contains approximately 5-6 kg nitrogen, 1.2 to 2.0 kg phosphorus and 5-6 kg potash per tonne. If properly preserved, the quantity of manure that can be produced per animal per year would be as much as four to five tonnes containing 0.5 per cent nitrogen. If available, well decomposed FYM should be applied @15-20 tonnes per ha for cereals and 5-10 tonnes per ha for pulses, which can supply about 75-100kg N per ha, 35-40 kg P_2O_5/ha and 75-100 kg K_2O per ha. FYM should be decomposed by adding *Trichoderma* powder.

1.2.3 Vermicompost

Vermicomposting is a simple biotechnological process of composting in which certain species of earthworms enhance the process of waste conversion and produce a better end product i.e vermicompost. It provides all nutrients in readily available form and also enhances uptake of nutrients by plants. Vermicomposting converts household compost within 30 days, reduces the C: N ratio and retains more N than traditional method of preparing compost. The African species of earthworms, *Eisenia foetida* and *Eudrilus eugenae* are ideal for the preparation of vermicompost. For the preparation of vermicompost, pits are made of 1 m deep and 1.5 m wide, however, the length varies as required and bottom of the pit is covered by polythene sheet on which 15-20 cm layer of organic waste material (it helps in improving nutritional quality of compost) and finally cow dung slurry should be sprinkled. Culture of *Pseudomonas fluorescens* may also be added (@ 200g/100kg). Pit is filled completely in layers as described and finally the top of the pit is pasted with soil or cow dung and material is allowed to decompose for 15-20 days. Selected earthworms (500 to 700) were released through cracks and water is sprinkled every three days to maintain adequate moisture. Vermicompost is ready in about 2 months if agriculture waste is used. The processed vermicompost is black, light in weight and free from bad odour.

1.2.4 Compost

Compost is organic matter (plant and animal residues) which has been rotted down by the action of bacteria and other organisms, over a period of time. The biodegradation process is carried out by different groups of heterotrophic microorganisms like bacteria, fungi and actinomycetes etc. Organic materials undergo intensive decomposition under thermophilic and mesophilic conditions in heap, pits or tanks with adequate moisture and aeration and finally yield a brown to dark brown coloured humified material called compost. Materials such as leaves, fruit skins and animal manures can be used for compost preparation.

For enrichment of the compost with rockphosphate, rockphosphate are added at the rate of 12.5 per cent in a mixture of plant residue+ FYM+ soil in ratio of 8: 1.0: 0.5 in the form of slurry on plant residue during composting. Likewise, for enriching the compost with pyrite, pyrite is added at the rate of 10 per cent in a mixture of plant residue+ FYM+ soil in ratio of 8: 1.0: 0.5 in the form of slurry on plant residue during composting. While for enriching the compost with inoculums, a mixture of FYM (10 kg) + soil (2kg) + inoculums (1 kg *Azotobacter* + 1 kg PSB + *Pseudomonas* + 1 kg *Thiobacillus* + 1kg *Beauveria* + 1 kg *Pant* biocontrol agent 1, 2 & 3) in a 100-150 litre of water was added on the top of layer while composting which is sufficient for 1 ton of enriched compost.

1.2.5 Bio-gas slurry

Bio-gas slurry is a good source of organic manure. Anaerobic digestion of raw animal dung by microbes in the bio gas plant offers more advantages in improving the manurial value of the slurry as compared to the manurial product of aerobic decomposition. All chemical elements except carbon, oxygen, hydrogen and sulphur contained in animal dung are conserved in bio-digested slurry which is reported to be rich in plant nutrients both macro & micro nutrients compared to FYM. Nutrient content of Bio-gas slurry approximately 1.43 per cent N, 1.21 per cent P and 1.01 per cent K on dry weight basis. In general, 10 tonnes per ha bio-digested slurry is recommended to be applied once in three years to maintain organic carbon in soil, besides providing nitrogen, phosphorus and potassium in form of organic fertilizers to the crop.

1.2.6 Non-edible oil cakes

Non-edible oil cakes have higher nutrient content as compared to other organic manures. Many oil cakes such as castor, neem, karanja, linseed, rapeseed and cotton seed may serve as good organic source. Neem cake contains the alkaloids-nimbin and nimbicidine which effectively inhibits the nitrification process and increasing the yield, nitrogen uptake and grain protein content of rice. Mahua cake has been successfully used in coastal saline soils for cultivation of rice. They are insoluble in water but their N become quickly available to plants about a week or 10 days after application. Commonly available non-edible oil cakes used as organic nutrient and their nutrient content is presented in Table 1.1.

Table 1.1. Non-edible oil cakes and their nutrient content

Oil cakes	N (%)	P_2O_5 (%)	K_2O (%)
Groundnut cakes	7.3	1.53	1.33
Linseed cakes	5.6	1.44	1.28
Castor cakes	4.4	1.85	1.39
Neem cakes	5.2	1.08	1.48

1.2.7 Poultry manure

Poultry manure is concentrated organic manure used as a nutrient source in organic farming particularly for vegetables comprising of 2.9 per cent nitrogen, 2.9 per cent phosphorus and 2.4 per cent potash. Broiler litter also contains 23-125 ppm copper, 125-667 ppm manganese and 106-669 ppm zinc. Poultry waste manure is highly complex and challenging because of associated problems like nitrate and heavy metal contamination in soil, crops, surface and ground water, air quality and odour, disposal of dead and diseased poultry and food safety.

1.2.8 Azolla

Inoculation of Azolla bio-fertilizer at 7 days after transplanting of rice crop @ 2 tonnes per ha in standing water and its growth during the rice crop adds organic matter and nitrogen to the soil. The Azolla incorporation at the time of puddling of rice soil @ 6 tonnes per ha can also provide about 25-30 kg N per ha to the rice crop in organic farming system. For Azolla incorporation we need to produce required amount of biomass in multiplication tanks/ponds.

1.2.9 Biofertilizers

Biofertilizers means the product containing carrier based (soild or liquid) living microorganisms which are agriculturally useful in terms of nitrogen fixation, phosphorus solubilization or nutrient mobilization to increase productivity of the soil and/or crop. Biofertilizers are live materials hence it should be handled carefully and a favourable environment in the field should be assured for desired results. In case of carrier based formulations, the product should have 30-50 per cent of moisture throughout the shelf life period to sustain microbial population and the microbial population should be in the range of 10^7 to 10^9 cells/g of moist product. In case of liquid formulations, the cell load should be in the range of 1×10^8 to 1×10^{10} during the entire period of shelf life. Three types of biofertilizers are used i.e. Symbiotic N_2 fixers such as *Rhizobium* culture for legumes; free living N_2 fixers (non-symbiotic bacteria) such as *Azotobacter* and *Azospirillum* spp. for cereals, blue green algae and Azolla for rice and phosphate solubilizers such as *Pseudomonas* sp. While symbiotic N_2 fixers inoculated in legumes can fix substantial amount of atmospheric N_2 to feed the host plant, free-living N_2 fixers contribute much less, usually 10-30 kg/ha. Phosphate solubilizers enhance the availability of native inorganic P.

1.2.10 Biodynamic Compost (BD)

There are eight known biodynamic composts, namely biodynamic preparation (BD) 500(Cow horn manure), 501 (Horn silica), 502 (Yarrow), 503 (Chamobile), 504 (Stinging nettle), 505 (Oak bark), 506 (Dandelion), and 507 (Valerian) and Cow-Pat Pit (CPP). These preparations are easy to formulate and can be done by farmers at their own farms. Out of these, formulation-500 (Cow-horn compost) and formulation-501 (horn silica) can be used directly in soil and plants. These BDs are very popular and are being used by large number of organic farmers. Formulation 502 to 507 is compost enrichers and promoters, while formulation 508 is of prophylactic in nature and helps in control of fungal diseases (Steiner, 1974).

BD-500 (Cow- horn manure) usually increases humus in soil and after dilution in water, it is sprayed directly on land during early spring (March-April) and autumn September-early October) concentration 30-35 gms in 12 litres of boiled cool water and stirred for 1 hour in the evening before sowing or transplanting. Mixing of PSM, Azotobacter, Azospirillium and Bacillus subtilis 100 ml each in solution ensures better yield in all crops.

1.2.11 Panchgavya

Panchgavya, an organic product has the potential to play the role of promoting growth and also provides immunity in plant system. Physico-chemical properties of Panchgavya revealed that they posess almost all the major nutrients, micronutrients and growth hormones (IAA and GA) required for crop growth. Predominance of fermentative microorganisms like yeast and lactobacillusmight be due to the combined effect of low pH, milk products and addition of jaggery/sugarcane juice as substrate for their growth.

Panchgavya consists of nine products viz., cow dung, cow urine, milk, curd, jaggery, ghee, banana, tender coconut and water. When suitably mixed and used, these have miraculous effects. Here for its preparation, the product of local breeds of cow is said to have potency than exotic breeds. For this mix 7 kg cow dung and 1 kg cow ghee thoroughly both in morning and evening hours and keep it for 3 days. After 3 days mix 10 litres of cow urine and 10 litres of water and keep it for 15 days with regular mixing both in morning and evening hours. After 15 days mix cow milk-3 litres, cow curd- 2 litres, tender coconut water – 3 litres, jaggery- 3 kg and well ripened poovan banana-12 nos. and Panchgavya will be ready after 30 days. All the above items can be added to a wide mouthed mud pot, concrete tank or plastic can as per the above order. The container should be kept open under shade and covered with a wire mesh or plastic mosquito net to prevent house flies from laying eggs and formation of maggots in the solution.

Panchgavya is sprayed on crops at a concentration of 3 per cent (3 litres panchgavya to every 100 litre of water is ideal for all crops). The solution of panchgavya can be mixed with irrigation water at 50 litres per hectare either through drip irrigation or flow irrigation. Also, 3 per cent solution of panchgavya can be used to soak the seeds or dip the seedlings (20 minutes before transplanting). Rhizomes of turmeric, ginger and sets of sugarcane can be soaked for 30 minutes before planting. Panchgavya is used at pre-flowering phase (once in 15 days, 2 sprays depending on duration of crop), flowering and pod setting stage (once in 10 days, 2 sprays) and fruit/ pod maturation stage (once during pod maturation).

1.3 WEED MANAGEMENT IN ORGANIC FARMING

In weed management approach under organic system, the central goal is to reduce weed competition and reproduction to a level that the farmer can accept. In many cases, this will not completely eliminate all weeds. Weed management should reduce competition from by preventing the production of weed seeds and perennial propagules - the parts of a plant that can produce a new plant. Consistent weed management can reduce the costs of weed control and contribute to an economical crop production system.

1.4 CULTURAL PRACTICES

1.4.1 Crop Rotation

Monoculture, that is growing the same crop in the same field year after year, results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc.).

1.4.2 Cover Crops

Rapid development and dense ground covering by the crop suppress weeds. The inclusion of cover crops such as ricebean, groundnut, rye, red, clover, buckwheat, wintering crops like winter wheat or forages in the cropping system can suppress weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation. Cover crops offer many benefits to an organic farming system, including protection against soil erosion, improvement of soil structure, soil fertility enhancement, and weed suppression. Cover crops can be used in a variety of ways to suppress weeds. Cover crops can suppress weeds, reduce weed populations in the subsequent crop, and reduce weed seed contributions to the soil seedbank.

1.4.3 Intercropping

Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds. However, the use of intercropping as a strategy for weed control should be approached carefully. The intercrops can greatly reduce the yields of the main crop if competition for water or nutrients occurs. Intercropping of soybean and groundnut in upland rice, maize or sorghum greatly reduces the weed problem.

1.4.4 Mulching

Mulches reduce weed competition by limiting light penetration and altering soil moisture and temperature cycles. Living mulch is usually a plant species that grows densely and low to the ground such as clover. Living mulches can be planted before or after a crop is established. A living mulch of *Portulaca oleracea* from broadcast before transplanting broccoli can suppress weeds without affecting crop yield. Often, the primary purpose of living mulch is to improve soil structure, aid fertility or reduce pest problems and weed suppression may be merely an added benefit.

Organic mulches include many materials that can be produced onfarm such as hay, straw, grass mulch, crop residues, and livestock or poultry bedding. Other materials, such as leaves, composted municipal wastes, bark, and wood chips, may be available from off-farm sources. Farmers must consider both the quantity and type of mulch to be applied, and the cost of the mulch and the equipment needed to manage it. Degradable materials do not need to be removed from the field, and some may be incorporated into the soil to speed degradation. Reusable materials such as black polypropylene mulch can be used for long- term weed management in nurseries and some high value crops (such as strawberry). Reusable cloth mulch has also been used in lettuce production to promote seed germination and prevent weeds (Finney and Creamer, 2008).

1.4.5 Stale Seedbed Preparation

This weed management strategy consists of preparing a fine seedbed, allowing weeds to germinate (relying on rainfall or irrigation for necessary soil moisture), and directly removing weed seedlings via light cultivation or flame weeding. Seeds or seedling can then be planted into the moist weed-free soil. This technique helps to provide an opportunity for crop emergence and growth before the next flush of weeds. If time allows, this can be done twice before planting.

1.4.6 Soil Solarization

Solarization consists of heating the soil to kill pest organisms, including fungi, bacteria, and weed seeds. It also reduces populations of various pathogens and nematodes. Soil is covered in summer with clear or black polyethylene plastic and moistened under the plastic, which is left in place for six to seven weeks or longer. Weed seeds and young seedlings are killed by the heat and moisture and through direct contact with the plastic, which causes scorching. Research has demonstrated that solarization from July to October with clear or black plastic provides effective weed control without reducing crop yield (Rieger et al., 2001). Solarization can also be used to produce weed–free soil or potting mix for container production in warm climates (Stapleton et al., 2002), and it has been used in Mediterranean climates to reduce weed competition and increase yields of field-grown cauliflower and fennel (Campiglia et al., 2000).

1.4.7 Planting Strategies

Date, density, and arrangement for many row and horticultural crops, rapid growth and early canopy closure can result in the suppression of weeds. For this reason, using transplants when possible for horticultural crop production is advantageous. Use of transplants will increase production costs, so the economic benefit of using transplants must be weighed against cost. When it is economically viable, as is the case with many vegetable crops, use of transplants should be considered.

1.4.8 Use of manure and compost

Use of organic manure can affect the competition between crops and weeds and in the subsequent crops. Quality of organic manure and method of application affects weed population in crop fields. Broadcasting favours weed than crops. Similarly improper decomposition of composts promote weeds in fields. Use of legume residues are opposed to chemical nitrogen fertilizer to supplement nitrogen needs of the crop can enhance weed suppression. Legume residues release nitrogen slowly with less stimulation of unwanted weed growth. Applying organic manure near the rows where it is more likely to be captured by the crop will suppress weed growth. Expensive bagged organic fertilizer may be applied in low rates at planting or side dress, relying on mid-season release of nutrients from compost and / or green manures for primary fertility.

1.4.9 Water management

Effective water management is key to controlling weeds in crop production. Time and method of irrigation influences weed growth in field. In drip irrigation water is applied in crop root zone and hence weed growth are minimum. There are a number of ways that careful irrigation management can help reduce weed pressure on crops. In rainfed farming water management practices such as mulching, intercropping etc. helps to reduce weed problem.

1.5 MECHANICAL WEED CONTROL

Mechanical removal of weeds is both time consuming and labor-intensive but is the most effective method for managing weeds especially in a organic farm. The choice of implementation, timing, and frequency will depend on the structure and form of the crop and the type and number of weeds. Cultivation involves killing emerging weeds or burying freshly shed weed seeds below the depth from which they germinate. It is important to remember that any ecological approach to weed management begins and ends in the soil seed bank. The soil seed bank is the reserve of weed seeds present in the soil. Observing the composition of the seedbank can help a farmer make practical weed management decisions. Burial to 1 cm depth and cutting at the soil surface are the most effective ways to control weed seedlings mechanically. Mechanical weeders include cultivating tools such as hoes, harrows, tines and brush weeders, cutting tools like mowers and stimmers, and dual-purpose implements like thistlebars. The choice of implement and the timing and frequency of its use depends on the morphology of the crop and the weeds.

1.5.1 Flame Cultivation

Broadcast flame cultivation prior to seeding the crop can be used effectively on most organically produced crops. It is more effective on a smooth soil surface than a rough or cloddy surface (Smilie et al., 1965). And it is more effective on broadleaf weeds than grasses, but its effectiveness decreases as weeds mature. Grasses and perennial weeds are most tolerant to flaming. Flaming burns grasses and perennial weeds to the soil surface, but sometimes these weeds are capable of regrowth. Seeding or transplanting crops after flame cultivation must be done carefully to prevent soil disturbance that can lead to weed seed germination and establishment.

1.6 BIOLOGICAL WEED CONTROL

1.6.1 Allelopathy

Allelopathy is the direct or indirect chemical effect of one plant on the germination, growth or development of neighboring plants. It is now commonly regarded as component of biological control. Species of both crops and weeds exhibit this ability. Allelopathic crops include barley, rye, annual ryegrass, buckwheat, oats, sorghum, sudan, sorghum hybrids, alfalfa, wheat, red clover, and sunflower. Vegetables, such as horseradish, carrot and radish, release particularly powerful allelopathic chemicals from their roots. One approach of utilizing the allelopathic property of crops is to screen genotypes to examine their potential for weed suppression. The strategy for using allelopathy for weed management could be either through directly exploiting natural allelopathic interactions, especially of crop plants, or applying allelochemicals as a source of natural herbicides. However, it is unclear whether the application of natural weed killing chemicals would be acceptable to the organic standard authorities.

1.6.2 Beneficial organisms

Little research has been conducted on using predatory parasitic microorganisms or insects to manage weed populations. However, this may prove to be a useful management tool in the future. Natural enemies that have so far been successful include a weevil for the aquatic weed *salvinia*, a rust for skeleton weed and probably the most famous, a caterpillar (*Cactoblastis* sp.) to control prickly pear. There is also considerable research effort aimed at genetically engineering fungi (myco-herbicides) and bacteria so that they are more effective at controlling specific weeds. Myco-herbicides are a preparation containing pathogenic spores applied as a spray with standard herbicide application equipment. Some biocontrol agents and Target weed mycoherbicides used for bioagents control are indicated below-

Parthenism hysterophorus:	*Zygrogramma bicolarata*
Lantana camara:	*Crocidosema lantana, Teleonnemia scrupulosa*
Opuntia dilleni:	*Dactylopiustomentosus, D. Indicus* (cochineal scale insect)
Eichhornea crassipes:	*Neochetina eichhornea, N. Bruchi* (Hyachinth weevil) *Sameodes alliguttalis* (hyancinth moth)
Salvinia molesta:	*Crytobagus singularis* (weevil) *Paulinia acuminate* (grass hopper), *Samea mutiplicalis*
Alternanthera philoxaroides:	*Agasides hygrophilla* (flea beetle) *Amynothrip sandersoni*

Commercial mycoherbicides:

Trade name	Pathogen	Target weed
Devine	*Phyophthora palmivora*	*Morreria odorata* (Strangler vine) in citrus
Collego	*Colletotrichum gleosporoides* f.sp. *aeschynomene*	*Aeschynomene virginica* (northen joint vetch) in rice and soyabean
Biopolaris	*Biopolaris sorghicola*	*Sorghum halepense* (Johnson grass)
LUBAO 11	*Colletotrichum gleosporoides* f.sp. *Cuscuttae*	*Cuscutta sp.* (Dodder)
ABG 5003	*Cercospora rodmanii*	*Eichhornea crassipes* (water hyancinth)

1.7 APPROVED HERBICIDES

A limited number of natural substances can serve as herbicides on organic farms.

1.7.1 Corn Gluten Meal

The most widely used product in USA is corn gluten meal, a byproduct of cornstarch production. Corn gluten meal may be applied as a pre-emergence herbicide. Time of application is extremely important, as the gluten must be present when weed seeds germinate to inhibit root formation. Weeds affected by corn gluten meal include redroot pigweed, black nightshade (*Solanum nigrum*), common lambsquarters, curly dock, creeping bentgrass (*Agrostis palustris*), purslane, common dandelion (*Taraxacumofficinale*), and smooth crabgrass (*Digitaria ischaemum*). Of weeds that have been tested, barnyard grass (*Echinochloa crus-galli*) and velvetleaf (*Abutilon theophrasti*) are the least susceptible to corn gluten meal. Broadleaf species are generally more susceptible than grasses to corn gluten meal. In field studies, weed cover has been reduced up to 84 percent when corn gluten meal was incorporated prior to planting (McDade and Christians, 2000).

1.8 PEST AND DISEASE MANAGEMENT

1.8.1 Tillage, land configuration and crop spacing

Tillage is old age practice of pest management in agriculture. Deep summer ploughing exposes the roots of many weeds and facilitate their drying. It also helps in exposing the hibernating stages of insects for predation or killing by desiccation. The sclerotia and other resting structures of many pathogenic fungi and stages of nematodes get destroyed by summer ploughing. Intercultural operations besides proving proper aerations and growing conditions to soil, also helps in weed management. Hence summer ploughing and proper interculture should be among main strategies for weed, pest and disease management in organic farming. Planting of crops especially turmeric, ginger, pulses, vegetables, maize etc. on raised beds or bunds particularly during rainy season provides protection against some soil borne diseases caused by *Pythium* and *Phytophthora* spp.

Crop spacing should be kept at larger side to avoid the build-up of congenial environment for pests and diseases attack. Widely spaced crops have proper aeration and lower humidity and lesser attraction for insect shelter and thus avoid the heavy attack of pests and diseases. Keeping 2' space vacant at every 3-4 meters in case of basmati or non-basmati rice helps in managing brown plant hopper, sheath blight disease and other pests. Larger plant to plant distance in case of okra helps in minimizing yellow vein mosaic disease due to lesser white fly vectors.

1.8.2 Soil solarisation

Soil solarisation is a technique of raising the soil temperature by clear plastic sheets which allows shorter wavelength solar radiation to enter into soil and heat it up and at the same time it restricts the longer wavelength radiation into soil during night time. Thus, the soil solarization keeps soil temperature continuously above lethal range (up to 60°C) to many soil borne plant pathogensof mesophilic nature (*Fusarium spp. Verticillium spp.* etc.), nematodes (root knot nematode), weeds (annual grassy weeds and some broad leaved weeds also), and hibernation stages of insect-pests. The thickness of clear polyethylene sheets should be in the range of 25-30 micron. The soil before solarization should be well prepared and has proper moisture for maximum conductivity of heat into the soil.

1.8.3 Multiple cropping and mixed cropping

Mixed cropping is also a strategy to compensate the losses caused by pests and diseases. If main crop is damaged by the disease or pests, the mixed crop can compensate for the losses in main crop. Some of the mixed crops i.e. cow pea or Dhaincha smother weeds in between the rows of wide spaced crops and also add nitrogen to the soil. Any other interested crop which is having weed smothering property and if, compatible with main crop, can be planted in rows of main crop. Intercropping of Marigold in between wide spaced crops can smoother the weeds and also controls many nematode species of the crops.

1.8.4 Use of resistant varieties

Since, the synthetic chemical pesticides are strictly prohibited in organic crop production and there are not many options under biological, botanical or other strategies of pest management allowed, the use of pest/disease resistant or tolerant and weed smothering varieties must be in our package of practices to manage the pests. The varieties of disease pest resistant or tolerant to pests vary from region to region; hence they should be selected according to locality. Induced resistance is another area which can be exploited in organic farming. Seed treatment with bioagents like *Trichoderma* and *Pseudomonas fluorescens/ Bacillus subtilis* has been reported to induce broad range resistance in many crops against various pathogens.

1.8.5 Seed treatment with Beejamrut

Bijamrit is a biodynamic preparation commercially exploited for seed treatment in organic farming and reported to suppress many seed borne diseases. For preparation of Bijamrit, put 5 kg fresh cow dung in a cloth bag and suspend in a container filled with water to extract the soluble ingredients of dung. Suspend 50g lime in one litre of water separately. After 12-16 hours, squeeze the bag to extract all the ingredients of cow dung and add 5 litre of cow urine, 50g of virgin forest soil, prepared lime water and 20 litre water. Again incubate the preparation for 8-12 hours. Filter the content and this filtrate is ready for seed the treatment. Apply he amount of Bijamrit on seed which can make a layer over it and dry it in shade before sowing.

1.8.6 Mechanical methods

Removal of affected plants and plant parts, collection and destruction of egg masses and larvae, installation of bird perches, light traps, sticky coloured traps and pheromone traps are most effective mechanical methods of pest control. In bigger plots of crop, put 'T' type of bird perches with 5-

6 feet height which attracts the birds to sit over and predate the insect larvae and adults infesting the crop. The boundary trees and shrubs planted in farm also serve the purpose of bird perches.

1.8.7 Use of Bio-pesticides

For the management of fungal diseases and nematodes the *Trichoderma viride* or *T. harazianum* are found to be best. Four to five kg of formulation with desired number of viable spores is sufficient for one hectare. They can be applied as spray at regular intervals for desired level of disease control. *Pseudomonas fluorescence* formulations @ 4g/kg seed either alone or in combination with *Trichoderma spp.* mange most of the seed and soil borne diseases. It can also be used as spray for managing the crop diseases. For controlling the insect-pests, formulations viz. *Beauveria bassiana, Metarhizium anisopliae, Nomuraea rileyi, Verticillium sp.,* are available in the market and can manage their specific insect-pest.

1.8.8 Use of botanical pesticides

Neem has been reported to be effective in the management of approximately 200 insects, pests and nematodes. Neem is very effective against grasshoppers, leaf hoppers, plant hoppers, aphids, jassids, and moth caterpillars.It has strong repellent and anti-feedant activities. Neem extracts, are also very effective against beetle larvae, butterfly, moth and caterpillars such as Mexican bean beetle, Colorado potato beetle and diamond black moth. Neem is very effective against grasshoppers, leaf minor and leaf hoppers such as variegated grasshoppers, green rice leaf hopper and cotton jassids. Neem is fairly good in managing beetles, aphids and white flies, mealy bug, scale insects, adult bugs, fruit maggots and spider mites.

1.8.9 Fermented Curd water

In some parts of central India, fermented curd water (butter milk or Chhaachh or mattha) is also being used for the management of white fly, jassids, aphids etc.

1.8.10 Dashparni Extract

Crushed neem leaves 5 kg + Tinospora cordifolia (giloya) leaves 2 kg, Annona squamosa (custard apple) leaves 2 kg, Nerium indicum leaves 2 kg, Pongamia pinnata (Karanja) leaves 2 kg. Green chilli paste 2 kg, garlic paste 250 gm, cow dung 3 kg, Calotropis procera leaves 2 kg and cow urine 5 litre in 200 litre water and fermented for one month. The suspension is shaken regularly three times a day. Extract is finally obtained after crushing and filtering. The extract can be stored up to 6 months and used to control insect-pests and diseases of crops @500 litre/ha.

1.8.11 Mixed leaves extract

Crush 3 kg neem leaves in 10 litres of cow urine. Crush 2 kg custard apple leaf, 2 kg papaya leaf, 2 kg pomegranate leaves, 2 kg guava leaves in water. Mix both the formulas and boil 5 times at some interval till it becomes half. Incubate for 24 hrs, then filter and squeeze the extract. This formula can be stored in bottles for 6 months. Dilute 2-2.5 litre of this extract in 100 litre of water for 1 acre of crop area. This is useful against sucking pest, pod/ fruit borers.

Effective management of nutrient, weeds, insect-pest and disease is the major challenge for successful organic farming. Integrated management comprising cultural, mechanical and biological practices are warranted for managing nutrient, weeds, pest and diseases in an eco-friendly way in organic farms. In addition to the growing concern for protection of environment, maintain biodiversity and protection of human and animal health, integrated crop management approaches are also good ways of climate change mitigation.

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Chapter 2

ORGANIC FARMING - STATUS AND ASPECTS

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2.1 INTRODUCTION

Organic farming systems are very much native to Indian Agriculture. Traditionally, precisely before dawn of the green revolution, crops and livestock have been reared together in all the farm households. Nevertheless, during pre-green revolution period (up to 1960s) the rate of national agricultural growth was not able to keep pace with population growth and virtually, ship to mouth situation prevailed. This was the major factor for introduction and large scale popularization of the high yielding varieties (HYVs) of crops, which were highly responsive to the chemical fertilizers and water use. As a result, the total food grain production increased phenomenally from mere 50.82 million tonnes in 1950-51 to 283.37 million tonnes in 2018-19 (As per 3rd advance estimate of Ministry of Agriculture and farmers welfare, Government of India). This can be primarily attributed to large-scale adoption of HYVs, combined with other green revolution technologies (GRTs) in cereal crops, expansion of gross irrigated area (22.56 million ha in 1950-51 to 95.77 million ha in 2013-14) and increase in fertilizer consumption (0.07 million tonnes in 1950-51 to 26.75 million tonnes in 2015-16).All of them put together have led to substantial increase in the productivity of crops, especially food grains (from 522 kg ha-1 in 1950-51 to 2028 kg ha-1 in 2014-15) culminating the status of India from a food importer to net food exporter (presently contribution of agriculture in total export value is 14.1%).

It has been proved scientifically and convincingly that integrated use of organic manures with chemical fertilizers improves the use efficiencies of the latter owing to concurrent improvement of soil physical, chemical and biological properties. The water holding capacity of the soil also gets improved on account of regular use of organic manures. It is estimated that various organic resources having the total nutrient potential of 32.41 million tonnes will be available for use in 2025. Out of these organic resources, considerable tapable potential of nutrients (N + P_2O_5 + K_2O) from human excreta, livestock dung and crop residues have been worked out to be only 7.75 million tonnes. As we know, organic is more of a description of the agricultural methods used on a farm, rather than food itself and those methods combine tradition, innovation and science. Organic agriculture, in simple terms, requires a shift from intensive use of synthetic chemical fertilizers, insecticides, fungicides, herbicides, PGRs, genetically engineered plants to extensive use of animal manures, beneficial soil microbes, bio-pesticides, bio-agents and indigenous technological knowledge, based on scientific principles of agricultural systems. Scientific evidences clearly establish that conversion of high intensive agriculture areas to organic systems lead to reduction in crop yields considerably (up to 25-30%), especially during initial 3-4 years; before soil system regains and crop yields come to comparable level. In this scenario, if all the cultivated areas are brought into organic production systems, the national food production integrated may get jeopardized; hence a phased approach may be desirable. integrated approach of crop management – including integrated nutrient management and inter/ mixed cropping – is also considered as **“towards organic”** approach; and at the same time it has been found to increase the use efficiency of all costly inputs especially fertilizers and water.This approach will be appropriate to adopt "towards organic approach" in the resource-rich states contributing major share to the food basket. This approach will also contribute to more crops per drop and less land, less resource/ time and more production" strategies of the government.

2.2 COUNTRY PROFILE

Geographically, India is divided in to 4 physical divisions (The great mountain walls, Indo-gangetic plains, Deccan plateau and Coastal ghats). Indian agriculture began by 9000 Before the Common Era (BCE) as a result of early cultivation of plants, and domestication of crops and animals. Settled life soon followed with implements and techniques being developed for agriculture. As per the land use statistics 2011-12, the total geographical area of the country is 328.7 m ha of which 140.8 m ha is the reported net sown area with 195.2 m ha as gross cropped area. Cropping intensity is 138.7 % with net irrigated area of 65.3 m ha. The agriculture sector contributes 13.9 % of India’s Gross Domestic Product (GDP),but 53.2 % of the population is still dependent on it. Rainfall is the important element of Indian economy as 75.5 m ha of net sown area is not irrigated.

Although, the monsoons affect most part of India, the amount of rainfall varies. from heavy to scanty on different parts. There is great regional and temporal variation in the distribution of rainfall. Over 80% of the annual rainfall is received in the four rainy months of June to September. The average annual rainfall is about 125 cm, but it has great spatial variations. The country is divided in to 15 agro-climatic zones and 131 NARP (National Agricultural Research Project) zones. Based on the crop growing period, the country is also divided in to 20 agro-ecological regions in which 8 regions (gross cropped area of 104.36 m ha) have less than 150 days of growing period. Backed by continued science led technological innovations in the agriculture sector, food grain production of India has more than doubled over the decades to a record 264 mt in 2014.

2.3 ASPECT OF ORGANIC AGRICULTURE SYSTEMS

- Organic systems may decrease yields, depending on intensity of inorganic inputs used before conversion.
- In irrigated lands, conversion to organic agriculture may lead to almost identical yields over a period of time.
- In low input traditional/ rainfed agriculture, conversion to organic agriculture has potential to increase yields.

2.4 CONCEPT AND STRATEGIC IMPORTANCE OF ORGANIC FARMING

Organic farming is very much native to this land. India and China have the long history of organic farming. This concept of organic farming is based on following principles.

- Nature is the best role model for farming, since it does not use any inputs nor demand unreasonable quantities of water.
- The entire system is based on intimate understanding of nature's ways. The system does not believe in mining of the nutrients from soil and do not degrade it in any way for today's needs.
- The soil in this system is a living entity and the soil's living population of microbes and other organisms are significant contributors to its fertility on a sustained basis and must be protected and nurtured at all cost.
- The total environment of the soil, from soil structure to soil cover is more important.

In today's terminology, it is a method of farming system which primarily aims at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers) to release nutrients to crops for increased sustainable production in an eco-friendly pollution free environment. Organic farming system relies on crop rotations, crop residues, animal manures, legumes, green manures, safe off-farm technologies with preference to depend on resources available either at farm or locally". According to Scialabba (2007), the strongest benefits of organic agriculture are its reliance on is a fossil fuel independent, locally available resources that incur minimal agro-ecological stresses and are cost-effective. She describes organic agriculture as neo-traditional food system, which combines modern science as well as indigenous knowledge.

India has other comparative advantages for organic production which are given below.

- India is strong in high quality production of certain crops like tea, some spices, rice specialties, ayurvedic herbs etc.
- India has a rich heritage of agricultural traditions that are suitable for designing organic production systems. Botanical preparations, some of which originate from the ancient Veda scripts, provide a rich source for locally adapted pest and disease management techniques. The widespread cultivation of legume crops facilitates the supply of biological fixation of nitrogen.
- In several regions of India agriculture is not very intensive in regards to use of agro-chemicals. Especially in mountain areas and tribal areas, use of agrochemicals is rather low, which easily facilitates conversion to organic production. On these marginal soils, organic production techniques have proved to achieve comparable or in some cases (especially in the humid tropics) even higher yields than conventional farming.
- The Non-Governmental Organizations (NGOs) sector in India is very strong and has established close linkages to a large numbers of marginal farmers. Many NGOs are engaged in promotion of organic farming and provide training, extension services information and marketing services to farming communities.
- The Indian Government has realized the potential and significance of organic agriculture for the country and has recently started to support organic agriculture on a large scale and on various levels. A national regulatory framework (standards, accreditation regulations) has already been passed in 2000 and as a result National Standards for Organic Production (NSOP) was notified in 2001 under National Programme of Organic Production. Ministry of Agriculture launched National Project on Organic Farming. Special schemes to support organic agriculture in North-Eastern states and Paramparaghat Krishi Vikas

Yojana also formulated to give impetus to organic systems. Indian Council of Agricultural Research provides research and technological back up in the country.

2.5 ORGANIC AREA, PRODUCTION AND EXPORT

In world, 97.7 million ha area in 178 countries is under organic agriculture which includes both cultivated (57.8 million ha) and wild harvest (39.9 million ha) during 2016.Emerging from 42,000 hectares under certified organic farming in 2003-04, the organic agriculture has grown many folds and India has brought 5.71 m ha area under organic certification process. Out of this cultivated area accounts for 1.49 m ha (26.1 %) while remaining 4.22 m ha (73.9 %) is wild forest harvest collection area. Currently, India ranks 9th in terms of cultivable land under organic certification. In terms of wild collection, India ranks 3rd next to Finland and Zambia. Around 8.35 lakhs producers are engaged in the country in various forms. Sikkim state has been declared as organic state from January 2016 and has highest net sown area (100 %) under organic certification while Madhya Pradesh is having largest area under organic production system. The domestic market for organic products in the year 2014-15 was estimated at Rs. 875 crores. The total volume of export during 2017-18 was 4.58 lakh tonnes. The organic food export realization was around Rs. 3453.48 crores (515.44 million USD).

India's first internationally certified organic products emerged in the mid 70's, supported by UK's Soil Association. Different parts of India have developed their own local or regional systems for ecological agriculture that are now gathered in one umbrella term '*Jaivic Krishi' or 'Jaivik Kheti'*.

2.6 PRINCIPLES OF ORGANIC AGRICULTURE, SCOPE AND OBJECTIVES

The organic community has adopted four basic principles (FAO 2001), and broadly speaking, any system using the methods of organic agriculture and being based on these principles, may be classified as organic agriculture:

2.6.1 The principle of health

Organic Agriculture should sustain and improve the health of soil, plant, animal, human and planet as one and indivisible.

2.6.2 The principle of ecology

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

2.6.3 The principle of fairness

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

2.6.4 The principle of care

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well being of current and future generations and the environment.

Organic farming is considered incomplete without livestock as livestock alone contributes 37.5 % of total organic manures in the country. Crop + dairy is the pre-dominant farming system practiced traditionally by Indian farmers over the centuries. Analysis of benchmark data of 732 marginal households across the 30 NARP zones indicates existence of 38 types of farming systems. Out of this, 47 % of households have the integration of crop + dairy, 11 % have crop + dairy + goat,9 % households have crop + dairy + poultry systems and 6 % households have only crop component. Hence, natural strength exists in the country for promotion of organic farming.

2.7 ORGANIC FARMING PRINCIPLES HAVING ALL THE FOLLOWING MAJOR OBJECTIVES AS:

Production of high quality food in harmony with natural systems and cycles

- Enhancing biological cycles within the farming system involving microorganisms, soil flora and fauna, plants and animals
- Maintaining long-term soil fertility and genetic diversity of the production system and its surroundings including plant and wildlife
- Promoting healthy use with proper care of water resources and all life therein
- Creating harmonious balance between crop production and animal husbandry
- Minimizing all forms of pollution

2.8 COMPONENTS OF ORGANIC FARMING

Essential components of organic farming are keeping the soil alive through effective management natural resources. They are as follows.

2.8.1 Enrichment of soil

Abandon use of chemicals, use crop residue as mulch, use organic and biological fertilizers, adopt crop rotation and multiple cropping, avoid excessive tillage and keep soil covered with green cover or biological mulch.

2.8.2 Management of temperature

Keep soil covered, plant trees and bushes on bund

2.8.3 Conservation of soil and rain water

Dig percolation tanks, maintain contour bunds in sloppy land and adopt contour row cultivation, dig farm ponds, maintain low height plantation on bunds.

2.8.4 Harvesting of sun energy

Maintain green stand throughout the year through combination of different crops and plantation schedules.

2.8.5 Self-reliance in inputs

Develop your own seed, on-farm production of compost, vermicompost, vermiwash, liquid manures and botanical extracts.

2.8.6 Maintenance of life forms

Develop habitat for sustenance of life forms, never use pesticides and create enough diversity.

2.8.7 Integration of animals

Animals are important components of organic management. Animal component only provide as source of plant nutrients animal products but also provide enough dung and urine for use in soil.

2.8.8 Use of renewable energy

Use solar energy, bio-gas and other eco-friendly machines

2.9 VARIOUS FORMS OF ORGANIC AGRICULTURE

2.9.1 Biodynamic Agriculture

Biodynamic agriculture is a method of farming that aims to treat the farm as a living system which interacts the environment to build healthy, living soil and to produce food that nourishes, vitalizes and helps to develop man kind. The underlying principle of biodynamics is making life-giving compost out of dead material. The methods are derived from the teachings of Rudolf Stainer and subsequent practitioners. The important components of biodynamic farming are as follows.

- Turning plant materials such as green crops and straw, Not using chemical fertilizers and pesticides
- Avoiding soil compaction by machinery or animals, particularly in wet weather
- Keeping soil covered by pasture, crops or mulch not destroying the soil structure by poor farming practices such as excessive use of rotary hoe or cultivation in unsuitable weather (too wet or too dry)
- Fallowing the land by planting deep-rooting permanent pasture species or using green crops
- Use of preparations BD-500 and BD-501
- Compost made with preparations BD-502 – BD-507
- Liquid manure made with preparations BD-502 – BD-507
- Cowpat pit manure made with preparations BD-502 – BD-507

These biodynamic preparations named BD-500 to BD-507 are not food for the plants, but they facilitate the effective functioning of etheric forces. They are also not the usual compost starters, but can stimulate compost organisms in various ways. In short they are biologically active dynamic preparations which help in harvesting the potential of astral and etheral powers for the benefit of the soil and various biological cycles in the soil. So far 9 biodynamic preparations have been developed, named as formulation 500 to 508. Out of these, formulation-500 (cow horn compost) and formulation- 501 (horn-silica) are very popular and are being used by large number of organic farmers. Formulations-502 to 507 are compost enrichers and promoters, while formulation 508 is of prophylactic in nature and helps in control of fungal diseases.

2.9.2 *Rishi Krishi*

Drawn from Vedas, the Rishi Krishi method of natural farming has been mastered by farmers of Maharashtra and Madhya Pradesh. In this method, all on-farm sources of nutrients including composts, cattle dung manure, green leaf manure and crop biomass for mulching are exploited to their best potential with continuous soil enrichment through the use of Rishi Krishi formulation known as "*Amritpani*" and virgin soil. 15 kg of virgin rhizosperic soil collected from beneath of Banyan tree (*Ficus bengalensis*) is spread over one acre and the soil is enriched with 200 lit Amritpani. It is prepared by mixing 250 g ghee into 10 kg of cow dung followed by 500 g honey and diluted with 200 lit of water. This formulation is utilized for seed treatment (*beej sanskar*), enrichment of soil (*bhumi sanskar*) and foliar spray on plants (*padap sanskar*). For soil treatment it needs to be applied through irrigation water as fertigation. The system has been demonstrated on a wide range of crops i.e. fruits, vegetables, cereals, pulses, oilseeds, sugarcane and cotton.

2.9.3 *Panchgavya Krishi*

Panchgavya is a special bioenhencer prepared from five products obtained from cow; dung, urine, milk, curd and ghee. Dr Natrajan, a Medical practitioner and scientist from Tamilnadu Agricultural University, has further refined the formulation suiting to the requirement of various horticultural and agricultural crops. The cost of production of panchgavya is about Rs. 25-35 per lit. Panchgavya contains many useful microorganisms such as fungi, bacteria, actinomycetes and various micronutrients. The formulation act as tonic to enrich the soil, induce plant vigour with quality production.

2.9.4 Natural farming

Natural farming emphasizes on efficient use of on-farm biological resources and enrichment of soil with the use of Jivamrita to ensure high soil biological activity. Use of Beejamrita for seed/ planting material treatment and Jeevamrita for soil treatment and foliar spray are important organic components. Jeevamrita has been found to be rich in various beneficial microorganisms. 200 lits of jeevamrita is needed for one application in one acre. It can be applied through irrigation water, by drip or sprinkler or even by drenching of mulches spread over the field or under the tree basin.

2.9.5 Natueco Farming

The Natueco farming system follows the principles of ecosystem networking of nature. It is beyond the broader concepts of organic or natural farming in both philosophy and practice. It offers an alternative to the commercial and heavily chemical techniques of modern farming. Instead, the emphasis is on the simple harvest of sunlight through the critical application of scientific examination, experiments, and methods that are rooted in the neighborhood resources. It depends on developing a understanding of plant physiology, geometry of growth, fertility, and biochemistry. Natueco Farming emphasizes "Neighborhood Resource Enrichment by" Additive Regeneration" rather than through dependence on external, commercial inputs. The three relevant aspects of Natueco Farming are:

- **Soil -** Enrichment of soil by recycling of the biomass establishing a proper energy chain.

- **Roots -** Development and maintenance of white feeder root zones for efficient absorption of nutrients.
- **Canopy -** Harvesting the sun through proper canopy management for efficient photosynthesis.

In all biological processes, energy input is required and solar energy is the only available resource. No time and no square foot of sun energy should be lost by not harvesting it biologically. Lost sun energy is lost opportunity.Photosynthesis is the main process by which Solar Energy is absorbed. It is of course the objective to obtain a higher degree of photosynthesis. Although genetically photosynthesis efficiency is around 1.5% to 2.5%, we can increase leaf index [area of leaf for every square meter of land] by caring for healthy canopies, use of multiple canopy utilizing direct and filtered sunrays.

2.9.6 Homa Farming

Homa farming has its origin from vedas and is based on the principle that "you heal the atmosphere and the healed atmosphere will heal you" The practitioners and propagators of homa farming call it a "revealed science". It is an entirely spiritual practice that dates from the Vedic period. The basic aspect of homa farming is the chanting of Sanskrit mantras (Agnihotra puja) at specific times in the day before a holy fire. The timing is extremely important. While there is no specific agricultural practice associated with homa farming, the farm and household it is practiced in, is energised and "awakened". The ash that results from the puja is used to energise composts, plants, animals, etc. Homa Organic Farming is holistic healing for agriculture and can be used in conjunction with any good organic farming system. It is obviously extremely inexpensive and simple to undertake but requires discipline and regularity. Agnihotra is the basic Homa fire technique, based on the bio-rhythm of sunrise and sunset, and can be found in the ancient sciences of the Vedas. Agnihotra has been simplified and adapted to modern times, so anybody can perform it. During Agnihotra, dried cow dung, ghee (clarified butter) and brown rice are burned in an inverted, pyramid-shaped copper vessel, along with a special mantra (word-tone combination) is sung. It is widely believed that through burning organic substances in a pyramidformed copper vessel, valuable purifying and harmonizing energies arise. These are directed into the atmosphere and are also contained in the remaining ash. This highly energized ash can successfully be used as organic fertilizer in organic farming.

2.9.7 Effective microorganisms (EM) technology

Effective microorganisms is a consortium culture of different effective microbes commonly occurring in nature. Most important among them are : N_2-fixers, P-solubilizers, photosynthetic microorganisms, lactic acid bacteria, yeasts, plant growth promoting rhizobacteria and various fungi and actinomycetes. In this consortium, each microorganism has its own beneficial role in nutrient cycling, plant protection and soil health and fertility enrichment.

2.9.8 Soil and crop management

The natural resources (soil, rainfall, dust) provide several nutrients for crop plants.Soil Organic Carbon (SOC) is central to soil health due to its influence on soil structure, water retention, microbial activities, soil aeration, and nutrient retention. It is the organic forms of C and not the source of nutrient which is important for soil-plant continuum. Hence, Bio-organic fertilizer merits consideration. Indian soils are, in general, poor in organic C, which is further going down with every intensification of agriculture. Promotion of green manuring is essential and quick way to improve the soil organic carbon status. Farmers should apply at least one green manuring crop once in every two years. In all rice fields, cultivation of green manuring plants as an intercrop is highly recommended (like one row of sesbania after every 10-15 rows of rice which can be incorporated into field after 30-35 days) to achieve the best productivity. Use of crop residue and weed biomass as mulch-wheat is highly recommended and rice straw can also be used with dung and cattle urine to increase organic carbon.

2.10 NATURAL SAFE PRODUCTS FOR CONTROL OF PEST, DISEASE, WEEDS, DISEASES AND GROWTH MANAGEMENT

Under organic systems, use of synthetic/ chemical pesticides, fungicides and weedicides is prohibited. Natural enemies shall be encouraged and protected e.g. raising trees in the farm attracts birds which kills pests of the crops, nest construction etc. Products collected from the local farm, animals, plants and micro-organisms, and prepared at the farm are allowed for control of pests and diseases (e.g. Neem Seed Kernel Extract, cow urine spray). Use of genetically engineered organisms and products are prohibited for controlling pests and diseases. Similarly, use of synthetic growth regulators is not permitted. Slash weeding is to be done between the plants. Weeds under the base of the plants shall be cleaned and put as mulch around the plant base. The weeded materials should be applied as mulch in the ground itself. The products that are permitted for control of pest and diseases are neem oil and other neem preparations like Neem Seed Kernel Extract, Chromatic traps, Mechanical traps, Pheromone traps, Plant based repellants, Soft soap and clay. The following products shall be used when they are absolutely necessary and taking environmental impact into consideration.

The certification agency shall be consulted before using these inputs.

- Bordeaux mixture
- Plant and animal preparations e.g. Cow urine spray, Garlic extract, Chilli Extract Light mineral oils e.g. Kerosene

Natural enemies of crop pests and diseases such as coccinellids, syrphids, spiders, micromus, chrysopa and campoletis were higher under organic management compared to integrated and inorganic management. Coccinellids, which naturally reduce the hoppers and leaf folders, was found to be two to three times higher under organic management in cotton, groundnut, soybean, potato and maize crop fields. Similarly, spiders which also control the pests are found to be twice higher under organic management compared to inorganic management. The diversity of arthropod population in soil viz., collembola, dipluran, pseudoscorpians, cryptostigmatids and other mites population were also found to be higher under organic management compared to integrated and chemical management (Annual Progress Report, 2010-2013, Network Project on Organic Farming, University of Agricultural Sciences, Dharwad, Karnataka).Further the weeds can be managed through live and organic mulches.

2.10.1 The major issues related to marketing of organic products are

- Lack of reliable supply chain
- Lack of sufficient retail chains
- Limited size of domestic market
- Lack the skills and creativity to find profitable markets
- Produce aggregation costs for distributed small growers
- Certification complexities

Market development for the organic products is a crucial factor to promote domestic sales. Supplies do not match the demand for organic products in the country and the absence of proper links between the two has been pointed out for the tardy growth of organic farming in the country. An important role of the government in this direction is giving various supports to the producer and consumer associations to market the products (NABARD, 2005).

Organic farming systems are very much native to India as traditionally crops and livestock are reared together and as of today also, present in more than 85% of the farm households. India s average fertilizer and pesticide consumption stands at 128.3 kg ha^{-1} and 0.31 kg a.i ha^{-1} and many of the states have lower than the national average consumption of these inputs. Inspite of technological advancements, the nutrient use efficiency is on lower side (33% for N; 15% for P; 20% for K and micronutrients). Organic production of niche crops (crops which yield higher under organic condition and have market demand) can be considered in the hilly and rainfed areas. However, organic farming technologies need to be fine-tuned and updated to further enhance the yields. Farmer friendly certification policies and supply-demand chain management is essential for the growth of organic farming in the country. It can be concluded that **"towards organic"** (integrated crop management) approach for intensive agricultural areas (food hubs) and **"certified organic farming"** with combination of tradition, innovation and science in the de-facto organic areas (hills) and rainfed/ dryland regions will contribute for safe food security in future besides increasing the income of farm households and climate resilience. This approach will also positively contribute to the cause of human, livestock and eco-system health.

2.11 WAY FORWARD AND RECOMMENDATIONS

Organic agriculture includes several aspects starting from crop husbandry to livestock to horticulture with complimentary activities on the farm. Presently, in India, several schemes have been formulated and implemented to promote the organic agriculture which have resulted in many fold increase in area and export over the years, but still lot has to be done. The salient recommendations for penetration of organic farming in the country are given below.

2.11.1 Availability of authentic statistical data is essential for planning, policy formulation, implementation and impact assessment. The present system of collecting data on organic farming by Agricultural Exports Development Authority (APEDA) is through producers, processors and certification agencies using TRACENET. In the recent times, lots of variations have been observed in reporting of area and production. Moreover, the area reported does not include the extensive areas under natural farming and/or uncertified chemical-free farming, as those do not come under the definition of either in conversion or certified. Hence, a comprehensive statistical data collection on all aspects of organic farming is essential and this needs to be institutionalized like other agricultural censuses.

2.11.2 Organic farming growth is constrained due to several factors, such as; a decline in yield during the initial years of conversion, insufficient availability of organic manures within the farm to meet out the nutrient demand, slow release of nutrients from organic manures leading to mismatch between crop demand and soil supply, difficulty in handling the bulky manures, and inadequate certification and marketing infrastructure. Hence an integrated strategy of addressing all these issues is essential.

2.11.3 The main problem of organic growers is lack of continuous and reliable supply of certified inputs (such as; seeds, bio-agents, bio-fertilizers, manures etc.) and economically viable marketing of organic farm produce. Hence, steady and reliable input-output chains need to be established in potential organic clusters. The organic input production units established in public/private sectors, under various developmental schemes in the country, should be linked up with suitable marketing channels to improve upon their capacity utilization and make them responsible and viable. Establishment of organic input marketing channels is the need of the hour for expansion of organic farming in the country.

2.11.4 To exploit high-end domestic and international export markets, potential organic agriculture zones need to be identified on the lines of "Special Economic zone" and be named as "Special Organic Agriculture Systems Zone". For example, creation of "Organic Spice" zone in Kerala, "Organic Coconut zone" in Nicobar district of Andaman and Nicobar Islands, "Organic Basmati Rice zones" in Uttarakhand, Western Uttar Pradesh, Haryana and Punjab, "Organic Cotton Zones" in M.P, Gujarat and Maharashtra, "Organic Seed-Spices Zones" in Rajasthan and Gujarat.Similarly, several specialized organic zones may be identified for production and marketing of different vegetables and fruits within the well established horticultural belts in different states. These zones can also be made as Agroecotourism centres for attracting the nature loving tourists. Tax holidays for those private investors, who will invest in establishing organic input production/ processing and packing units within the zone, may be considered.

The zone should be planned in such a manner that all requirements of inputs, certification, processing and packing are met within the zone itself.

2.11.5 Wide spread existence of crop + livestock farming system is the strength for organic India. This should be considered a great opportunity for establishing integrated organic farming system in all the niche areas, which should serve as research-cum-demonstration unit.

2.11.6 Organic farming package adoption and its promotion for individual crops should be done away with. The system approach should be adopted.

Cropping and farming system approach of providing required nutrient and other inputs are proved to be successful. "Model Organic Farm" in farming system mode for marginal and small farmers should be developed in each District of identified and potential states.

2.11.7 The approach of "Towards Organic" should be adopted instead of immediately switching over to organic from inorganic in the high intensive agricultural areas to have safe food security in the country. This approach will reduce the immediate heavy yield losses during the conversion period and also will contribute for increased use efficiency of fertilizers and water. Government schemes of Integrated Nutrient Management, Plant Protection and Water Management needs to be amalgamated so as to get desired output.

2.11.8 The guidelines of national standard for organic production are having the equivalence with European Union and other important countries. It is good for the export. However, the domestic standard which also follows the export standards for organic production and certification needs to be reviewed. As **"safe food for all"** is possible through **"towards organic"** approach which includes integrated crop management practices. The domestic standard can consider the production practices of integrated approach with prescribed maximum use of nutrients (can be up to 50 %) in the form of chemical fertilizers. However, the pest, disease and weed management practices should be as per the export standard. This recommendation also holds well in the light of the argument that regardless of sources including organic, plants absorb nutrients in the form of inorganic.

2.11.9 "Certified organic farming" with combination of tradition, innovation and science in the de-facto organic areas (hills) and rainfed/ dryland regions will contribute for safe food security in future besides increasing the income of farm households and climate resilience. This approach will also positively contribute to the cause of human, livestock and eco-system health. Hence, organic farming should be promoted in niche areas and crops.

2.11.10 Favourable certification policy is essential. Certification agencies should be able to practically audit the organic farms instead record verification. Government support is required for cheaper access to organic certification of farms. Presently only 25 certification agencies are involved in the entire country. This needs to be increased to atleast 100 by involving the government departments and agencies. Grower Group Certification (GGC) and Participatory Guarentee Systems (PGS) which are recognized by the international agencies like IFOAM should be promoted and government support is essential in formation of clusters and groups. "Know Your Farmer and Know Your Pattern" will also be successful. Sustainable

Fund (TSF) should be created in all the organic clusters promoted by government.

2.11.11 Farmer Producer Organizations (FPO s) should be involved in production, processing and marketing of organic produces in the country. Infact, linking with assured market will be very important for organic promotion. Anand pattern which was successful in dairy should also be explored for organic farming expansion in the country.

2.11.12 On the line of Minimum support price, the organic produces should also have premium minimum support price to ensure the better profitability to organic growers. Support for organic seed production with seed production chain of arable crops, green manures (dhaincha/ sunhemp) should be given thrust.

2.11.13 Establishment of sufficient and accessible laboratories for testing of products mainly for pesticide residues to maintain the quality of organic produce and inputs are essential.The North Eastern Region of India is having very good potential for organic farming considering the fact that the use fertilizers, chemicals etc. are negligible especially in hills. They should be given preference and infrastructure support especially for input production and output storage, branding and marketing. At least one cold storage facilities/ godown should be considered for each hub/ cluster to store organic produce and get adequate benefit for the farmers.

2.11.14 Optimally utilization of scare resources particularly natural resources should be top priority in terms of development of community institutions ie. SHGs, Mahila Groups, Youth Groups and user group associations which may provide better option of management of fragmented land and water resources.

2.11.15 The awards and recognition should be given at regional/state level to the researchers/ extension workers/ organizations/ farmers involved in promotion of organic farming.

2.11.16 Capacity building followed by arranging critical inputs, implementation cum monitoring, linking with assured market using cluster approach will be a way forward for success of organic farming. Organic farming practices are for the farmers, by the farmers and of the farmers. All locality based scientific research should include an analysis of farmer's knowledge.The organic farming practices should be implemented in farmers participatory mode right from the planting, implementation and monitoring. Further, cluster approach of demonstrating the organic farming can help to reach organized organic market.

2.11.17 As a farmer-centered and grassroots movement, organic agriculture has largely relied on farmer-to-farmer networks and exchanges to disseminate information. Research has to support the linking of the farmers with the other stakeholders in the food supply chain, specifically markets for organic food in developing countries. At the same time, farmer knowledge needs to be valued as a source of experience and a base for innovation. This can be accelerated by investing in farmer education, which will also empower the rural communities.

2.11.18 Participatory planning of organic agriculture should be given top priority and decision making process may be simplified.

2.11.19 Organic agriculture research is still at a formative stage, and needs to build related human capacities. Farmer innovators and farmer organisations grouped around value chains have to build networks to commonly solve their many problems and address their specific research needs to the scientists. All the (State Agricultural University) in the country should start the department of organic farming or sustainable agriculture and offer courses on these areas. Research network to be further strengthened to undertake basic research and develop innovative organic inputs for higher productivity. Plant Breeding for organic farming is still lacking in the country and needs to be given thrust as performance of varieties varies under organic, integrated and inorganic management.

2.11.20 Organic farming research stands to benefit all farmers and consumers. Organic food should not be limited to affluent consumers in wealthy countries – as access to healthy food is a fundamental human right. Organic farmers have pioneered a number of sustainable technologies, allowing researchers to fine-tune solutions that can in turn be adopted by non-organic farmers, as was the case for the use of pheromones and the introduction of beneficial fungi as antagonists to soil-borne pathogens.

2.11.21 Organic agricultural practices adopted for traditional crops and varieties by forefathers needs to be documented and a hub on this can be established in all states.

2.11.22 Government of India has recently launched Paramparagat KrishiVikasYojana (PKVY), development of indigenous cattle and Swacch Bharat Abhiyan (Clean India campaign). Synergy among all these three schemes is essential as the contribution of indigenous cattle in organic farming is immense. Also, the recyclable and bio-degradable wastes from clean India campaign can go for making green farming.

2.11.23 Low awareness among state extension functionaries on benefits of organic agriculture systems is also major problem in promotion of organic farming. Regular capacity building programmes should be organized to sensitize the important field level functionaries.

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Chapter 3

NICHE CROPS AND AREAS FOR PROMOTION OF ORGANIC FARMING IN INDIA

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3.1 INTRODUCTION

Organic farming as a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc.) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection. Its encourages the development of agricultural technologies and farming practices that not only increase crop productivity, but also reduces the soil degradation, promotes and enhances agro-ecosystem health, rehabilitate, restore and enhance biological diversity and monitor adverse effects on sustainable agricultural diversity. However, organic is not only about replacing inputs, which is the starting point of the process, it goes beyond, as enshrined in the four principles of organic farming advocated by IFOAM;

3.1.1 Principle of health

Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. For instance, it provides pollution and chemical free, nutritious food for humans and amimals.

3.1.2 Principle of ecology

Organic agriculture must fit the ecological balances and cycles in nature work with them, emulate them and help sustain them.

3.1.3 Principle of fairness

Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities. Organic farming claim good quality of life and helps in reducing poverty. Natural resources must be judiciously used and preserved for future generations to ensuring sufficient quality food for increasing population.

3.1.4 Principle of care

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

3.2 THE KEY CHARACTERISTICS OF ORGANIC FARMING INCLUDE

- Maintaining or enhancing soil organic matter levels for ensuring/ protecting long term fertility of soils, encouraging soil biological activity and careful mechanical intervention
- Providing crop nutrients indirectly using relatively insoluble nutrient sources which are made available to the plant by the action of soil micro-organisms
- Effective recycling of organic materials including crop residues and livestock manures as well as use of legumes as a source of biological nitrogen fixation.
- Use of natural predators, diversity, organic manuring, resistant varieties, thermal, biological and chemical intervention for weed, disease and pest control.
- The extensive management of livestock, paying full regard to their evolutionary adaptations, behavioural needs and animal welfare issues with respect to nutrition, housing, health, breeding and rearing
- Careful attention to the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats

The regenerative organic agriculture sector is currently the fastest growing food sector. Growth rates of organic lands are impressive in Europe, Latin America and the United States. Globally, certified organic agriculture occupies less than 1 percent of lands. Nearly 35 million hectares of agricultural land are managed organically by almost 1.4 million producers. The regions with the largest areas of organically managed agricultural land are Oceania (12.1 million hectares), Europe (8.2 million hectares) and Latin America (8.1 million hectares). The countries with the most organic agricultural land are Australia, Argentina and China. The highest shares of organically managed agricultural land are in the Falkland Islands (36.9 percent), Liechtenstein (29.8 percent) and Austria (15.9 percent). The countries with the highest numbers of producers are India (340’000 producers), Uganda

(180’000) and Mexico (130’000). More than one third of organic producers are in Africa. About one-third of the world’s organically managed agricultural land – 12 million hectares is located in developing countries. Most of this land is in Latin America, with Asia and Africa in second and third place. The total organic agricultural area in Asia is nearly 3.3 million hectares. This constitutes nine percent of the world’s organic agricultural land. 400’000 producers were reported. The leading countries by area are China (1.9 million hectares) and India (1 million hectares). Organic wild collection areas play a major role in India and China, while Aquaculture is important in China, Bangladesh and Thailand.

Emerging from 42,000 ha under certified organic farming during 2003-04, the organic agriculture grew 29 fold during the period up to 2008-09. By March 2011 India had brought more than 4.43 million ha area under organic certification process. Out of this cultivated area accounts for 0.77 million ha while remaining 3.65 million ha was wild forest harvest collection area (Yadav, 2012). Now practically all 30 states are represented on organic agriculture map of India. Area under organic certification process which has seen rapid growth till the year 2008-09 is now under consolidation phase (Table 3.1).

Table 3.1. Growth of area under organic management

Sl. No.	Year	Area under organic certification process (ha)	
		Cultivated (organic + in –conversion)	Wild harvest
1	2003-04	42,000	NA
2	2004-05	76,000	NA
3	2005-06	1,73,000	NA
4	2006-07	5,38,000	24,32,500
5	2007-08	8,65,000	24,32,500
6	2008-09	12,07,000	30,55,000
7	2009-10	10,85,648	33,96,000
8	2010-11	7,77,517	36,50,000

(Source: National Centre for Organic Farming, Gaziabad)

3.3 NICHE AREAS FOR ORGANIC FARMING IN INDIA

In India around 60% people directly or indirectly depends upon Agriculture. In ancient times the agriculture occupation is considered to be a greatest service to the society and this practice is inter-twined in their tradition and culture. Organic agriculture is a system for crops, livestock and fish farming that emphasizes environmental safety and the use of natural farming techniques. In India, the practices of organic agriculture have probably been practiced in traditional forms for centuries i.e., 'no chemical inputs use, crop rotations, environmental safety and preservation'. Furthermore, organic agriculture became visible on a wider scale in the 1960s, when stakeholders/farmers and consumers became concerned that the high amount of synthetic chemicals used in crop and animal production could have negative consequences for human and animal health and the environment. Since then, it has developed or spread into a more cohesive and organized movement and it is now the fastest growing food sector globally. The growth of organic agriculture in Indian context has three dimensions and is being adopted by farmers for divergent reasons. On the basis of different adoption reasons the Indian organic farmers divided into three categories.

3.3.1 Those which are situated in no-input or low-input use zones (non-availability of synthetic agrochemicals), for them organic agriculture is a way of life and they are doing it as a tradition for meeting their food requirements (may be under compulsion in the absence of resources needed for conventional high input intensive agriculture). Pathak and Baghel (2006) stated that farmers in north eastern region grow a wide range of local varieties with different characteristics as a risk management strategy and also to meet the farmers' diverse household needs. Majority of farmers in this category are traditional (or by default) organic they are not certified.

3.3.2 Those which have recently adopted the organic in the wake of ill effects of conventional agriculture (Excess use of synthetic agrochemicals) may be in the form of reduced/deteriorate soil quality, food toxicity (high chemical residue level in harvested product) or increasing cost and diminishing returns. In this category farmers comprised of both certified and un-certified.

3.3.3 The third category comprised of farmers and enterprises which have systematically adopted the commercial organic agriculture due to increasing the demand of organic product in national as well as in international markets and to capture emerging market opportunities and premium prices. Majority of this category farmer are certified. These are the third category commercial farmers which are attracting most attention. The entire data available on organic agriculture today, relates to these commercial organic farmers.

In India more than 60% cropped land area comes under the rainfed agriculture or not irrigated and it can be safely assumed that high-input demanding crops are not grown on these lands. Moreover, the farmers of these areas mainly depends monsoon rainfall for growing of crops. Non availability of irrigation water is a major constraint in rainfed areas for crop production in *rabi* and summer seasons. Furthermore, fertiliser use on drylands is always less as chemical fertilisers require sufficient water to respond. Pesticide use in these lands for controlling diseases and insects would also be less as the economics of these hardy or "not-so profitable" crops will not permit expensive inputs. Seven sister states of northeast India comprising Assam, Manipur, Meghalaya, Arunachal Pradesh, Mizoram, Nagaland and Tripura are the best organic farming hot spot in India. By this somewhat degrading term they mean that small farmers, located mostly in the Eastern and North-Eastern regions of the country, have no choice except to farm without chemical fertilizers or pesticides. Sikkim State has made sincere efforts for agricultural products investments, various techniques of crop production and marketing of products, etc. Nearly 25-30 Thousand hectares of land area out of the total 58,128 hectare of available cultivable land has been certified as organic in Sikkim. Regions of North-Eastern and Eastern states where consumption of synthetic chemical fertilizers and pesticides is already low, need to be encouraged for organic farming. Similarly some of the specific areas where there is high demand for organic products, more emphasis need to be given. Madhya Pradesh is having highest number of certified cultivated organic area followed by Maharastra, Rajasthan and Gujarat (Table 3.2).

Government of India and its Ministry of Agriculture and Farmers Welfare started an ICAR research institute in Eastern part of the country recently to promote organic farming in these regions. A National Organic Farming Research Institute has been established in Sikkim to promote research and education in the country. Indian Institute of Farming System Research, Modipuram, Meerut is operating two projects – All India Network Programme on Organic Farming and All India Coordinated Research Project on Integrated Farming System which collaborate with Agricultural Universities for research in this area. In addition National Centre for Organic Farming, Ghaziabad is working on promotion of organic farming through its regional Centres. Though this is true in many cases, it is also true that a significant number of them have chosen to farm organically, as their forefathers have done for thousands of years. These areas are at least "relatively organic" or perhaps even "organic by default". While neither of these terms necessarily denotes a healthy farm or a recommended agriculture system, it would at least imply a non-chemical farm that can be converted

Table 3.2. State-wise area under organic farming (registered under accredited certification bodies) for the year 2010-11 (as on March 2011).

State Name	Certified Cultivated Organic Area (ha)	In-conversion cultivated Area (ha)	Total area cultivated under Certification process (ha)	Wild Area (ha)	Total Cultivated +Wild (ha)
Andhra Pradesh	6070.90	6279.72	12350.62	2000	14350.62
ArunachalPradesh	243.09	0	243.09	0	243.09
Assam	2001.75	45.33	2047.08	0	2047.08
Andaman	0	334.68	334.68	0	334.68
Bihar	0	1303.62	1303.62	0	1303.62
Chhattisgarh	321.99	126.93	448.92	8000	8448.92
Daman & Diu	0	0	0	0	0
Delhi	127.5	138.82	266.32	0	266.32
Goa	13044.65	259.05	13303.7	0	13303.70
Gujarat	42267.48	6251.43	48518.91	0	48518.91
Haryana	2343.05	12420.54	14763.60	0	14763.60
HimachalPradesh	2265.46	1781.41	4046.87	627855.12	631901.99
J&K	640.50	135.97	776.47	0	776.47
Karnataka	9128.01	10400.63	19528.64	69200	88728.64
Kerala	3870.27	2727.37	6597.65	0	6597.65
Lakshadweep	0	12.127	12.127	0	12.127
Madhya Pradesh	270955.69	27407.17	298362.87	2568209	2866571.87
Jharkhand	0	0	0	24300.00	24300
Maharashtra	124547.03	50298.44	174845.47	2500	177345.47
Manipur	2336.718	455.30	2792.02	0	2792.02
Meghalaya	1564.05	855.65	2419.66	0.0001	2419.6661
Mizoram	4471.6	8072.53	12544.13	0	12544.13
Nagaland	654.00	949.54	1603.54	0	1603.54
Orissa	16883.73	6218.56	23102.29	1315.255	24417.54
Punjab	2118.21	3907.56	6025.78	0	6025.78

State Name	Certified Cultivated Organic Area (ha)	In-conversion cultivated Area (ha)	Total area cultivated under Certification process (ha)	Wild Area (ha)	Total Cultivated +Wild (ha)
Rajasthan	57566.93	9145.26	66712.19	151000	217712.19
Sikkim	1391.03	27.30	1418.34	308	1726.34
Tamil Nadu	3244.61	829.98	4074.59	30803.5	34878.092
Tripura	203.56	144.83	348.385	0	348.385
Uttar Pradesh	17212.43	23800.40	41012.82	70632	111644.82
Uttarakhand	9513.76	2073.03	11586.78	93879.2	105465.98
West Bengal	5014.94	1110.78	6125.72	0	6125.721
TOTAL	**600003**	**177513.98**	**777516.88**	**3650002.07**	**4427519.05**

(Source: APEDA)

Table 3.3. State wise area under organic certification (including wild harvest) 2011-12

Name of States	Area (ha)
Andhra Pradesh	47456.77
Arunachal Pradesh	520.43
Assam	2048.27
Andaman	0
Bihar	188.60
Chhattisgarh	299970.60
Delhi	100238.70
Goa	153684.60
Gujarat	41978.94
Haryana	17442.36
Himachal Pradesh	933798.20
Jammu & Kashmir	26834.26
Jharkhand	29794.42
Karnataka	118739.70
Kerala	15790.49
Lakshadweep	891.93

Name of States	Area (ha)
Madhya Pradesh	432129.50
Maharashtra	245339.30
Manipur	1296.91
Meghalaya	288.23
Mizoram	7023.97
Nagaland	7762.60
Orissa	43868.18
Punjab	927.28
Rajasthan	222319.10
Sikkim	25716.55
Tamilnadu	38554.33
Tripura	4.05
Uattar Pradesh	2593821.0
Uttarakhand	122880.60
West Bengal	19095.55
Total	**5550405.0**

(Source: APEDA)

very easily to an organic one providing excellent yields and without the necessity and effort of a lengthy conversion period.

3.4 NICHE CROPS FOR ORGANIC FARMING IN INDIA

Most suitable crops for the organic farming are those crops which require fewer inputs and can be grown under limited or available resources. About 70% of pulses and oilseeds are grown under rainfed condition and these crops require comparatively less inputs than major cereals. The demand of the organic pulses and oilseeds is increasing day by day tremendously in the globe market due to health safety. Mustard in Rajasthan, groundnut in Gujarat and soybean in Madhya Pradesh are mainly grown under limited resources and rainfed conditions. Some commercial crops such as cotton, coffee, tea, basmati rice and sugarcane are the potential crops for organic cultivation (Table 3.4 and 3.5). Pulses such as pigeon pea, chickpea, green gram, black gram etc. are also niche crops for organic cultivation in Rajasthan and rainfed areas of Haryana and Madhya Pradesh. Demand of organically grown vegetables such as potato, cabbage, cauliflower, lady's finger, chilli, tomato, brinjal and cucurbits is increasing due to heavy application of pesticides under conventional cultivation. Organically grown fruit and vegetables have better storage quality and shelf life. An area located to near cities have huge scope and wider acceptability for organic cultivation of flowers and vegetables. Now a day cultivation of flowers under organic farming is increasing because of improved self life of organically produced flowers.

Northeast India is organic by default. This means most small farms have never used pesticides or synthetic fertilizers. Farmers are still using traditional methods of farming for food production. Old fashioned farming has become strength. They now have a big advantage because this naturally ascribes the land as the best organic farming region. North Eastern Region (NER) is home to some niche crops like Assam Lemon, Joha Rice, Medicinal Rice and Passion fruit which has high market demands. NER accounts for 45 percent of total pineapple production in India and an Agri-Export Zone (AEZ) is already set up in Tripura. Karuppaiyan et al. (2008) grouped the crops cultivated in north east hills into following three categories.

3.4.1 Economic security crops which are commercially important to meet food and nutritional security of the people (cereals, millets, pulses and oilseeds).

3.4.2 Livelihood security crops-are underutilized, component crops in mixed farming system or homestead farming (millet, barley, buckwheat, peas, chillies, pumpkin, cucumber, cowpea, tapioca, sweet potato, radish, chow-chow, rai sag, radish, fenugreek, onion, garlic) and

3.4.3 Regional organic crops- which have regional production as well as marketing advantage (ginger, turmeric, large cardamom, mandarin, passion fruit, orchids, gladiolus, gerbera, etc).

Sikkim perhaps is the only region that has no intensive Shifting cultivation. 90% of the cultivated area in the plain areas of Tripura, Manipur and Assam are under irrigated condition. The rest are rain fed. Ginger, turmeric, arecanut, pineapple, orange, litchis, large cardamom, passion fruit, etc are grown in the mid hills. In the high hills and mountain areas the maximum cultivars are fruits like plums, pears, peaches, apricots, apples, potato, cabbage, cauliflower, radish, carrots, beans, broccoli, maize, millet and large cardamom. Wild Cardamom occurs naturally in the region. Passion fruit grows in the hills of Mizoram, Nagaland and Manipur as home garden fruit; however Nagaland and Sikkim in recent times have explored its commercial local and export potential. Sikkim is the largest producer of large cardamom (54 percent share) in the world. NER is the fourth largest producer of oranges in India. Best quality ginger (low fiber content) is produced in this region and an Agri-Export Zone (AEZ) for ginger is established in Sikkim.

Table 3.4. Category-wise production of certified organic products for the year 2010-2011.

Products	Total production (mt)
Cereals (except Rice)	171684.66
Coffee	13122.03
Cotton	552388.47
Dry Fruits	52369.09
Fresh Fruits & Vegetables	335863.11
Medicinal & Herbal Plants	1792014.86
Oil Seeds	360837.17
Pulses	42721.61
Rice	176683.17
Spices-Condiments	129878.46
Tea	27684.26
Misc	221191.96
TOTAL	3876438.85
	3.88 million tonne

(Source – APEDA)

Table 3.5. Commodity-wise Production Details of Top Ten Products (2011-12)

Sl. No.	Product Name	Organic Production (mt)	In Conversion Production (mt)	Total Production (mt)
1.	Cotton	107591	3792.0	111383
2.	Cereals &Millets (excluding rice)	33888	6898.0	40786
3.	Rice (Basmati & non Basmati)	17345	5329.0	22674
4.	Pulses	12504	453.0	12957
5.	Fruits and Vegetables	7801	427.0	8228
6.	Tea	5272	1.0	5273
7.	Oil Seeds excluding Soybean	2835	15.0	2850
8.	Coffee	1139	238.0	1377
9.	Dry Fruits	490	32.0	522
10.	Medicinal & Herbal Plants	189	0.	189

Source: APEDA

Extent of chemical consumption in farming is far less than the national average. Approximately 18 lakhs ha (hectare) of land in NER can be classified as "Organic by Default". Dependence of mid and high altitude farmers on within farm renewable resources. Among the major organic foods produced in India tea and rice contributes around 24% each, fruits and vegetables together make 17% of organic produce (Garibay and Jyoti 2003).

The Apatani tribe of Arunachal Pradesh has been practicing a rice-fish culture for many decades. Their practice, locally termed 'Aji Gnui Assonii', is free from the use of inorganic chemicals or off-farm inputs. Field preparation starts in April-May and rice seedlings are transplanted in May-June. Ten days after transplanting, local strains of common carp are stocked at fry stage and reared in the field for about 4 months. Sometimes they harvest fish partially from the field after 2 months. About 200-300 kg/ha of fish are partially harvested before the final harvest. The final harvest is about 500 kg/ha. The dykes of rice field are utilized for growing millet in June and are harvested during August-September. The system is an example of integrated intensive farming with organic practice. It is based solely on available natural resources in the ecosystem and provide livelihood support to the tribal (Saikia and Das, 2004). In NE region approximately 30.92 lakh ha is affected by jhum but at any one point of time about 16 lakh ha is under jhum which is almost organic by default. Therefore, Bujarbaruah (2004) suggested that jhum land could easily be transformed into organic by establishing necessary infrastructure for certification. The products from Jhum should be certified and marketed as organic.

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Chapter 4

INTEGRATED FARMING SYSTEM – TOWARDS ORGANIC AGRICULTURE

Jag Pal Singh and N. Ravisankar

4.1 INTRODUCTION

Looking into the present agriculture scenario at Small and Marginal Farm Holders, the single commodity / discipline based research efforts made in past are not sufficient to meet the future demands of small farm holders representing more than 4/5th of total farm families in India. Though, in isolation but concerted efforts made by several researchers in different parts of the countryconfirmed that Integrated Farming System Approach is the only way through which the livelihood of smallholders can be ensured, the production base soil and water can be sustained for a long and environment can be saved against problem of soil, air and water pollution. Farming system is a complex inter-related matrix of soil, plants, animals, implements, power, labour, capital and other inputs controlled in parts by farming families and influenced in varying degrees by political, economic, institutional, social and environmental forces that operate at many levels. It is the sound management of farm resources to enhance the farm productivity, reduce the environmental degradation, and improve quality of life of resource poor farmers and to maintain sustainability. Farming systems approach is a highly location specific approach involving appropriate combinations of complimentary farm enterprises viz., cropping systems, livestock, fisheries, forests, poultry and the means available to the farmers to raise them for profitability. In general, farming system approach is based on several objectives that include sustainable improvement of farmhouse hold systems involving rural communities, enhanced input efficiency in farm production, satisfy the basic needs of farm families, improve their nutrition and raise family income through optimum use of resources and proper recycling of residues within the system. This is achieved by following essential five steps: 1) Classification - identification of homogenous groups of farmers with similar natural and socio-economic characteristics is the first step and it forms the basis for the setting of priorities and for targeting of research and extension to particular farm types; 2) Diagnosis is to identify the limiting factors, constraints and development opportunities of particular target farm types;3) Experimentation either on-farm or on-research station or at both sites and recommendation is made from the knowledge clearly gathered; Implementation of farming systems programs through a direct support to the extension agencies; 4) Recommendations and 5) Implementation & Evaluation is an important component that will lead to acceptance or modifications on farming systems for a wider adoption. Integrated Farming System Approach is defined as a "A judicious mix of two or more components/enterprises while minimizing competition and maximizing complementarities with advanced agronomic management tools aimed at sustainable and environment friendly improvement of farm income and family nutrition". Preservation of biodiversity, diversification of cropping or farming system and maximum recycling of residues ensure the success of this farming systems approach (Singh and Shankar,2016). This is the only path through which we can reach to the target of achieving organic farming in Indian Agriculture. Further, "Towards Organic Farming" rather than pure organic farming is more easy to popularize in remote tribal and hilly areas and also among small and marginal farm conditions having more organic farm resources and cultivating low input crops alongwith large holding farmers practicing inorganic or integrated nutrient management farming.

4.2 AIMS OF INTEGRATED FARMING SYSTEM

Looking into the past and present scenario of Indian Agriculture and future demands of the farmers and country as a whole, the major aims of integrated farming system are as under;

- Livelihood security
- Nutritional security
- Income growth
- Poverty alleviation
- Employment generation
- Multiple uses of resources
- Judicious use of land and water resources
- Increased options of organic agriculture
- Sustainable agricultural development
- Environmental safety

4.3 POSSIBLE OUTPUTS OF INTEGRATED FARMING SYSTEM

To meet growing demand of human and animals, provide gainful employment and promoting organic agriculture, IFS has several advantages over arable farming such as;

a) Increased food supply: Horticultural and vegetable crops can provide 2-3 times more calories than cereal crops on the same piece of land and will provide food and nutritional security. Similarly inclusion of Bee keeping, fisheries, sericulture, mushroom, cultivation under two or three tier system of integrated farming can give substantial additional high energy food without affecting production of food grains.

b) Increased options of Organic Farming through recycling of farm residues: Proper collection & utilization of cowdung & urine of animals in the form of FYM and vermicompost alone can save about 50% of NPK requirements of the crops. Vermicompost containing 3 to 4 % more N content than FYM can be produced from crop residue mixed with cowdung for restoring soil fertility. Further, if we utilize even 1% of annually available 200 metric ton crop residue for mushroom cultivation then we can produce 2 lakh tons mushroom against only 40 tons of present day production.This all will meet nutrient demand of farming to a great extent thus encouraging organic farming.

c) Use of marginal and wastelands: Combination of forestry, fishery, poultry, dairying, mushroom and bee keeping can be combined with crop raising and all these activities can be undertaken on marginal to wastelands too.

d) Increased employment: Studies conducted in India and elsewhere, indicated 200 to 400 per cent increase in gainful employment and additional income to farm families to increase their standard of living.

e) Restoration of soil fertility and conserving environment: With efficient recycling of crop and animal residue in crop-live stock- poultry-fishery system, at least half of the nutrient (if not more) can be saved along with restoration of soil fertility and cleaner environment be maintained. Preparation and large scale use of vermi compost will further help in decreasing dependence on chemical fertilizers and keeping clean and healthy environment.

4.3.1 Role of Diversification In Farming System

Desirable change is to tilt the existing system towards a more balanced cropping or farming system to meet ever increasing demand of food, feed, fibre, fuel and fertilizer while maintaining agro-ecosystem. Diversification is considered to be a good alternative to improve system yield with enhanced profitability. Further, the farming systems approach is highly location specific involving appropriate combinations of complimentary farm enterprises viz., cropping systems, livestock, fisheries, forests and poultry utilizing the available resources of farmers to raise their income. Two approaches of farming systems such as holistic and innovative are considered to be powerful tools to increase the income and employment opportunities of the farm family. Holistic approach deals with improving the productivity of existing components in totality while innovative approach aims for improving the profitability of existing farming systems with user-perception based introduction of new components. The sequential stages of farming systems approach of research are i) classification, ii) diagnosis, iii) experimentation, iv) recommendations and v) implementation and evaluation. The classification part involves identifying homogenous groups of farmers for targeting research, extension and development while diagnosis looks to identify constraints, needs and priorities of target group. Similarly, various options available to address constraints are investigated through on-station or on-farm participatory research programs. Large scale results are analyzed and recommendations are synthesized. These recommendations are then demonstrated on a large scale using cluster participatory approach. Impact of large scale demonstrations are evaluated and selected for wider adoption

4.4 MULTIPLE USES OF FARM RESOURCES

Knowledge generated for management of natural resources is to be integrated in the system mode for an effective resource recycling. Multiple use of the resource such as land and water are essential to enhance the system productivity and profitability. Farm level self-sufficiency in water and nutrient is possible through modern technological interventions such as rain water harvesting and recycling with nutrient and energy based input-output relationships. Multiple uses of water for household, irrigation, dairy, poultry, duckery and fish rearing is the best example. Small and medium size water bodies can be brought under multi-component production systems using in and around areas which will ultimately lead to improved income, nutrition and livelihood of small farm holdings. It is estimated that water productivity increases by 12 times (1.8 kg/m^3 in okra and 2.6 kg/m^3 in French bean to 40 kg/m^3) in pond based integration of crop, fish, poultry and duckery in humid areas. Similarly, integration of proper waste resource recycling in the small and marginal farmers holding will pave way for reduced fertilizer usage which in turn will have positive effect on national exchequer in the form of reduced fertilizer subsidy for production and transportation of fertilizers. For example, the egg laying khaki Campbell duck produces more than 60 kg of manure per bird on wet basis. The duck droppings provide essential nutrients such as carbon, nitrogen and phosphorus in the aquatic environment which serve as natural food for fish. From 10 to 20% of feed (23 to 30 g/day) are lost in the normal circumstances of feeding ducks. In the farming systems mode, feed given to ducks were also partially utilized by fish while washing the shed.

4.4.1 Farming System Research in India

Studies conducted across the country has revealed that diversification of existing cropping systems and farming system as a whole through integration of proven scientific technologies and low cost enterprises suited to farmer's need and their resources has been found effective for overall improvement in livelihood of small farmers and bring sustainability in agriculture. Significant achievement of IFS studies on Integrated Farming System Approach conducted at ICAR-IIFSR, Modipuram and other centres of AICRP-IFS are summarized below;

4.4.1.1 ICAR-IIFSR, Modipuram, Meerut, Uttar Pradesh

Looking into the average holding size, resource availability, economic conditions of the small farm families and to meet out all the essential household food, feed, fodder & nutritional requirements, an IFS model was initiated during 2004-05 at Modipuram, district Meerut, U.P. The IFS Model comprised of crops/cropping systems (comprised 1.04 ha), fruit production (0.22 ha), milch animal unit with 2 murrah buffaloes and 1 H.F. cow, fish pond having a mix fish culture of rohu, katla, mrigal, silver/common carps (0.10 ha), mushroom unit (six multi - storied racks), biogass unit (1.5 Cu.m), vermicompost unit (0.01 ha), boundary plantation all around the farm boundaries and kitchen gardening in backyard of the house is developed. Looking in to the performance of individual enterprises and family requirements, need based corrections was also made in technical programme in successive years of the study. A pictorial presentation of diversified IFS Model at IIFSR,Modipuram is presented in Fig.1.

4.4.1.1.1 Impact of crop diversification on farm income and profitability:

Inclusion of crops with diverse nature of crop canopy, growth habits, root system and requirements of water & nutrients have shown direct and indirect effect on crop yields, farmer income and soil properties. More number of crops in a cropping system (two or more) and inclusion of legumes in the system (Mix/Intercropping) besides giving economic benefits also helps in increasing soil fertility through producing more crop residues and adding nutrients through recycling and also nitrogen fixing into the soil. To meet family food & feed demands and overall livelihood improvement a number of cropping systems were tested in the IFS model and their respective average gross and net returns (per hectare basis) are given below;

Table 4.1: Gross and net returns of different cropping systems tested under IFS

Cropping System	Gross Return (Rs./ha)	Net Return (Rs./ha)
Sorghum (F)- Mustard (G)- Maize+ Cowpea (F)	419012	282162
Rice- Wheat- Sesbania (GM)	242075	90325
Sorghum (F)- Potato- Wheat	499287	291150
Maize+ Redgram- Oats (F)	342357	201200
Sorghum (GF)- wheat + mustard (G)	277000	168100
Rice- oats (GF cum grain) -Sesbania aculeate (G.M.)	378050	234812
Soghum(GF) – Potato	342000	178380
Rice –Potato - Sesbania aculeata (GM)	502800	233425
Maize(Cobs)+ cowpea (GF) – Maize + Black gram	190000	121062
Soghum (GF) – Oat- Sesbania aculeata (GM)	211875	138437
Soghum (GF)–chickpea - Sesbania aculeata (GM)	197812	116100
Rice – Mustard(Grain)+Cowpea (GF)	235125	108887
Maize(G)+redgram–Wheat + mustard (G) - Sesbania aculeata (GM)	330621	203878

** According to their family need and farm location (village or nearby town/city) farmers can choose cropping system.

Inclusion of leguminous crops like pulses including chickpea, redgram, blackgram and green fodder or green manuring crops, cowpea & Sesbania aculeate are some of the important crops which were included in the systems to get daily food and fodder requirements and also improvement in soil fertility through recycling of crop residues, green manuring and nitrogen fixation etc. Similarly, crops like mustard, oats- less input requiring crops and potato, rice, wheat – more input but high value crops were also included to get high profits per unit area and per unit time.

Fig. 1. Pictorial presentation of diversified IFS at IIFSR, Modipuram

4.4.1.1.2 Impact of diversification on prevailing system of farming:

Horticulture, fishery, apiary, mushroom, vermi-composting, bio-gas, boundary plantations and kitchen gardening were some of the enterprises integrated with most prevailing farming system Crops + dairy of the region for its diversification. Long term impact (2005-15) of IFS approach revealed that gross and net return increased by 293% and 188% , respectively and over initial year of the study (Fig. 2).

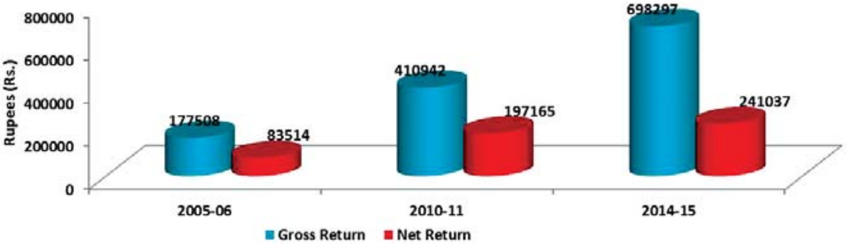

Fig. 2. Gross and net returns from IFS

After deducting cost and family consumption, a net saving of Rs.72,110/ ha/year or more could be achieved. Besides improving economic condition the system could provide round the year balanced food and fodder by producing milk, pulses, oilseeds, vegetables, fruits, mushroom for family members and green leguminous fodders for animals.

4.5 AICRP-IFS- NETWORK PROGRAMME

Not only at ICAR-IIFSR, Modipuram but similar type of region specific On-Station IFS Models have been developed at 34 AICRP-IFS centres covering all the 15 Agro Climatic Regions (ACRs) across the country. The composition of different IFS models developed at different AICRP-IFS centres and contribution of these towards livelihood improvement, economic growth and sustainable agriculture is summarised in Table 2&3 below;

Major performance indicator of IFS Model are total farm production (RYE), gross and net returns, role of recycling in reducing cost on market inputs. The results of fourth year of the establishment of these models (2014-15) revealed that total farm production could reached as high as 62.16 t/ha/ annum at Sabour (Bihar) followed by 52.4 t/ha at Ludhiana (Punjab), 48. 78 t at S.K. Nagar (Gujrat), 40.4 t at Hisar (Haryana) and 36.26 t at Modipuram (U.P). Similarly, gross and net returns were recorded significantly higher viz; Ludhiana (Rs. 7,33 411 and 3,80, 308), Sabour (6, 88, 095 & Rs. 3,52, 243), Coimbatore (Rs. 6 29, 046 & 2,62,44), Chhata (Rs 6,03,567 & Rs. 3,06,202). S.K. Nagar (Rs. 5,85, 400 & 3,61,416) and Modipuram (Rs. 5,58,380 & Rs. 2,62, 447). Cost of production ranged in between Rs. 8805 at Portblair to Rs. 2, 76,897 at Coimbatore. Efforts made to reduce cost on farm inputs through recycling of farm wastes, crop residues and use of G.M & bio-fertilizer etc, could saved as much as 41.3% of total input cost at Sabour followed by 39.3 % at Rahuri 32.8% at Modipuram, 33.2 % at Ranchi 34.1% at Siruguppa and 30% at Kanpur. The major contribution in gross and net return were reported as crops (15 -37%), dairy animals (25-60%), horticulture crops (8 - 38%) followed by fishery and poultry. Boundary plantation and kitchen gardening was a mandatory to all the centres. Average net returns and percent increase over prevailing system of farming in different regions are given in table 4.4 below;

Considering labour engaged and recycled inputs as farm inputs, cost of production could be reduced by half or more than that in most of the IFS centres as presented in table 4.5 below;

Nutrient (NPK) Budgeting Under IFS Approach: Studies conducted at IIFSR, Modipuram on nutrient budgeting under On-Farm conditions

Table 4.2: Composition of IFS models at different AICRP-IFS centers

Center	Size of Model (m^2)	Crop (m^2)	Dairy Animal	Hort. (m^2)	Fish Fish	Centers	Size of Model (m^2)	Crop (m^2)	Dairy Animal	Hort. (m^2)	Fish Pond (m^2)
Akola	10000	7000	-	2500	400	Palampur	10000	7500	2C	1750	-
Bhubneshwar	12500	3787	2 C	895	3300	Pantnagar	10000	5200	1C	1900	-
Chhata	15000	4500	1C+1B	3050	1000	Parbhani	10000	7100	1C+1B	2000	-
Coimbatore	12000	10200	2 C	1600	-	PatnaM1	4000	2000	NA	900	-
Durgapura	14500	10000	2C	2500	-	PatnaM2	8000	5000	2C	1000	1000
Hisar	10000	9000	NR	600	-	Portblair	10000	6100	2C	2000	-
Jabalpur	10000	9000	3C	240	600	Rahuri	10000	7200	2 C	2000	-
Jorhat	10000	6643	2C	950	920	Raipur	10000	5980	2C	2220	725
Kalyani	6600	4100	2 C	1100	900	Rajendrnagar	10000	7000	2 B	2000	-
Kanpur	10000	7200	1C+1B	1920	-	Ranchi	10000	8000	2C	NA	1000
Karjat	10000	5000	3C	4000	-	Sabour	10000	7014	2 C	1412	800
Karmana	10000	8000	1C+1B	-	700	S.K.Nagar	10000	7000	2B	2500	-
Kathalgere	10000	9000	2C+1B	1000	100	Siruguppa	10000	7200	2C+2B	2000	300
Kumarganj	10000	7000	2 C	2000	1000	Umaim	10000	7000	-	2000	500
Ludhiana	10000	6400	2C	2000	1000	Varanasi	10000	8100	6C	600	1000
Modipuram	7000	3800	2C+1B	3000	-	-	-	-	-	-	-

Table 4.3: Other additional (supplementary/complementary) farm enterprises integrated at different centers

Goatary (9)	Akola (12), Coimbatore (10+1), Durgapura (5+1), Karjat (6), Parbhani (5+1), Patna (20+1), Rajendernagar (5+1), Sabour (10+1), Siruguppa (10)
Poultry (13)	Chhata (50), Karjat (90), Karmana (50),Kathelgere , Palampur (25), Parbhani 300),Patna(100),Rahuri (400),Varanasi (200x6batch), Rajendernagar (30), Bhubneshwar (80), Umaim (600Broiler+50 Layer), Raipur
Duckery (4)	Patna (30+5) , Sabour (25), Bhubneshwar (20), Karmana (50)
Piggery (2)	Umaim (3) and Port Blair.
Agro-forestry (3)	Pantnagar, Ludhiana , Bhubaneswar
Apiary (4)	Modipuram, Jorhat, Kanpur and Ranchi
Mushroom (6)	Modipuram, Patna, Karmana, Ranchi, Varanasi ,Raipur

Boundary plantations and kitchen gardening – Almost all AICRP-IFS centers as an mandatory enterprise/ farm practice

revealed that scientific management and on farm recycling of farm wastes, crop residues and cowdung / urine and incorporation of leguminous crops for grain & green manuring etc. minimised chemical load by adding plant nutrients to the extent of 760.4 kg NPK (121.7 kg N + 226.8kg P + 411.9 kg K) thus turning prevailing farming, "towards organic farming" and making it more profitable and sustainable (Table-4.6).

Similar study was also conducted at the centre for marginal farmers also under AICRP-IFS during 2011-12 to 2015-16. Prevailing farming system crop + dairy opted by more than 84% of the total farm families was diversified with integration of i) fruit crops (0.30 ha) having Mandarin var. kinnow and Banana var. G-9 under Agro – horti system, ii) round the year production of mushroom, value addition in cowdung by adopting scientific composting methods - pits and vermicomposting (0.01 ha), biogas unit of one cubic meter and backyard poultry with 15 birds alongwith boundary plantations of guava & karonda. Initial four years results (2011-12 to 2014-15) of IFS studies in irrigated cultivated area of 0.70 hectare, revealed that out of total cost of production of Rs. 2,90,933, only 42.56% was the share of market inputs and rest of the expenditure was met from on - farm inputs (farm labour 24.62% & recycled inputs 32.82%), thus economizing the production cost to a great extent. Considering plant nutrient as a major input, about 336 kg of NPK in available form could be added

Table 4.4: Average net returns and percent increase above and over farmer Practice.

A.C.R.	AICRP-IFS enters	IFS Approach	Farmer Practice	% increase
W.H.R.	Chhata	294754	83,148	254
	Palampur	116709	28,730	306
	Pantnagar	226131	1,17,500	92
E.H.R.	Jorhat	314055	40,809	669
T.G.P. R.	Ludhiana	400870	1,63,938	144
	Hisar	221199	61855	257
U.G.P.R.	Modipuram	213126	64,300	231
	Kanpur	130341	67,754	92
M.G.P.R.	Kumarganj	265632	65,000	308
	Varanasi	380231	71,573	431
	Sabour	332509	83,800	296
	Patna2	1,37,209	60252	127
L.G.P.R.	Kalyani	131669	95116	38
E.P.H.R.	Raipur	135023	57500	134
	Ranchi	94193	23617	298
W.P.H.R.	Akola	60963	19270	216
	Rahuri	242411	197665	226
	Parbhani	87554	65,248	34
S.P.H.R.	R.nagar	159020	67484	135
	Coimbatore	297627	1,32,005	125
	Kathalgere	182330	91890	98
	Siruguppa	208779	95576	118
E.C.P.H.R.	Bhubneswar	1,57802	43,138	265
W.C.P.H.R.	Karjat	144896	114798	26
	Goa	167321	45000	271
W.D.R.	Durgapura	308241	1,18,998	159
G.P.H.R.	S.K.Nagar	3,12,908	68,798	354
	Thanjavur	176637	68490	157

Table 4.5: Per cent share of different inputs in total production cost:

Centers	Market Inputs (Rs.)	(%)	Input recycled (Rs.)	(%)	Farm Labour (Rs.)	(%)	Total cost (Rs.)
Chhata	208299	(65%)	36578	(11%)	74688	(23%)	3,19,500
Palampur	117627	(52%)	61209	(27%)	48875	(21%)	2,27,711
Jorhat	113706	(42%)	94705	(35%)	64170	(24%)	2,72,582
Hisar	16736	(14%)	28120	(23%)	76500	(63%)	1,21,356
Modipuram	129320	(51%)	62032	(25%)	64080	(25%)	2,55,432
Kanpur	53,827	(26%)	1,10,675	(52%)	46,398	(22%)	2,10,900
Kumarganj	86559	(39%)	66896	(30%)	70070	(31%)	2,23,525
Varanasi	256749	(52%)	86171	(17%)	148955	(30%)	4,91,875
Sabour	63,095	(17%)	1,59,733	(44%)	1,44,142	(39%)	3,66,970
PatnaM1	57032	(33%)	38220	(22%)	58800	(34%)	1,54,652
PatnaM2	40391	(22%)	48216	(26%)	76540	(41%)	1,65,141
Kalyani	35986	(27%)	34725	(26%)	62125	(47%)	1,32,836
Raipur	86739	(45%)	27291	(14%)	76716	(40%)	1,90,746
Ranchi	30621	(22%)	38339	(27%)	71044	(51%)	1,40,004
Akola	97402	(52%)	22652	(12%)	66,600	(36 %)	1,86,654
Rahuri	56613	(35%)	29936	(18%)	76650	(47%)	1,63,199
Parbhani	59834	(31%)	49875	(26%)	80640	(42%)	1,90,349
R.nagar	154726	(42%)	101407	(28%)	109500	(30%)	3,65,633
Coimbatore	78422	(17%)	166549	(35%)	226696	(48%)	4,71,667
Kathalgere	20995	(24%)	49511	(44%)	27000	(31%)	88,500
Siruguppa	90180	(35%)	78857	(31%)	87848	(34%)	2,56,885
Bhubneswar	109839	(46%)	28920	(12%)	98600	(42%)	2,37,359
Karjat	170925	(36%)	101469	(21%)	204210	(43%)	4,76,605
Karmana	80104	(53%)	18273	(12%)	53200	(35%)	1,51,577
Goa	99,320	(44%)	60551	(30%)	55899	(25%)	2,23,,866
Durgapura	151140	(39%)	105515	(27%)	137064	(35%)	3,88,206
S.K.Nagar	22,847	(12%)	108151	(57%)	58884	(31%)	1,89,882
Thanjavur	42410	(20%)	60108	(28%)	114678	(53%)	2,17,196

Table 4.6: Nutrient budgeting under Integrated Farming System (IFS Model, Modipuram-1.5 ha)

Source of nutrients and percent nutrient content (N:P:K) on dry wt. basis	Available Quantity (kg)	Approximate released quantity of nutrients N, P & K (Kg)			
		N	P	K	Total
Green manure crops					
Sesbania spp. (1.29:0.36:1.64)	8800	18.9	5.3	24.0	48.2
Cowpea (1.29:0.36:1.64)	8500	18.3	5.1	23.2	46.6
Crop residues (dry wt.)					
Sugarcane leaves (0.4:0.18:1.28)	900	3.6	1.6	11.5	16.7
Arhar leaves (1.29:0.36:1.64)	232	3.0	0.8	3.8	7.6
Potato leaves (0.52:0.21:1.06)	1450	7.5	3.0	15.4	25.9
Cow dung (dry wt.) (0.4: 1.2 : 1.9)	17600	70.4	211.0	334.0	615.4
Total	-	121.7	226.8	411.9	760.4
Considering 30% use efficiency	253.4 kg				
Nutrient requirement/year (field + plantation crops)	-	285.3	116.3	109.9	511.5 kg

in to soil (Table-4.7) and a sum of rupees eleven thousand three hundred seventy seven (Rs.11377/year) was saved which otherwise to be spent on chemical fertilizers.

Similar observations were also reported at other AICRP-IFS centres. Some of them including Karmana (Kerala), Kathelgere (Karnataka) and Akola (Maharashtra) are presented in table 4.8 - to 4.13 below;

In another studies including Homestead, Coconut and Banana based systems conducted at the same centre Karmana, nutrient budgeting recorded are given in table- 4.9-4.11.

Table 4.7: Nutrient budgeting under Integrated Farming System (IFS Model, Modipuram-0.7 ha)

Recyclable farm produces	Quantity (kg/liter)	Nutrient content (%) and recyclable nutrients (kg)			Total NPK (1008 kg)	Market Value (Rs.)
		N	P	K		
Green manures	9100	1.29 (107)	0.36 (33)	1.64 (149)	289	9826
Potato leaves	1670	0.52 (8.7)	0.21 (3.5)	1.06 (17.7)	30	1017
Banana leaves	1751	2.50 (43.8)	0.40 (7.0)	4.00 (70.0)	121	4107
Litter fall	320	1.29 (4.1)	0.36 (1.2)	1.64 (5.3)	15	360
FYM	3456	0.70 (24.2)	0.19 (6.6)	1.37 (47.3)	78	2655
Vermicompost	15000	1.68 (252)	0.23 (34.5)	1.26 (189)	475	16167
Total NPK turned into the soil					= 1008 kg	34132
(33% of total added nutrients NPK)					= 336 kg	11377
Saving through nutrient recycling					= Rs.11377/year.	

Table 4.8: Nutrients generated and recycled (kg) under Rice based IFS model (2015-16) Karmana

Nutrients	Crop	Dairy	Total (kg)
N	39.95	70.30	110.25
P_2O_5	8.00	34.68	42.68
K_2O	14.57	37.49	52.06
Total NPK	62.52	142.47	204.99

*The duck manure directly went to the pond and served as fish feed.

In another studies including Homestead, Coconut and Banana based systems conducted at the same centre Karmana, nutrient budgeting recorded are given in table- 9-11.

Table 4.9: Nutrients generated and recycled (kg) under Homestead based IFS model (2015-16) Karmana.

Nutrients	Crop	Dairy	Poultry	Vermicompost	Total
N	9.47	57.09	2.69	2.78	72.03
P_2O_5	7.36	30.13	3.14	0.97	41.6
K_2O	9.05	30.61	1.8	1.81	43.27

Table 4.10: Nutrients generated and recycled (kg) in Coconut based IFS (2015-16) Karmana.

Nutrients	Crop	Dairy	Azolla	Total (kg)
N	41.4	90.85	0.07	126.89
P_2O_5	26.6	44.93	0.02	69.08
K_2O	32.0	47.89	0.05	75.99

Table 4.11: Nutrients generated and recycled (in kg) in Banana based IFS model (2015-16) Karmana.

Nutrients	Crop	Dairy	Total (kg)
N	2.55	150.85	153.4
P_2O_5	0.85	74.93	75.78
K_2O	5.27	77.89	83.16

Table 4.12: Total amount of nutrient added through recycling and its market value during 2015-16-Kathelgere.

Recyclable farm waste	Quantity (kg)	Nutrient content (%) and recyclable nutrients (kg)			Quantity of fertilizers	In terms of rupees
		N (kg)	P (kg)	K (kg)	(kg)	(Rs.)
Vermicompost	3217	32.17	11.91	17.05	540.5 (Urea)	3784
Cow dung	7754	85.29	33.34	36.44	489.2 (SSP)	4256
Sheep litter	4462	131.63	33.02	81.65	229.7 (MOP)	4594
Total	15433	249.09	78.27	135.14	-	12634

Table 4.13: Nutrient contribution and saving in nutrient use through goat manures, urine& crop residues– Akola

SN	Particulars	Nutrient contribution in goat manure & urine				Saving in terms of money (Rs.)			
		N	P	K	Total	N	P	K	Total
1	Urine (3850 L)	52	2	81	135	676	97	256	2929
2	Manure (1850 kg)	12	8	16	36	156	400	427	983
3	Leaf litter (320 kg)	4.21	2.88	5.12	12.21	55	145	137	306
4	Crop residues (881 kg)	5.75	7.98	9.19	22.92	75	401	245	776
	Total (1+2)	73.96	20.86	111.31	206.13	962	1043	1065	4995

4.5.2 Long term effect of nutrient managementon soil fertility in IFS

Long term effect of nutrient management on soil build up under diversified agriculture system was studied in detail at some of the centers.

4.5.2.1 AICRP-IFS center at Rahuri

The soil fertility status in respect of chemical (pH, EC, organic carbon, available major nutrients (NPK) and micronutrients (Fe, Mn, Zn and Cu) and physical properties (Bulk density and hydraulic conductivity) were evaluated after the harvest of three cropping systems (CS1, CS2 and CS3) of IFS model during the year 2015-16. The soil analysis data (Table -4.14) from various cropping systems of IFS model indicated improvement in soil chemical and physical properties in all cropping systems over the initial soil fertility status of IFS model (2011-12). Amongst three cropping systems of IFS model, the soybean -wheat- Leafy vegetable cropping system (CS1) was observed more effective in improving soil fertility status in respect of organic carbon, available nitrogen, bulk density and hydraulic conductivity over other cropping systems (CS2 and CS3) in IFS model. The improvement in soil fertility status suggests that the diversified IFS model is having sustainable crop productivity after five years of data analysis.

Table 4.14. Soil properties, initial and after five years (0-15 cm of soil layer) (2015-16)–Rahuri

Sr. No.	Parameter	Initial	Cropping system CS1	CS2	CS3	Horti system
1.	P^H	8.17	8.16	8.15	8.16	8.17
2.	EC (dSm^{-1})	0.24	0.23	0.24	0.23	0.20
3.	O.C (%)	0.50	0.59	0.56	0.57	0.56
4.	Av.N (kg ha^{-1})	213	221	218	217	213
5.	Av.P (kg ha^{-1})	12	14	13	14	13.3
6.	Av.K (kg ha^{-1})	314	320	323	324	320
7.	DTPA extract Fe (mg kg^{-1})	4.68	4.82	4.80	4.77	4.70
8.	DTPA extract Mn (mg kg^{-1})	4.35	4.38	4.40	4.47	4.40
9.	DTPA extract Zn (mg kg^{-1})	1.20	1.40	1.36	1.43	1.48
10.	DTPA extract Cu (mg kg^{-1})	1.48	2.24	2.18	2.64	2.21
11.	Bulk density (Mg m^{-3})	1.34	1.30	1.32	1.32	1.31
12.	Hydraulic conductivity (cm/hr)	1.50	1.67	1.66	1.65	1.56
13.	Infiltration (cm/hr)	1.85	2.21	2.15	2.19	2.05

4.5.2.2 AICRP-IFS Centre at Rajendernagar (Telangana)

From the system through residue recycling and manure production (Fig.3), on an average, 8625 kg of FYM and 1269 kg of vermicompost was produced during the period under study. Around 135-77-103 kg worth of N, P and K were produced and saved fertilizer worth of Rs 9000/- during the 2015-16. Continuous use of crop residues and manures through residue recycling over five years helped improving the soil fertility of the unit with perceptible improvement in organic carbon from an initial status of 0.36 % in ID block to 0.49%. Similar advantage in increased available phosphorus and potassium was observed from an initial status of 14.8 and 170 kg ha^{-1} to 19.3 and 200 kg ha^{-1}.

Fig.3: Management of available by-product cowdung/urine etc. from dairy unit and residue recycling at AICREP-IFS centre Rajender nagar

4.6 SCOPE OF ORGANIC FARMING UNDER INTEGRATED FARMING SYSTEM APPROACH

In addition to traditional practice of organic agriculture by default in most of the hilly & tribal areas and weak financial status alongwith poor farm resources under small and marginal conditions, India has other comparative advantages for organic production which are given below;

- India is strong in high quality production of certain crops like tea, some spices, rice specialties, Ayurvedic herbs etc.

- Has a rich heritage of agricultural traditions that are suitable for designing organic production systems. Botanical preparations, some of which originate from the ancient veda scripts, provide a rich source for locally adapted pest and disease management techniques. The widespread cultivation of legume crops facilitates the supply of biological fixation of nitrogen.
- In several regions of India agriculture is not very intensive as regards to use of agro-chemicals. Especially in mountain areas and tribal areas, use of agro-chemicals is rather low, which easily facilitates conversion to organic production. On these marginal soils, organic production techniques have proved to achieve comparable or in some cases (especially in the humid tropics) even higher yields than conventional farming.
- The Non-Governmental Organizations (NGOs) sector in India is very strong and has established close linkages to a large numbers of marginal farmers. Many NGOs are engaged in promotion of organic farming and provide training, extension services information and marketing services to farming communities.
- The Indian Government has realized the potential and significance of organic agriculture for the country and has recently started to support organic agriculture on a large scale and on various levels. A national regulatory framework (standards, accreditation regulations) has already been passed in 2000 and as a result National Standards for Organic Production (NSOP) was notified in 2001 under National Programme of Organic Production. Ministry of Agriculture launched National Project on Organic Farming. Special schemes to support organic agriculture in North-Eastern states and Paramparaghat Krishi Vikas Yojana also formulated to give impetus to organic systems. Indian Council of Agricultural Research provides research and technological back up in the country.
- Under AICRP-IFS on Organic Agriculture ICAR-IIFSR, Modipuram is engaged to conduct research on Organic Farming at more than 20 OAS centers in 13 states of India. Studies are in progress on identification of crop and their varieties suitable and profitable for organic farming conditions and also on nutrient management alongwith plant protection methods under organic agriculture. Agronomic practices based on research results have been developed for a number of crops and published.

4.6.1 Towards Organic Farming – Why?

Bhattacharya and Chakraborty (2005) estimated the current status of organic farming in India and other countries. They noticed various problems in the conventional farming in India and opined that the integration of organic and inorganic farming i.e.,"Towards Organic Farming" would be an ideal model. Based on their results, the industrial nitrogen fixation (INF) is 40 mt/year which accounts for only 15.3% of total nitrogen fixation. On the other hand, the quantity of biological nitrogen fixation (BNF) is 175 mt/year contributes for 67.3% of the total amount. Plant also uses nutrients from organic sources through mineralization and billions of microorganisms are available in soil for this job. India is endowed with various types of naturally available organic form of nutrients in different parts of the country and which will help for organic cultivation of crops substantially. Sources of nutrients from organic manures estimated by Bhattacharya (2006) are presented in Table 4.15. There is enough scope for production of sufficient organic inputs exists in India and it works out to 7 mt in terms of nutrients. As a component of integrated farming system livestock accounts for lion share (nearly 40 per cent). It is followed by crop residues (30 per cent) and other sources (15 per cent). Other sources include the rural compost, vermi-compost and agricultural wastes. All these sources if recycled and managed in proper scientific manner can change the nutrient scenario in crop production in particular and agriculture as a whole. The other estimate by Tandon (1995) indicates potential of 39.9 mt (Table 4.15) which includes forest litter, urban and sewage sludge wastes.

Table 4.15: Sources of nutrients from organic manures in India

Source	Quantity (mt)
Livestock	2.47
Crop residues	2.00
Bio-gas slurry	0.12
Bio-fertilizer	0.20
Green manure	0.10
City refuse	0.68
Others (Rural, vermicompost and other agricultural wastes)	1.00
Total	6.57

Table 4.16: Potential of plant nutrients (mt) from various sources in India

Source	Plant nutrients (mt)			
	N	P_2O_5	K_2O	Total
Cattle	2.997	0.793	1.332	5.102
Buffalo	0.745	0.276	0.487	1.508
Goat and sheep	0.214	0.063	0.020	0.297
Pig	0.044	0.027	0.029	0.100
Poultry	0.027	0.020	0.010	0.057
Other livestock	0.079	0.018	0.069	0.166
Human beings	3.228	0.776	0.715	4.719
Farm crop wastes	5.600	2.300	10.700	18.600
Forest litter	0.075	0.030	0.075	0.180
Water hyacinth compost	0.060	0.033	0.075	0.168
Rural compost	1.130	0.678	1.130	2.938
Urban compost	0.024	0.015	0.030	0.069
Sewage sludge	0.012	0.009	0.003	0.024
Total	14.215	5.038	14.675	39.928

(Source: Tandon, 1995)

4.6.2 Live stock –Largely available potential source of manure for crop farming

Animal dung and other waste can play important role in the overall sustainability of the IFS. The nutrient dynamics in a crop-livestock farming system is quite interesting in context of today's agriculture and animal husbandry practices. A large amount of nutrient of farm origin is consumed by the livestock as crop- residue and a reasonable amount of nutrient is recycled back (as manure in the form of dung, urine) to system (Fig 4).

However, neither the cropping system can completely fulfil the requirements of livestock farming system, nor the animal manure alone can provide required nutrients for sustainable crop production and maintenance of soil fertility. Thus, external input in the form of fertilizer (for cropping system) and concentrate and leguminous fodder (in addition to crop residue) for livestock are always required and hence the nutrient dynamism in integrated crop-dairy farming system works as an open nucleus

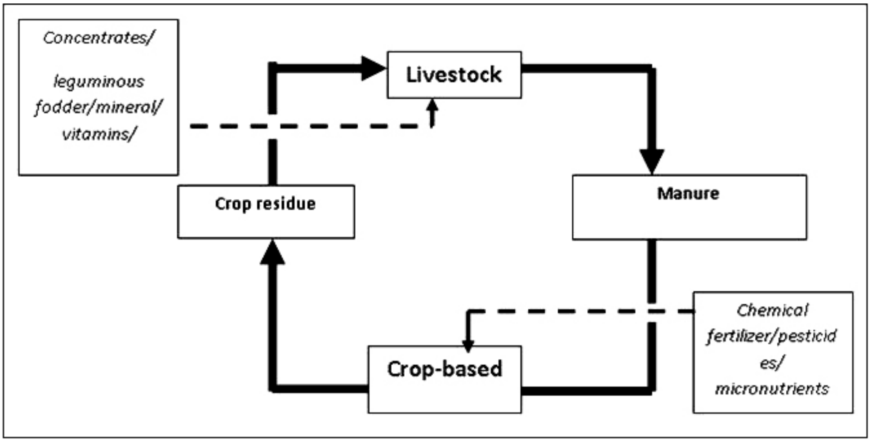

Fig. 4. Nutrient dynamics in integrated crop-livestock farming system

nutrient recycling module. Thus, the relationship in integrated crop-dairy farming system is partially inter-dependent, and not fully complementary to each other.

The amount of nutrient that can be recycled by dairy and other domestic animals species through production of manure (dung + urine) by an adult unit that can be recycled for crop farming are given below (Table 4.17).

Table 4.17: Manure (Dung+ Urine) produced by adult cattle and other livestock species

Species	Manure yield as a percentage of total live body weight/day	Fresh manure /animal/year (in Kg)	Dry matter/ animal/year (in Kg)
Dairy Cattle	9.4%	6000	1260
Sheep/Goat	3.6%	800	290
Pig	5.1%	3000	-
Chicken	6.6%	25	6-11
Duck	3.88%	55-75	24-32

(Compiled from the Source: http://www.fao.org/docrep/field/003/ab467e)

The manure obtained from cattle and other livestock species are rich in nitrogen, phosphorus and potassium. The average chemical composition of manure of different species is given in Table 4.18. However, because of low density as compared to chemical fertilizer, maintenance of present day crop-productivity /unit area is not possible solely depending on manures of farm origin. Moreover, farmers prefer chemical fertilizer because of easy availability, faster action on crop and easier for use.

Table 4.18: Average chemical composition (%) of cattle and other livestock manures

Species	Moisture	Organic matter	Nitrogen	Phosphate (P_2O_5)
Dairy cow	79	17	0.5	0.1
Sheep/Goat	64	-	1.1	0.3
Pig	71	25	0.5	0.4
Chicken	56	26	1.6	1.5
Duck	57	26	1	1.4

(Compiled from the Source: http://www.fao.org/docrep/field/003/ab467e)

Source of organic nutrients and their possible combinations/ratio for optimum use under organic farming:

A number of organic nutrient sources available at farm and market have been tested in different ratios/combinations at different OAS centres working under IIFSR, Modipuram. The cropping systems adopted and nutrient sources used are given in table-4.19 below;

Table 4.19: Identified nutrient packages for various cropping systems at different OAS centres

Location	Cropping System (s)	Sources
Jabalpur (Madhya Pradesh)	Basmati rice-wheat-berseem (seed)	Vermicompost (VC) + Farm Yard Manure (FYM) + Non Edible Oil Cakes (NEOC) @ 1/3 N
Coimbatore (Tamil Nadu)	Cotton-maize-GM Chillies-sunflower-GM	FYM + NEOC @ ½ N each + Panchagavya (PG)
Raipur (Chhatisgarh)	Rice-chickpea	Enriched compost (EC) + FYM + NEOC @ 1/3 N each + Bio dynamic (BD)+PG
Calicut (Kerala)	Ginger-fallow	FYM + Neem Cake (NC) + 2VC + PG + biodynamic + Rock phosphate (RP)
Dharwad (Karnataka)	Groundnut-sorghum Maize-chickpea Chilli +onion	EC + VC + Green leaf manure (GLM) + biodynamic spray @ 12 g/ha with PG spray

Location	Cropping System (s)	Sources
Karjat (Maharashtra)	Rice-red pumpkin Rice-cucumber	FYM + rice straw + gliricidia @ 1/3rd each of N during kharif and FYM + NC + VC @ 1/3 each of N during rabialong with spray of PG
Ludhiana (Punjab)	Maize-wheat-summer moong	FYM + PG + BD in maize, FYM + PG in wheat and FYM alone in moong
Bhopal (Madhya Pradesh)	Soybean-wheat Soybean-chickpea Soybean-maize	FYM+PG + BD
Pantnagar (Uttarakhand)	Basmati rice-wheat Basmati rice-chickpea Basmati rice-vegetable pea	FYM + VC + NC + EC @ ¼ N each + BD + PG
Ranchi (Jharkhand)	Rice-wheat Rice-potato	VC+ Karanj cake (KC) + BD+ PG
Umiam (Meghalaya)	Rice-maize Rice-toria	FYM + VC + PG

Nutrient potential and farm management of some of the organic sources:

Green Manure Crops/Green manuring: Green manuring can be defined as a practice of ploughing or turning into the soil un decomposed green plant tissues for improving physical structure as well as soil fertility. Green manuring, wherever feasible, is the principal supplementary means of adding organic matter to the soil. The green-manure crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop, due to its ability to fix nitrogen from the air with the help of its root nodule bacteria. The green-manure crops also exercise a protective action against erosion and leaching. Green manure to be incorporated in soil before flowering stage because they are grown for their green leafy material, which is high in nutrients and protects the soil. Green manures will not break down in to the soil so quickly, but gradually, add some nutrients to the soil for the next crop. The nutritional potentials and nutritional contents of some important green manures are given in the Table 4.20 and 4.21 respectively.

Oilcakes: Edible and non-edible oil cakes makes good proportion of organic materials in the country. They are rich source for nitrogen,

Table 4.20. Nutrient potential of green manures

Green manure	Biomass (t/ha)	N accumulation (kg/ha)
Sesbania aculeate	22.50	145.00
S. rostrata	20.06	146.00
Crotalaria juncea	18.40	113.00
Tephrosiaperpurea	6.80	6.00
Green gram	6.50	60.20
Black gram	5.12	51.20
Cow pea	7.12	63.30

(Source: Krishan Chandra, 2005)

Table 4.21. Nutrient content of important green manures

Green Manure	Nutrient content (% dry weight basis)		
	N	P_2O_5	K_2O
Sesbania aculeate	3.3	0.7	1.3
Crotalaria juncea	2.6	0.6	2.0
Sesbaniaspeciosa	2.7	0.5	2.2
Tephrosiapurpurea	2.4	0.3	0.8
Phaseolustrilobus	2.1	0.5	-
Green leaf manures			
Pongamiaglabra	3.2	0.3	1.3
Glyricidiamaculeata	2.9	0.5	2.8
AzadirachtaIndica	2.8	0.3	0.4
Calatropisgigantecum	2.1	0.7	3.6

(Source: Krishan Chandra, 2005)

phosphorus besides potassium. Some of the non-edible oilcakes such as castor and neem cakes are having the insecticidal properties also. The nutrient content of oil cakes are given in Table 4.22.

Farm Yard Manure: FYM is partially composed dung, urine, bedding and straw. Dung comes mostly as undigested material and the urine from the digested material. More than 50 % of the organic matter that is present

Table 4.22. Nutrient composition of edible and non-edible oil cakes

Oilcakes	N	P_2O_5	K_2O
	Edible		
Coconut cake	3.0	1.9	1.8
Groundnut cake	7.3	1.5	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Sesame cake	6.2	2.0	1.2
	Non-Edible		
Castor cake	4.3	1.8	1.3
Cotton cake	3.9	1.8	1.6
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.8
Neem cake	5.2	1.0	1.4
Safflower cake	4.9	1.4	1.2

(Source: Hand book of manures and fertilizers, 1964)

in dung is in the form of complex products consists of lignin and protein which are resistant to further decomposition and therefore the nutrients present in dung are released very slowly. The nutrients from urine, becomes readily available. Dung contains about 50 % of the nitrogen, 15 per cent of potash and almost all of the phosphorus that is excreted by animals. Straw, saw dust or other bedding materials are used in cattle sheds to reduce the loss of urine and to increase the bulk of manure. On an average, about 3 - 5 kg bedding material per animal is used by farmers. FYM contains approximately 5 - 6 kg nitrogen, 1.2 - 2.0 kg phosphorus and 5 - 6 kg potash per tonne. The quantity and quality of FYM depend upon the type (draught, mulch) and age of the animals, the way they are feed and the care taken to collect and store the material. Though FYM is the most common organic manure in India, the farmer, in general, do not give adequate attention to the proper conservation and efficient use of the resource. For preparing better quality FYM, the use of pit method for areas with less than 1000 mm precipitation and heap method for other places is recommended. In the pit method, the cattle shed wastes are conserved in pits of 2 m wide, 1 m deep and of convenient length with a sloping bottom towards one end. In the pit, an absorbent layer is created at the bottom by spreading straw at the rate of 3 - 5 kg per animal kept. The substrate containing well mixed dung, urine and straw is spread over the absorbent layer daily to form a layer of 30 cm thick and the process continued until the pit is filled. Each day's layer should be pressed, moistened if dry and covered with a 3 - 5 cm layer of well ground fertile soil to hasten the decomposition and to absorb the ammonia. The pit should be prepared on high lying area to avoid the entry of rain water. In the heap method, the daily collections from cattle shed are spread in uniform layers until the heap attains a maximum height of one meter above ground. The top of the heap is rounded and plastered with dung and mud mixture. In both the pit and heap methods aeration is allowed in the beginning and later on anaerobic conditions set in and continue for a long period. The manure is ready for use after 5 - 6 months. These methods should be initiated prior to rainy season and continued throughout the year. If properly preserved, the quantity of manure that can be produced per animal per year would be as much as four to five tonnes containing 0.5 per cent nitrogen. This is in contrast to one or two tonnes per animal per year containing 0.5 % nitrogen, which is obtained by indigenous method. The materials should not contain any heavy metal (Krishan Chandra, 2005).

Looking in to the increasing demand of food and other components of daily meal and animal fodder & feed etc. and in light of reducing cultivated area , decreasing soil fertility, increased water & air pollution, there are big challenges before agricultural scientists and government planners to look in to the measures to be adopted for increasing farm production as well as farmers profits, sustaining soil fertility and reducing pollution for overall sustainability in Indian agriculture. Integrated farming system approach based on the principals of diversification not only in cropping systems but farming system as a whole has been the only answer which not only provide livelihood improvement but besides providing all component of home consumption to fill stomach as well as balancing diet of family members and also domestic animals. In addition, diversification by way of recycling farm wastes and crop residues and adopting other organic means of crop nutrients maintain soil fertility by reducing chemical load and also pollution.

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Chapter 5

INTEGRATED ORGANIC FARMING SYSTEM : CONCEPT AND STRATEGIES

Amit Kumar, N. Ravisankar, M. Shamim, Debashis Dutta, P.C. Ghasal, L.K. Meena, A.L. Meena and A.S. Panwar

5.1 INTRODUCTION

A well-organized set of two or more components which interact consistently between or among each other with in a certain boundary is called as a 'System'. Similarly in agricultural science, an integrated farming system (IFS) is the outcome of complex interactions of a number of inter-dependent components or farming enterprises *viz.*, crop production, livestock, fisheries, fruits and vegetable crops, agro-forestry and so on. Thus, an IFS model is a judicious mix of at least two or more farm enterprises that not only minimizes the competition for resources between or among the enterprises but also maximizes complementarity with advanced agronomic management.

India's dominant farming community belongs to small and marginal farmer's group (>80% of the total farming community). Apart from this, it is estimated that by the year 2020 in India the average size of land holding will be less than 0.1 ha. With unabated shrinkage of land-holding size, income from cropping activity alone is becoming hardly sufficient to sustain these farm-families' needs. Further, small farm families also suffer from malnutrition due to lesser availability of diversified food products within the farm and their lower affordability to purchase from market due to high costs. Hence, it will be very unrealistic to have the livelihood security and sustainability of our small and marginal farmers with a single farm enterprise without resorting to IFS (Mahapatra, 1994). In light of the above facts several workers have suggested the farming system approach (Norman, 1978) in order to meet the multiple objectives of poverty reduction, food security, competitiveness and sustainability. Likewise, across the globe the organic farming systems (OFSs) are becoming more and more important at present juncture of time as they are linked by common objectives of economic, environmental, and social sustainability (Stockdale *et al.,* 2001).

At present in our country around 1280 million people are rearing a total livestock population of 529.7 million head (15% of world's livestock population in 2% of world's geographical area), which in future is expected to grow at 0.55% rate and will reach about 780.7 million by 2050. A country wide survey on farming systems as a whole highlighted that milch animals; cows and buffaloes irrespective of breed and productivity is the first choice of the farmers as an integral part of their farming system. It is noteworthy that in our country around 86% of farm house hold of small and marginal farming community has crop + livestock farming system.

The Indian agriculture had seen significant growth during last five and half decades under the influence of Green Revolution technologies that has not only made the country self-dependent in food grains production but also has improved livelihood status of Indian farmers. The adoption of Green revolution technologies such as high analysis fertilizers, high yielding varieties, pesticides and others by Indian farming community has improved food grain production from 50.8 million tonnes in 1950–51 to 252.2 million tonnes in the year 2015–16 (4th Advance estimate as on 2nd August, 2016). However, with the passage of time it also gave birth to many second generation problems such as deterioration of soil health, receding water tables, plateauing of yield, environmental pollution, build-up of obnoxious weeds, pesticide toxicity, loss of biodiversity, declining factor of productivity and development of multiple nutrient deficiencies (Sharma and Behera, 2004; Jain, 2008). Therefore, scientists and policy makers are very keen to look into the new agricultural production practices that can meet the multiple objectives of food, livelihood and environment security. In this context the integrated pest and nutrient management systems and certified organic agriculture can reduce reliance on agrochemical inputs as well as make agriculture environmentally and economically sound. Organic farming is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes, the use of management practices in preference to the use of off –farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system (FAO, 1999). Organic farming is a production system which avoids, or largely excludes, the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. The aim of organic agriculture is to augment ecological processes that foster plant nutrition yet conserve soil and water resources. Organic systems eliminate agrochemicals and reduce other external inputs to improve the environment and farm economics. Under organic farming, livestock based products *viz.,* dung, urine, milk, ghee and so on are of utmost importance as they are basic on farm materials for preparation of various crop management inputs under organic farming systems. Moreover, under the conventional agricultural systems external supply of inputs increases cost of cultivation by 13%. Thus for reducing this cost use of on farm inputs can be advocated. Therefore, it is the need of hour to extract more knowledge out of integrated as well as organic farming systems together through the integrated organic farming system research.

5.2 CONCEPTS OF INTEGRATED FARMING SYSTEMS

A system refers to combination of things or parts forming a complex or unitary whole. Under system approach while selecting combination of enterprises decision making must be done by taking into consideration whole farm rather than the individual crops or enterprises (Gupta and Nagrath, 2008). Likewise in a farming system lead managing role of agricultural operations is performed by the farm family by taking into account the components of soil, water, crops, livestock, labor, capital, energy, and other resources. The capability and resources available with farm family, socio-cultural setting, and interaction of above components with physical, biological and economic factors are main constraints that affect the decision making of farm family while designing its farming system. The farming system structure in its wider sense includes, land use pattern, production relationships, land tenures, size of holdings and their distribution, irrigation, marketing including transport and storage, credit institutions and financial markets, and research and education. Therefore it can be stated that the farming system is the result of complex interactions among a number of interdependent and interrelated components. As per his knowledge base the individual farmer manages farm through allocation of certain quantities and qualities of production factors *viz.,* land, labor, capital and management to crop, livestock and off-farm enterprises in order to achieve his goals (Mahapatra, 1994). The farmer, farm, enterprise or enterprises, resources at the command of farmer, and farming environment all together makes a complex system, which can be termed a farming system (Behera *et al.,* 2013; Fig. 1). Each individual farm has its own specific characteristics arising from variations in resource endowments and family circumstances. The household, its resources, and the resource flows and interactions at this individual farm level are together referred to as a farming system (FAO, 2001). The biophysical, socio-economic and human elements of a farm are interdependent, and thus farms can be analysed as systems from various point of view.

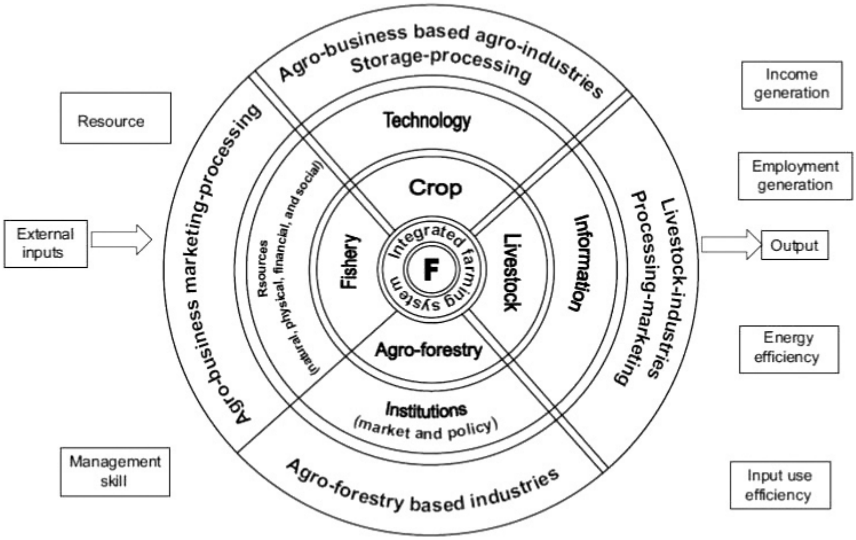

Fig 1. Representation of a farming system influenced by the socio-economic, political and biophysical environment and managed by the farmer (F). (Adopted from Behera, 2013)

5.3 DEFINITION OF FARMING SYSTEMS

The different authors and organizations have defined farming system in different ways. A farming system can be defined as a diverse and complex interrelated matrix of soil, plants, animals, implements, power, labor, capital and other inputs controlled in parts by farming families and influenced to varying degrees by political, economic, institutional, and social forces that operate at many levels (Mahapatra, 1994). Integrated Farming System is a judicious mix of two or more components/enterprises while minimizing competition and maximizing complementarities with advanced agronomic management tools aimed at sustainable and environment friendly improvement of farm income and family nutrition". Preservation of biodiversity, diversification of cropping or farming system and maximum recycling of residues ensure the success of this farming systems approach. Some others (Okigbo, 1995) has defined IFS as a mixed farming system that consists of at least two separate but logically interdependent parts of a crop and livestock enterprises. Jayanthi *et al.* (2000) based on experiences from Tamil Nadu, India, described it as a mixed animal crop system where the animal component is often raised on agricultural waste products while the animal is used to cultivate the soil and provide manure to be used as fertilizer and fuel. Agbonlabor *et al.* (2003) defined the IFS concept as a type of mixed farming system that combines crop and livestock enterprises in a supplementary and/or complementary manner. The difference between mixed farming and integrated farming is that, enterprises in the integrated farming system are mutually supportive and depend on each other (Csavas, 1992). From all the above descriptions pertaining to integrated farming systems it is unequivocal that synergies and complementarity between enterprises is key to formation as well as sustenance of the integrated farming systems. In this respect, integration usually occurs when outputs (usually by-products) of one enterprise are used as inputs for another within the context of the farming system.

5.4 INTEGRATED FARMING SYSTEM *VIS-À-VIS* INTEGRATED ORGANIC FARMING SYSTEM

Much has been talked about the concepts and definitions of the integrated farming systems. It is observed that in India crop + livestock is the pre-dominant farming system as around 85% of farm households practice it. Although, natural integration of components exists, but it lacks much needed recycling within the farm for reducing external dependence on market. Therefore this integration gap can be properly filled through the judicious understanding of the integrated organic farming systems (IOFS). The basic concept and definition of the IOFS as identical with simple IFS. However, for development of the IOFS it is very important to understand and apply the basic principles, methods, practices, and standards applicable to organic farming. Integrated organic farming is a commonly and broadly used word to explain a more integrated approach to farming as compared to existing monoculture approaches. It refers to agricultural systems that integrate livestock and crop production and may sometimes be known as Integrated Bio systems. It denotes a holistic system of farming which optimizes productivity in a sustainable manner through creation of interdependent agri-eco systems where annual crop plants (e.g. wheat), perennial trees (e.g. horticulture) and animals (including fishes where relevant) are integrated on a given field or property in sustainable manner. Presently it is estimated that around 25–30% of nutrient needs of Indian agriculture can be met by various organic sources. Though under the system approach by proper interlinking of the component enterprises the above stated value of nutrient supply can be improved.

5.4.1 Principles of organic farming

According to IFOAM, organic agriculture should be guided by four principles:

- *The Principle of Health* - Organic agriculture should sustain and enhance the health of soil, plant, animal and human as one and indivisible.
- *The Principle of Ecology* - Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help to sustain them.
- *The Principle of Fairness* - Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.
- *The Principle of Care* - Organic agriculture should be managed in aprecautionary and responsible manner to protect the health and well being of current and future generations and the environment

5.5 ORGANIC AGRICULTURE IN INDIA AND THE WORLD

Organic agriculture is rapidly growing around the world. Currently it is being practiced in 50.9 Million ha across 179 countries with 2.4 million producers including significant number of organic farmers in developing countries like India. The global market for organic products has reached to US$ 81.6 billion. India continues to be the country with the highest number of producers (5,85,200) and 87 countries now have an organic legislation across the world (Willer and Lernoud, 2017). In India, the cultivated area under certified organic farming has grown almost 17 fold in last one decade (42,000 ha in 2003-04 to 7.23 lakh ha in 2013-14). Alongside cereals, spices, cotton, tea etc, the Government of India is now keen to promote organic animal husbandry through focused attention on native breeds and local practices. In XII plan, the GOI has launched Paramparagat Krishi Vikas Youjana, under which Rs. 300 Crores (Union Budget 2015-16) were allocated to promote organic agriculture including organic animal husbandry. The organic livestock and poultry standards have also been notified for implementation since 1st June, 2015 (APEDA, 2015).

5.6 DEVELOPMENT OF THE IOFS

For growing the different crops under organic farming certain standard are to be followed. These standards are also applicable for development of IOFS model.

National Standards for Organic Production (Source: Participatory Guarantee System for India [PGS-India]: Operational Manual for Domestic Organic Certification, Edition 2015)

5.7 GENERAL REQUIREMENTS

5.7.1 Habitat Management

Habitat management is an important part of organic management system and forms the first step towards organic conversion. To ensure proper living conditions for all living beings, steady supply of green material for manuring and to create diversified plant stand it is essential that diversified plants/ trees etc are planted on bunds and other non-cultivated area of the farm. Adequate space may be provided for plantation of nitrogen fixing trees. Nitrogen fixing tree hedge not only act as biological fence but also ensure steady supply of biologically fixed nitrogen and other nutrients drawn from deeper layers of soil. These plants also provide home and shelter to friendly insects and birds. If required rain water harvesting pits and farm ponds can also be created.

5.7.2 Diversity

Diversity in crop production is second most important step of organic management which not only helps in management and control of pests and diseases but also ensure balance nutrition of the soil. Diversity can be achieved by a combination of mixed cropping, intercropping, relay cropping and rotation with legumes. Use of trap crops and barrier crops also add to the diversity.

5.7.3 Integration of Animals/ livestock

As successful organic farming depend upon continuous supply of dung and urine, efforts should be made to integrate crop production with livestock rearing.

5.7.4 Conversion period

The time taken for a farm to comply with the PGS organic standards is defined as the conversion period. In other words, it is the time required by the conventional farm to attain full PGS organic status. The whole farm including the crop production and animal husbandry shall be converted to organic management. Parallel or part conversion is not allowed under PGS organic management. For newly acquired fields or fields managed conventionally, the conversion period shall be not less than 24 months in case of seasonal and annual crops while it shall be not less than 36 months in case of perennial and permanent crops from the last date of use of prohibited inputs or from the date of taking the pledge, whichever is later. However, Regional Councils in some cases may allow conversion in phases, but in any case the entire farm holding of the group members must be brought under PGS organic management within 24 months of joining the group. Duration of conversion period can be reduced to 12 months if no prohibited substances have been used since last three years and all the members in the group are fully satisfied with past history of no synthetic input use and collectively declare so. Conversion period for animal products shall be not less than 12 months provided they are fed with fully organic feed and fodder and all the members of group are satisfied that the standard requirements have been met since last 12 months. In case of existing ICS groups (under NPOP) or members of such groups joining PGS, their certification status, as granted by accredited certification body and valid at the time of joining PGS shall continue, provided the group/ members meets all other requirements of PGS and have necessary documents to prove their claim to the full satisfaction of other group members (if they join an existing group) or RC (if they join as independent group).

5.7.5 Contamination control

All organic production units shall have effective measures to check accidental contamination with prohibited substance through drift or water flow. All organic farms shall be either protected with biological fence (hedge/hedge rows etc) or maintain a buffer zone. Organic farms also need to be protected from contaminated water flow from adjoining nonorganic fields. This can be achieved by putting appropriate bunds and escape channels.

5.7.6 Soil and Water conservation

Relevant measures should be taken to prevent erosion, salination of soil, excessive and improper use of water and the pollution of ground and surface water. Clearing of land through the means of burning organic matter, e.g. slash-and burn, straw burning shall be restricted to the minimum. The clearing of primary forest is prohibited.

5.8 STANDARD REQUIREMENTS FOR CROP PRODUCTION

5.8.1 Selection of seed and planting material

Seeds and planting material varieties should be well adapted to the soil, climatic conditions, suitable for organic management, resistant to pests and diseases and preferably of organic origin. In case organically grown seeds are not available then, chemically untreated conventional materials shall be used. The use of genetically engineered seeds, pollen, transgenic plants or planting material is not allowed.

5.8.2 Fertilization

On-farm biodegradable material of microbial, plant or animal origin shall form the basis of fertilization policy. Green manuring, intercropping or crop rotation with legumes shall be the integral part of cropping system planning. Off-farm/ purchased biodegradable material of microbial, plant or animal origin can also be used provided it is ensured that no prohibited substances have been used in their preparation. Microbial preparations such as biofertilizers, biodynamic preparations, EM solutions etc can be used. Off-farm/industry produced inputs approved by NPOP accredited certification body as approved input for use in organic farming can be used without further approval of the group. Mineral fertilizers shall be used in their natural powdered form as supplementary source of nutrients. Use of synthetic fertilizers is strictly prohibited in any form, directly or indirectly.

5.8.3 Pest, Disease and Weed Management including Growth Regulators

Selection of pest resistant varieties, suitable crop rotations, green manures, balanced fertilization, early planting, mulching, cultural, mechanical and biological control measures (including use of insect pest parasites and predators), disturbance in pest life cycles and ensuring survival of pest enemies should form the basis of pest management programme. Thermic weed control or thermic sterilization of soils can be resorted to only when it becomes absolutely necessary. Microbial pest control formulations such as biopesticides can be used. On-farm fermentation products and botanical extracts can also be used. Off-farm purchased microbial or botanical preparations can also be used provided it is ensured that such products are approved as organic inputs under NPOP by accredited certification agencies. Use of synthetic herbicides, fungicides, insecticides and other chemical preparations including synthetic plant growth regulators and synthetic dyes are strictly prohibited. Use of genetically engineered organisms or products are also prohibited.

5.8.4 Equipments/ implements and storage containers

All farming equipments, implements and tools etc must be washed and cleaned before use on the organic farm. Bags and containers used to harvest, store and transport organic produce must be clean and free from any chemical contamination and should not have been used for storage of conventional produce. All such containers and bags shall be clearly labeled “Organic Only”.

5.8.5 Storage and Transport

Organic Products must be protected at all times from co-mingling with non-organic products.

Use of synthetic or chemical storage pesticides/ fumigants are prohibited. Natural and traditional ways and means for storing organic produce are allowed. Use of carbon-di-oxide, nitrogen or any other such inert gas is permissible.

5.9 STANDARD REQUIREMENT FOR ANIMAL PRODUCTION

5.9.1 Conversion requirements

The whole farm, including livestock, should be converted to organic within the specified conversion period. Part conversion or parallel production is not allowed under PGS after 24 months. The minimum conversion period for all animals except poultry shall be not less than 12 months. The poultry birds for egg production or for meat purpose shall be fed only on organic diet from 2 day onwards after hatching.

5.9.2 Rearing environment

The management of animal environment shall ensure free movement, sufficient access to fresh air, day light, water, lying and resting place and protection against excessive sunlight, rain and wind etc. Mutilations in any form should not be resorted except for castrations, tail docking, dehorning, ringing and mule sing.

5.9.3 Breeds and breeding

Breeds should be chosen which are adapted to local conditions. Breeding goals should not be at variance with the animal's natural behaviour and should be directed towards good health. Reproduction techniques should be natural. Artificial insemination is allowed. Hormonal heat treatment and induced births are not allowed, unless applied for medical reasons under veterinary advice. Genetically engineered species or breeds are not allowed.

5.9.4 Animal Nutrition

The livestock should be fed 100% organically grown feed of good quality. All feed shall come from the farm itself or be produced on the farms of other group members or have been harvested from wild where no prohibited substances have been used. Products from the organic feed processing industry shall be used. Colouring agents shall not be used in organic livestock production.

The following products shall not be included nor added to the feed given to farm animals:

- Synthetic growth promoters or stimulants
- Synthetic appetisers
- Preservatives, except when used as a processing aid
- Artificial colouring agents
- Urea
- Farm animal by-products (e.g. abattoir waste) to ruminants
- Droppings, dung or other manure (all types of excreata) even if technologically processed
- Feed subjected to solvent (e.g. hexane), extraction (soya and rape seed meal)
- Feed prepared with the addition of other chemical agents
- Pure amino acids
- Genetically engineered organisms or products thereof

Vitamins, trace elements and supplements shall be used from natural origin when available in appropriate quantity and quality.

5.9.5 Veterinary Medicine

The well-being of the animals is the primary consideration in the choice of illness treatment. Natural medicines and methods, including homeopathy, ayurvedic, unani medicine and acupuncture, shall be emphasised. The use of conventional veterinary medicines is allowed when no other justifiable alternative is available. Where conventional veterinary medicines are used, the withholding period shall be at least double the legal period.

Use of the following substances is prohibited:

- Synthetic growth promoters
- Substances of synthetic origin for production, stimulation or suppression of natural

5.9.6 Growth

- Hormones for heat induction and heat synchronisation unless used for an individual animal against reproductive disorders, justified by veterinary indications

Vaccinations shall be used only when diseases are known or expected to be a problem in the region. Legally required vaccinations are allowed. Genetically engineered vaccines are prohibited.

5.9.7 Requirement for Bee Keeping

As bee keeping is considered a part of animal husbandry, general principals of animal husbandry shall also apply on bee keeping. In addition following requirements shall also be met:

- Bee hives shall be made of natural materials free from toxicity.
- Bee hives shall be placed in organically managed farms and/ or wild natural areas, away from the fields or areas where prohibited substances have been used.
- Veterinary medicines/ antibiotics shall not be used in bee keeping and no repellents consisting of prohibited substances be used when working with the bees.
- For pest and disease control and for hive disinfection use of caustic soda, lactic, oxalic, acetic, formic acids, sulphur, etheric oils and *Bacillus thuringensis* are allowed.

Case studies on improved income and livelihood through adoption of Integrated Organic farming System

Few case studies have been done on the integrated organic farming system model across the country. Some of them are as under:

Case study from Meghalaya (Umiam)

Source: Annual Report 2014-15, Network Project on Organic Farming

Under the Network project on the organic farming an Integrated Organic Farming System Model (IOFS) was developed at the Umiam in Meghalaya. The model comprised of different enterprises like cereals *viz.,* rice and maize, pulses and oilseeds *viz.,* soybean, lentil and pea, vegetable crops *viz.,* frenchbean, tomato, carrot, okra, brinjal, cabbage, potato, broccoli, cauliflower, chilli, coriander, etc. fodder, fruits *viz.,* Assam lemon and papaya, livestock unit (dairy), vermicomposting and fishery unit (Fig 2). Apart from this a farm pond of 460 square metre area with average depth of 1.5 m was part of the IOFS model for life saving irrigation and aquaculture. The value of rice equivalent yield (REY) is found to be comparatively higher in case of vegetable crops like cole crops, french bean, tomato and broccoli. The effect (legume) of soybean on other subsequent crops such as tomato and french bean and potato was found to be high. The good dividends from components such as permanent fruit crops and live stock were also derived. In the model one cow along with one calf produced 1458 liters of milk per year with gross return of as Rs.43740.

In an area of 6249 m^2 under gross cropping, 9.37 t of FYM (@15t/ha) is required for organic crop production. FYM produced within existing farming system is 6.3 t [6t + 0.3t (FYM equivalent from 0.15 t vermicompost)]. Hence initially, only 3.07 t of FYM is required to be purchased from outside to sustain the model in the first year of establishment. The requirement of FYM would be reduced substantially with the efficient recycling of on farm biomass, pond silt, intercropping with legumes, etc. and the model can be self-sustainable. The net income from 0.43 ha area of IFS model was Rs.58321 or Rs 4860 per month or Rs. 160 per day. The increase in net income over farmers practice was found to be 5 times. Considering the benefits from the IFS model with a net income of Rs 160 per day, it can sustain a four member family as the model could also meet the requirement of healthy food for the family.

Components	Crop Area (m^2)	Net Area (m^2)	Production (t)	Cost of cultivation (Rs.)	Gross Income (Rs.)	Net Return (Rs.)	REY (t/ha)
Cereals							
Rice	1579	1579	0.71	48000	7515	2715	4.5
Maize	485	485	0.23	1780	2338	558	4.82
Pulses / oilseeds							
Soybean	485	Intercrop with maize and okra	0.04	316	460	162	0.99
Lentil	225	Under rice fallow	0.03	282	450	168	2.00
Pea	225	Under rice fallow	0.06	388	1200	812	5.34
Vegetables							
French bean	234	Rotation with maize and okra	0.23	1043	3506	2463	20.00
Tomato	403	Rotation with maize and brinjal	0.44	1560	6646	4764	16.50
Carrot	110	Rotation with okra	0.15	953	1500	547	14.00
Okra	337	337	0.29	1569	2861	1292	17.00
Brinjal	262	262	0.23	1351	2300	549	8.15
Cabbage	101	161	0.36	1133	3616	2493	20.00

Potato	256	Rotation with maize and okra	0.38	1467	3837	2360	15.00
Broccoli	116	116	0.18	1050	4500	3450	38.27
Cauliflower	116	116	0.24	1100	3600	2500	30.00
Chilli	96	96	0.02	350	576	220	5.94
Coriander	32	32	0.02	321	465	164	15.00
Fruits							
Assam Lemon	60	60	0.04	595	1600	1005	
Papaya	50	54	0.14	667	1400	713	
Live stocks							
Dairy (1 cow with 1 calf)	36	36	1458.6 t/year	36488	43740	13252	
Milk			4.5		4500		
Cow dung (adult)			1.5		1500		
Cow dung (Calf)							
Fishery							
Common fish culture	460	460	0.24	84620	19200	10738	
Vermi compost	72	72	0.15	400	1200	800	
Fodder	382	382	4.01	1826	8026	6200	
Total	6249	4311		68256	126576	56321	
Rice equivalent yield (t/ha)	12.66						
Cropping intensity	144.54						
Farmers' Practice (Rice mono cropping)		1724	8622	17240	8616		

Fig . 2. Area, production and economics of the IOFS model at Umiam

Though many benefits are associated with organic farming such as secure and safe food production, soil health improvement, less external input requirement (around 12-13%), sustainable agricultural systems, reduction in soil erosion (50%), improvement in environment health and 15% more rural job opportunities (Pimental *et al.,* 2005). However, in India farmer's apprehension regarding organic farming is mainly rooted in unavailability of organic sources of nutrient (only 25% nutrient demand can be met from different organic sources), bio fertilizers and local market for organic produce and poor access to guidelines, certification and input costs. Therefore in promotion of organic farming the concept of integrated organic farming system models can play a vital role. The need of the hour is to do the study in the farming system perspective so that the new possible integration among the enterprises can be found. Moreover, there is a need of integrated efforts from government and nongovernment agencies to encourage farmers to adopt organic agriculture as a solution to climate change, health and sustainability issue.

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Chapter 6

INTEGRATED ORGANIC FARMING SYSTEM STRATEGIES FOR SOUTHERN PLAINS

E. Somasundaram, D. Udhaya Nandhini and N. Ravisankar

6.1 INTRODUCTION

Presently the farming situation urges need to develop farming techniques, which are sustainable from environmental, production, and socio-economic points of view. Modern agricultural production throughout the world does not appear to be sustainable in the long run. Sustainable agricultural development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner to assure the attainment and continued satisfaction of human needs for the present and future generations. Such sustainable development in the agriculture, forestry and fishery sectors, conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable. Such concerns imparted a way to organic farming. It is the need of the day to understand the prospects and problems of organic farming to launch a successful and flawless organic production programme in the farm environment (Somsundaram *et al*., 2015).

"Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests". Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs.

Ensuring food security for a fast growing global population estimated at 9.1 billion in 2050 and over 10 billion by the end of the twenty first century is a mammoth challenge for the present agricultural production system (UNPFA, 2011). Shrinking average farm size in India and financial constraints for higher investment in agriculture due to 80% farm families belonging to small and marginal farmer categories further heighten the challenge. For securing food and nutrition security for sizable population, productivity enhancement may provide a vital solution. This involves the adoption of scientific agronomic practices and technologies which promise an augmentation of the productive capacity of traditional agricultural systems. Agronomic practices such as the liberal use of inorganic pesticides and fertilizers during the twentieth century enhanced productivity significantly but undesirable environmental degradation accompanied by increased operational costs in agriculture raised concerns about economic feasibility and sustainability (IAASTD 2009). About 75% of the adversely affected households belong to rural communities of developing economies whose livelihood is directly or indirectly dependent on agriculture and allied activities (FAO, 2009). Unsustainable farming leads to environmental pollution and threatens the livelihood of millions of small farm holders. Strengthening agricultural production systems for greater sustainability and higher economic returns is a vital process for increasing income and food and nutrition security in developing countries (Ravallion and Chen, 2007). Therefore IFS is a multidisciplinary whole farm approach and very effective in solving the problems of small and marginal farmers. The approach aims at increasing income and employment from small-holding by integrating various farm enterprises and recycling crop residues and by products within the farm itself. The farmers need to be assured of regular income for living at least above poverty line. The progress in production or steady growth in output is necessary to face the challenges posed by present economic, political and technological environment. In this context, farming system approach is one of the important solutions to facethis peculiar situation as in this approach the different enterprises can be carefully undertaken and the locationspecific systems are developed based on available resources which will result into sustainable development (Dashora and Hari Singh, 2014).

6.2 PRINCIPLES OF ORGANIC FARMING

The four principles of organic agriculture are as follows:

- *The Principle of Health* - Organic agriculture should sustain and enhance the health of soil, plant, animal and human as one and indivisible.
- *The Principle of Ecology* - Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help to sustain them.
- *The Principle of Fairness* - Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.
- *The Principle of Care* - Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well being of current and future generations and the environment

6.3 CURRENT SCENARIO OF ORGANIC AGRICULTURE

6.3.1 Growing area under certified organic agriculture

- About 35 million hectares of agricultural land are managed organically by almost 1.4 million producers.
- The regions with the largest areas of organically managed agricultural land are Oceania (12.1 million hectares), Europe (8.2 million hectares) and Latin America (8.1 million hectares). The countries with the most organic agricultural land are Australia, Argentina and China.
- The highest shares of organically managed agricultural land are in the Falkland Islands (36.9 per cent), Liechtenstein (29.8 per cent) and Austria (15.9 per cent).
- The countries with the highest numbers of producers are India (340’000 producers), Uganda (180’000) and Mexico (130’000). More than one third of organic producers are in Africa.
- On a global level, the organic agricultural land area increased in all regions, in total by almost three million hectares, or nine percent, compared to the data from 2007.
- Twenty-six percent (or 1.65 million hectares) more land under organic management was reported for Latin America, mainly due to strong growth in Argentina. In Europe the organic land increased by more than half a million hectares, in Asia by 0.4 million.
- About one-third of the world’s organically managed agricultural land – 12 million hectares is located in developing countries. Most of this

land is in Latin America, with Asia and Africa in second and third place. The countries with the largest area under organic management are Argentina, China and Brazil.

- 31 million hectares are organic wild collection areas and land for bee keeping. The majority of this land is in developing countries – in stark contrast to agricultural land, of which two-thirds is in developed countries. Further organic areas include aquaculture areas (0.43 million hectares), forest (0.01 million hectares) and grazed non-agricultural land (0.32 million hectares).
- Almost two-thirds of the agricultural land under organic management is grassland (22 million hectares). The cropped area (arable land and permanent crops) constitutes 8.2 million hectares, (up 10.4 per cent from 2007), which represents a quarter of the organic agricultural land.

6.3.2 The following strategies should be followed for adoption of integrated organic farming

6.3.2.1 Site Selection/land consolidation

Places which have history of producing crops without using chemical inputs or with minimum intervention should be preferred.

6.3.2.2 Cooperative/community approach

In view of the fragmentation of land-holding, the community approach is a must for the organic farmers.

6.3.2.3 Availability of organic inputs

Easy availability of organic inputs is the pre-requisite for organic farming. The farmers, in due course, have to produce their own organic inputs. The suitability/adaptability of different green manure crops should be tested. All sources of organic material that can (or presently cannot) be used as manure should be identified, this should include industrial wastes also. Gaps in technology that prevent the utilisation of some wastes should then be identified. This should be done to satisfy critics that not enough organic material is available for organic farming.

6.3.3 Selection of crops and cultivars

Whether grown for domestic consumption or export purpose, crops must be selected based on its suitability for a specific location.

Selection of crops suited for a particular location.

6.3.4 Quality of organic inputs

The organic inputs are sold in different brand names, no standards yet available. Quality control laboratory should be set up to standardize the quality.

6.3.5 Cropping system approach

The cropping system approach will be more remunerative in organic farming. Selection of shallow and deep-rooted crops is important in rotation. Part of the crop residue should be returned to soil/fed to cattle or be used for composting.

6.3.6 Developmental and promotional activities

Incentive and encouragement for the production of quality organic manure bio-pesticide, bio-fertiliser and green manuring crop should be considered. Effort should be made for the development of new pesticide of plant origin. The uses of bio-agents need to be promoted.

6.3.7 Certification and accreditation

Cost of inspection and certification is cost prohibitive. It should be simple and at a lower cost.

6.3.8 Sales and marketing

Organic farming is labour intensive. So it will be more remunerative if the farmer gets a premium price for their produce. Promotion of farm level processing, value addition and encouragement of the use of organic farm produce in food industry.

6.3.9 Subsidize organic inputs and produce.

Subsidies may be provided for organic inputs and produce while the industry is still getting established. In India, subsidies are mainly provided by the national government and channelled through state agriculture departments; the technique is well-tested, having already been used for the synthetic fertilizer and pesticide industry. Indeed, subsidies have been provided for setting up biofertilizer and vermicomposting units under NPOF and for setting up export schemes under NPOP. Additional subsidies could be provided for:

- Setting up organic input production units for composting, biopesticides etc.
- Compensating organic farmers during the period of conversion to organic techniques, to compensate for yield reductions if any.

- Establishing village-level grading and packaging units for organic produce.
- Developing local and regional marketing infrastructure for organic produce in dryland areas, where regional/local food security is more important than crops for export.

6.3.10 Develop organic farming clusters of villages

Since the drylands are already an area of focus for governmental development programs based on a watershed approach, clusters of villages previously established for such programs (Khan, 2002) may be converted into organic clusters of villages by providing technical support. This will be cost-effective and make the eventual certification process of organic produce easier for these villages once the local organic produce market has been well established.

6.3.11 Increase public awareness and build capacity

Conferences, seminars, and farmers' fairs may be organized to raise awareness and encourage adoption of organic farming. Programs demonstrating how to establish organic systems, and training in how to produce and manage organic inputs, may be started at the village level.

6.4 INTEGRATED ORGANIC FARMING SYSTEM

Farming system approach addresses itself to each of the farmer enterprises, inter relationship among enterprises and between the farm and environment. Thus farming system research has the objective of increasing productivity of various enterprises in the farm. Farming system approach introduces a change in farming technique for high production from a farm as a whole with the integration of all the enterprises. The farm produce other than the economic products for which the crop is grown can be better utilized for productive purposes in the farming system approach. A judicious mix of cropping system with associated enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio economic status of farmers would bring prosperity to the farmer.

Combination of Integrated farming system (IFS) along with organic farming so called integrated organic farming system (IOFS) appear to be the possible solution to the continuous increase of demand for food production, stability of income and improvement of nutrition for the small and marginal farmers with limited resources. Integration of different enterprises with crop activity as base will provide ways to recycle products and waste materials of one component as input through another linked component and reduce the cost of production of the products which will finally raise the total income of the farm. This becomes quite essential as crop cultivation is subjected to a high degree of risk and provides only seasonal, irregular and uncertain income and employment to the farmers. With a view to mitigate the risk and uncertainty in agriculture, IOFS serves as an informal insurance.

Production of agricultural crops, vary in response to changes of the seasons. In recent period stable income of agricultural crops has become unstable. Redressing these by integrating crops with agro-based industries like livestock farming is essential. An integrated organic farming system applies the concept of "Low External Input Sustainable Agriculture" (LEISA) and this system develops the livestock business and the crop business in one location or area using local resources to optimize inputs. Designing a farming system to tie together principles of sustainability and productivity is complex. Organic farmers must consider how the various components of their system - rotations, pest and weed management, and soil health - will maintain both productivity and profitability. This section outlines the major principles incorporated into organic farming systems.

Efficient cropping systems for a particular farm depend on farm resources, farm enterprises and farm technology because farm is an organized economical unit. The farm resources include land, labour, water, capital and infrastructure. When land is limited intensive cropping is adapted to fully utilized available water and labour when sufficient and cheap labour is available, vegetable crops are also included in the cropping systems as they require more labour. Capital intensive crops like sugarcane, banana, turmeric etc. find a space in the cropping system when capital is not a constraint. In low rainfall regions (750 mm/annum) mono cropping is followed and when rainfall is more than 750 mm, intercropping is practiced, with sufficient irrigation water, triple and quadruple cropping is adopted, when other climatic factors are not limiting farm enterprise like daring, poultry etc. also influenced the type of cropping system. When the farm enterprises include dairy, cropping system should contain fodder crops as components change in cropping system take place with the developments of technology. The feasibility of growing for crop sequences in Genetic alluvial plains inputs to multiple cropping.

Applying an extensive knowledge of indigenous and organic practices, the farm is strategically structured in distinct components that are designed to maximize one another.

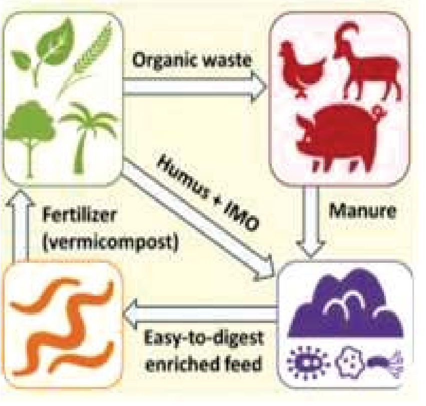

Fig. 1. Nutrient recycling system on the farm

A nutrient recycling system generates a virtuous closed loop process on the farm (Fig. 1), and biodiversity is intensified to multiply key ecological functions and processes within and among the components (e.g. natural pest management andoptimal use of sunlight, rainfall and soil fertility).

Biodiversity-based farming systems are not new. For centuries, farming communities have painstakingly developed resilient and bountiful agricultural systems based on biodiversity, and on their knowledge of how to work with them in equally complex biophysical and socio-cultural settings. Farmers have used diversity for food and economic security through a complex array of home garden designs, agroforestry systems and diversified and integrated lowland farming systems. It differs substantially from conventional modern agriculture in that its focus is the establishment of functional diversity in the farm, rather than monoculture.

The integration of several allied enterprises with crop components is crucial in order to optimize the synergies. These integrated systems provide scope not only to augment income of the farmers but also bring improvement in soil health through recycling of organic wastes and thereby increase the overall productivity of the crops. Thus, energy obtained from IFS in various forms is much higher than energy input, as the by-product/ wastes of these allied enterprises provide all raw material and energy required for the food chain in another system. This complimentarity when carefully chosen, keeping in view the soil and environmental conditions generates greater income.

6.4.1 Design of integrated farming system model

1. The diversity of the farm should be increased as much as possible by introducing at least 5-6 types of cereals and pulses/oilseeds, 10-12 varieties of vegetables, 5-6 fruit crops, fuel wood and fodder trees, 5-6 types of spices and medicinal plants, 5-6 livestock, 3-4 types of fish. This could ensure food and livelihood security of the farmer throughout the year.
2. External inputs will have to be reduced. Effective utilisation of resources must be made in the farm to recycle the farm wastes

3. Measures to be taken for conserving the rain water by constructing the water harvesting structures like farm pond and percolation pond.
4. Recycling of farm waste is important.
5. Weeds which are grown in its own onfarm, should be processed as a compost and used to meet the consumption requirement of farmer and livestock
6. Establish a manure pit in the corner of the field for composting the farm wastes. Separate composting units for farm wastes and weeds should be established.
7. Fast growing trees should be planted as they add nutrient to soil and provide habitat for local wildlife, including bird species who also contribute to a healthy ecosystem on the farm.
8. Adjoining land use, buffers
9. Soil fertility management and inputs
10. Proper crop rotation
11. Weed, pest and disease management, materials to be used, and justification
12. Farmers should take initiatives to sell their produce in a processed farm in order to receive more profit. Oil from coconut, groundnut, sesame, fruit juices are few examples of such post-harvest technologies.
13. Integration of livestock at right time and quantum might serve many of our purpose at free of cost. Local breed of ducks in paddy fields, poultry in orchards will save works like weeding fertilizing and aerating the soil.

6.4.2 Prerequisites to establish IOFS

Before you start designing your farm, you need to assess your farm according to the following points;

- Existing farm size
- Living area for animal and human
- Ploughing frequency
- Distance of farm areas from household
- Weeding style and frequency
- Transport after harvest

- Soil water conservation techniques
- Existing farm inputs
- Cropping pattern
- Type of livestock
- Type of fodder

6.4.3 Characteristics of an ideal integrated organic farm

Organic agriculture aims at successfully managing natural resources to satisfy human needs while maintaining the quality of the environment and conserving resources. Organic agriculture thus aims at achieving economic, ecological andsocial goals at the same time:

1. Ecological goal: "How does the farm improve nature and survival of other organisms?"
2. Social goal: "How do other people benefit from the farm?"
3. Economic goal: "What benefits do I generate from the farm?"

6.4.3.1 The ecological goal

The ecological goal basically relates to maintenance of quantity and quality ofnatural resources. Farming should be done in an environmentally-friendly manner,whereby the soil, water, air, plants and animals are protected and enhanced.Organic farmers pay special attention to the fertility of the soil, the maintenanceof a wide diversity of plants and animals, and to animal friendly husbandry.

6.4.4 Important environmental goals are:

- Prevention of loss and destruction of soil due to erosion and compaction.
- Increasing the humus content of the soil.
- Recycling farm-own organic materials and minimizing use of external inputs.
- Promotion of natural diversity of organisms - being a criterion of a balancednatural ecosystem.
- Prevention of pollution of soil, water and air.
- Ensuring husbandry that considers natural behaviour of farm animals.
- Use of renewable energy, wherever possible.

To achieve these goals organic farmers maintain wide crop rotations, practiceintercropping and cover cropping, plant hedgerows and establish agro-forestry systems.

6.4.4.1 The social goal

Organic farming aims at improving the social benefits to the farmer, his/her familyand the community in general.

6.4.5 Important social goals include:

- Creating good working conditions for all.
- Ensuring a safe nutrition of the family with healthy foods.
- Ensuring sufficient production for subsistence and income.
- Encouraging fair and conducive working conditions for hired workers.
- Encouraging learning and application of local knowledge.

From an organic perspective, at the household level fair participation in farmactivities of all family members and proper sharing of the benefits from the farm activities is essential. On community level, knowledge and experiences should be shared, and collaboration strengthened in order to obtain higher benefits.

6.4.5.1 The economic goal

In an economic sense organic farming aims at optimizing financial benefits to ensureshort- and long-term survival and development of the farm. An organic farm should not only pay for production costs, but also meet the household needs of the farmer's family.

Important economic goals include:

- Satisfactory and reliable yields.
- Low expenditures on external inputs and investments.
- Diversified sources of income for high income safety.
- High value added on-farm products through improvement of quality and on-farmprocessing of products.
- High efficiency in production to ensure competitiveness.

Organic farmers try to achieve this goal by creating different sources of incomefrom on- and off-farm activities. Usually different crop and animal enterprisesare adopted simultaneously in a mixed production system. The target also includes being more self-sufficient in terms of seeds, manures, pesticides, food,feeds, and energy sources and thereby minimizing cash outlay to purchase off-farmitems.

6.4.6 Strategies to improve long-term productivity of the integrated organic farm

Reduce production risks

- Diversification
- Build soil fertility
- Reduce external inputs

Improved overall production

- Use improved adapted local varieties
- Improve soil fertility
- Ensure proper pest and disease management
- Integrate livestock

Enhance value of farm products

- Adopt profitable enterprises
- Improve product quality
- Establish storage and processing facilities
- Obtain organic certification

Reduce expenses

- Reduce own manure
- Produce own planting materials and seeds
- Make own herbal pesticides and organic inputs
- Share equipment and machinery

6.4.7 Integrated organic farm model using 2.5 acres (1.0 ha) land

Following is a model (Fig. 2) which could be used in garden lands (irrigated uplands) of Tamil Nadu. This model comprises the following subsystems:

1. Crops production (grains, root crops, coconut, fruit trees, vegetables) - 8250 m^2

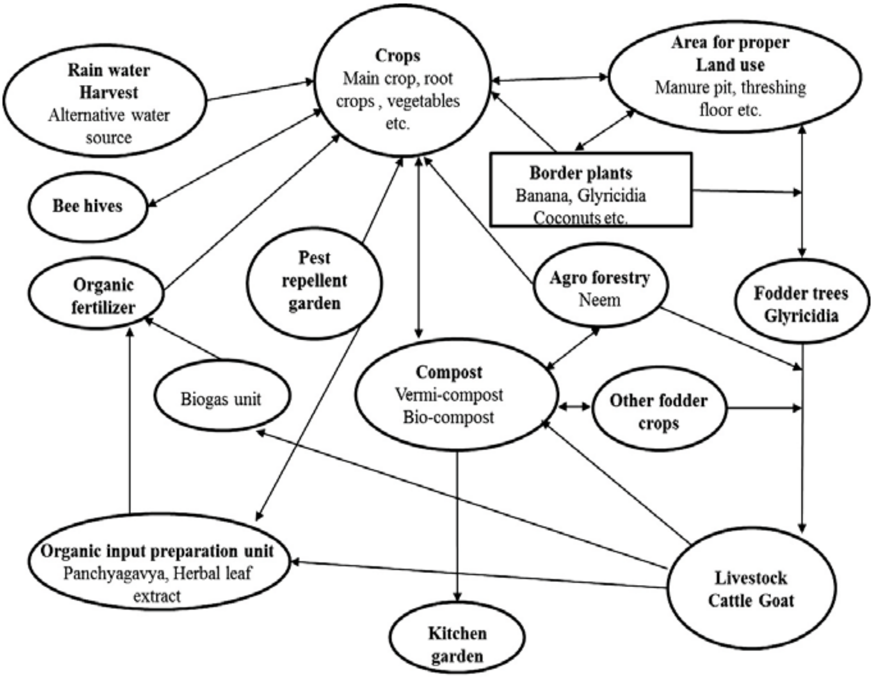

Fig. 2. Integrated organic farming system model

2. Fodder crops (hedge lucerne (*Desmanthus* sp)+ cumbu (bajra) napier CN5 grass)- 1000 m^2
3. Livestock – Cattle/ poultry, Goat 100 m^2

Over view of Integrated Organic Farming System Model

4. Biodigester - 20 m^2
5. Compost/vermiculture - 60 m^2
6. Pest repellent cafeteria - 100 m^2
7. Organic fertilizer production -20 m^2
8. Area for proper land use – 100m^2
9. Rain water harvesting – 100 m^2
10. Bee hives – 20 m^2
11. Agroforestry - 200 m^2
12. Kitchen garden – 30 m^2

6.5 DESCRIPTION OF THE AGROECOSYSTEM

6.5.1 Crops -8250 m^2 of area (1. Bhendi + leaf coriander - maize + cowpea (Fodder) – 2. Green manure - cotton –sorghum) would be required to produce adequate corn, sorghum, cotton and vegetables for farm use as well as for sale.

6.5.2 Selection of crops in a system

- Season/climate
- The market
- Labor needs
- Other production costs

Green manure-bhendi-maize

Green manure-cotton-sorghum

- Pest susceptibility
- Companion planting
- Crop rotation
- Soil fertility
- Erosion
- Personal preference

6.5.3 Organic farming practices for various crops and cropping systems

6.5.3.1 Seed treatment

- Cowdung slurry treatment 1%
- *Trichoderma viride* @ 4 g / kg of seed
- *Pseudomonos* @10 g / kg of seed
- Azophos 500 g commercial product per ha
- Soaking in Panchagavya (1%)

6.5.3.2 Nutrient management

- Well decomposed FYM @ 12.5 t/ha
- Enriched FYM 750 kg/ha for rainfed
- Vermicompost and composted crop residues on N equivalent basis
- Neem cake @ 250 kg/ha
- Soil application of biofertilizers @ 5 kg/ha
- Silicate solubilizing Bacteria @ 2.2. kg/ha
- Green manuring with Sunnhemp / Daincha and incorporation *in situ* before 50% flowering
- *Insitu* incorporation of crop residues
- Application of tank silt

6.5.3.3 Soil fertility improvement

- Sunnhemp, lucerne, cowpea and clitoria incorporation increased yield (Subramanian *et al.* 1995)
- 25 % of N fertilizer can be reduced
- N balances of 92 kg/ha for 1:1 and 48 kg/ha for 2:1 (Rusinamhod zi*et al*. 2006).

- Cover cropping – *Melilotus indica* promising at Sirsa.
- *in situ* GM of green gram (Praharaj *et al.* 2004) and cowpea substitute 25 % of N
- Chilli – *desi* cotton and *Stylosanthes hamata* as cover crop at 1:2 with a cutting interval of 45 days saved the 25-50% of NPK. Organic N addition to the extent of 144 Kg/ha and increased soil organic carbon from 0.58 to 0.73%
- Lucerne at 1:2 row at 30 days cutting frequency.
- increased by 13.62 % and reduced weed intensity
- fertilizer reduction to 25–50%
- Lucerne green manuring with 50 % N recorded higher yield (Kamble, 2003).

6.5.3.4 Foliar spray

- TNAU Panchagavya @ 3% in three times at 45, 60 and 75 DAS
- TNAU consortium – Bio mineralizer
- PPFM 500 @ ml/ha

6.5.3.5 Pest management

- Raising trap crop (castor) and pest repellent crops
- Fish oil resin soap spray 1%
- Spray Azafoetida 500 g + 500 g garlic paste + 500 g Acorus powder in 100 lit of water
- Release of *Chrysoperla* sp, @ 500 / ha on 20 – 25 DAS and again at 35 DAS
- Release of *Trichogramma chilonis* @ 5 cards / ha on 45 DAS
- Spray of H-NPV @ 250 larval equivalent / ha (2 x 10^8 PIBS / larval equivalent) for young bollworms of *Helicoverpa armigera*
- Alternative spray with Bt formulation @ 1.5 liter / ha
- Application of neem-based formulations – neem oil @ 1.0 liter/ha and neem seed kernel extract 1%
- Bird perches @ 4 /ha
- Plant extracts with cow urine (Neem, *Aloe, Vitex, Calotropis, Clerodendron*)
- Deep ploughing the fields during summer season help in killing pests, larval and eggs

- Clean cultivation by destruction of weeds and other alternate hosts
- Adopting crop rotation
- Draining of water out of fields at times of pests growing in number
- Use of resistant varieties
- Growing of trap crops
- Release of parasites and predators
- Use of pheromone traps and light traps
- Use of biological insecticides and mechanical weed control
- Cover cropping to control weed seed germination.

6.5.3.6 Weed management

- Using stale seedbed technique before sowing of crop.
- Mulching with crop residue a polythene cover
- Intercropping with Navadhanya or green manure (daincha / sunhemp or using azolla as dual crop with rice)
- Use of Miniature weeder or power weeder at 25 and 40 DAS and conoweeder / rotary weeder using in rice crop
- Hand weeding at 15 and 30 DAS
- Allelopathic effects of crop extract and weed extract spray also using for weed control

6.5.4 Fodder crops - 1000 m^2 of area would be planted to a mixture of fodder grass Cumbu-Napier Co (CN)5 and Desmanthus. These would be sources of feed for livestock.

Cumbu Napier var. CO (CN) 5

Desmanthus around the field & in between treatments

6.5.5 Dairy unit– 100 m² of area to have livestock. Two numbers of cross bred Holstein Friesian cows (2 milch animals and 2 calves) are being maintained. Fodder obtained from crop component (Maize and Cumbu Napier) is being fed to the animals.

6.5.6 Biogas plant: Biogas plant will be very important input where animal wastes would be converted into organic fertilizer for crops and cooking gas will be used at home and other farm activities.

6.5.7 Compost/Vermicompost: 60 m² of area would be required to establish a shed for composting unit. These will provide organic fertilizer by utilizing farm wastes.The cornerstone of the organic farming system is a vermicompost component that enables autonomous recycling of organic and inorganic matter on the farm, maintaining soil quality without chemical inputs. Crop waste on the farm contributes to feed the livestock (pigs, chickens, goats) whose manure is mixed with small debris and humus that is rich in Indigenous Micro-Organisms (IMO), contributing to biodegradation and nitrogen fixation.

Manure pit

Vermicompost in silpaulin

6.5.8 Pest repellent cafeteria - 60 $m^2$of area would be planted with pest repelling trees and plants which will be used for making herbal pesticides.

6.5.9 Organic fertilizer production – 30 m^2 of area would be allotted for the purpose of making organic fertiliser like biogas slurry etc.,

6.5.10 Area for proper land use – 100 m^2 of area can be used for threshing purpose and on farm manure pit.

6.5.11 Rain water harvesting – 100 m^2 allotted for farm pond to harvest the rain water and the runoff water

6.5.12 Bee hives – 40 m^2 would be used to keep bee hives at the rate of 5/ha improves seed setting in sunflower. Introduction of bee hives in the farming system improves seed setting in sunflower and other crops by enhancing the pollination processs. The harvested honey can be used for consumption or sale.

6.5.13 Agroforestry - 200 m^2 would be allotted for planting multipurpose trees. All areas planted to permanent crops like neem, pungam, malivembu, kumil. These would be sources of feed for livestock. Neem and pungam trees would also be used to supply leaves for extraction of natural insecticide. Millets and other rainfed crops will be grown in between the trees. Same field becomes farm during rainy season and forest during dry season tree leaves used as a green manure and fodder. Pulses, oilseeds etc., can be grown after the rainfed crops are harvested, utilizing the residual moisture of the soil to enhance the income and balance diets and improve the soil quality.

Glyricidia

Daincha

6.5.14 Border plants - Bananas are mainly used as human food, a considerable amount of rejected fruit could be fed to livestock. Coconut would be used by the chicken and rest would be available for sale, to use as additional feed or to use in the production of coconut oil. The latter would produce oil for sale and retain the residues for feed to poultry, pigs or cattle. In general, Surrounding lands instead of setting up of iron fencing fodder trees can be planted as bio fence. Surrounding the land larger growing trees like udhiyan, thespesia, kodukkapuli such wood species could be planted in 4 to 5 m intervals. The small gap between these small trees like Supabul, Glyricidia can be grown. These trees should be pruned at 1.5 m height to generate new lateral branches that can be used as feed for animals. From the bio fence we can get 3 or 4 tonnes of fodder to livestock annually.

Annual Moringa

Glyricidia

Desmanthus

Banana

6.5.15 Kitchen garden–in any part of the field a platform can be made and any creeper vegetables can be grown over it. Below the platform medicinal herbs, mint, coriander, greens and other vegetables can be grown. Moringa and arecant can be used as the poles.

6.6 METHODOLOGY

A long term field experiment was established in 2013 and continuing for the 4 consecutive years in an experimental farm of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India with an objective of developing a suitable integrated organic system model. The experimental field was located at 11° North latitude and 77° East longitude at an altitude of 426.7 MSL. The experiment was conducted in a non-replicated strip plots and treatments included components mentioned below. In mixed farming about 85 per cent of the area was covered under grain crops and rest under other components. The farmyard manure prepared from the dung and wastes was used as manure in the system itself. Crops and animals were raised by applying all recommended package of practices. A multi-disciplinary team of research scientists from agronomy (author), animal sciences, economics and statistics was involved in carrying out these studies.

Components of organic farming system model

Components	Treatments/ Remarks
Crop component	Cropping Systems:1. Bhendi + Leaf coriander - Maize + Cowpea (Fodder) 2. Green manure - Cotton - Sorghum 3. Fodder grass and Desmanthus
Agro forestry	*Azardhiracta indica, Melia dubia, Sesbania grandiflora, Pongamia pinnata, Gmelina arborea, Ailanthus excelsa,* perennial redgram (*Cajanus cajan), Sesbania sesban*
Dairy	Milch animal: 2 cows with one bull calf
Vermicompost unit	The residue of the crops and manure from the dairy unit will be converted into vermicompost and used as manure for crops
Area under supporting activities	Manure pit, threshing floor etc.
Border plants	Moringa,, Coconut, Banana, *Desmanthus.*

6.7 FINDINGS

The results of several studies carried out during 2013 to 2017 indicate that integration of various enterprises tend to be more profitable than arable farming alone, and the detailed result is given below under separate headings.

6.7.1 IOFS effect on soil health

Cropping system 1: Bhendi + Leaf coriander - Maize + Cowpea (Fodder)

BHENDI

Table 6.1: Soil health status after harvest of bhendi under integrated organic farming system model

Soil nutrient status	2013-14	2014-15	2015-16	2016-17
Organic carbon (%)	0.44	0.46	0.47	0.57
N (kg/ha)	252	248	252	238
P (kg/ha)	8.6	8.4	8.6	10.4
K (kg/ha)	473	475	473	488

Table 6.2: Soil health status after harvest of maize under organic farming system model

Soil nutrient status	2013-14	2014-15	2015-16	2016-17
Organic carbon (%)	0.46	0.46	0.48	0.50
N (kg/ ha)	257	259	264	265
P (kg/ha)	11.5	11.6	12.4	11.2
K (kg/ha)	458	461	475	480

Cropping system 2: Green manure- Cotton- Sorghum

Table 6.3: Soil health status after harvest of cotton under organic farming system model

Soil nutrient status	2013-14	2014-15	2015-16	2016-17
Organic carbon (%)	0.44	0.46	0.49	0.60
N (kg/ha)	251	250	258	268
P (kg/ha)	9.4	9.3	10.2	10.2
K (kg/ha)	477	479	482	475

6.7.2 IOFS effect on economics and crop/ system productivity

Economic performance of Green manure-Bhendi-Maize

Year	Maize equivalent yield (kg/ ha)	System productivity (kg/ha/day)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	BCR
2013-14	4344.2	11.90	127,325	224037	96,712	1.76
2014-15	4268.6	11.69	124200	218488	94,288	1.76
2015-16	3596.1	9.85	97,432	180292	82,860	1.85
2016-17	4284	11.7	95,030	192790	97,760	2.03

Economic performance of Green manure-Cotton- Sorghum

Year	Cotton equivalent yield (kg/ ha)	System productivity (kg/ha/day)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	BCR
2013-14	1830	5.01	57552	87684	30132	1.52
2014-15	Poor sorghum crop establishment and hence viciated					
2015-16	Sorghum is in establishment stage					

6.7.3 Weed dynamics

Dry matter production of weeds and crops during 2013-14 and 2014-15

S.No.	Cropping systems	2013-14 Weeds (Kg/ha)	2014-15 Weeds (Kg/ha)
1	Bhendi-Maize +	478	817
	Cowpea (Fodder)	301	361
2.	Green manure-	-	-
	Cotton- Sorghum	545	618

6.7.4 Other Components

6.7.4.1 Dairy unit

Two numbers of cross bred Holstein Friesian cows (2 milch animals and 2 calves) are being maintained. Fodder obtained from crop component (Maize and Cumbu Napier) is being fed to the animals. Concentrated feed as per the prescribed ration to the milch animals and calves is being provided.

Particulars	Milk quantity (lit) 2014-15 Milk yield (litre/ year)	2014-15 Income (Rs/ year)	2015-16 Milk yield (litre/ year)	2015-16 Income (Rs/ year)	Mean Milk yield (litre/ year)	Mean Income (Rs/ year)	Cowdung (kg/year) (Dry) 2014-15	Cowdung (kg/year) (Dry) 2015-16
1.	2004.5	66308	2499.5	99960	2252	83134	2500	2004

Substantial increase in milk yield was observed in 2 years.

6.7.4.2 Vermicompost bed in silpaulin (2015-16)

S.No.	Quantity of cowdung applied (kg)	Quantity of crop residues added (kg)	Quantity of vermicompost obtained (kg)
1.	1887	Cow dung alone	1316
2.	50	560	364

There was 65% conversion efficiency with the crop residues collected from IOFS model farms.

6.7.4.3 Green fodder- Cumbu Napier Co(CN) 5

Fodder grass (Cumbu Napier var. CO (CN) 5) is being cut at regular intervals and fed to the animals. About 250t/ha has been cut from a total of 5 cuttings/year.

Particulars	2014-15 (t/ha)	2015-16 (t/ha)
1st cutting	28.50	23.00
2nd cutting	64.00	(Single harvest was done)
3rd cutting	76.00	
4th cutting	52.00	
Total	**220.50**	

6.7.4.4 Green fodder- Desmanthus

Particulars	2014-15 (t/ha)	2015-16 (t/ha)
1st cutting	12.00	3.00
2nd cutting	8.00	(Single harvest was done)
3rd cutting	17.20	
4th cutting	13.00	
Total	**50.20**	

Desmanthus crop is being maintained along the borders of organic farming system model farm and in between the treatment plots of cropping systems. It is being cut at regular interval to feed the animals. Approximately 45 t/ha has been cut from a total of 4 cuttings.

6.7.4.5 Biomass production- *Glyricidia* (Live fence)

Apart from existing border plants, new cuttings have been planted. Leaves are used for feed and for composting. Approximately 3-3.5 kg/ tree were harvested.

Particulars	No. of trees	Quantity/ tree (kg)	Total quantity (kg)	Usage
1st cutting	58	2.0	87	Used as goat feed
2nd cutting	75	3.0	195	Used as raw material for compost

6.7.4.6 Yield of kitchen garden during 2014-15 and 2015-16

Particulars	2014-15	2015-16
Vegetables in Agroforestry (500 m^2)		
Bitter gourd (kg)	2.92	
Snake gourd (on fence) (kg)	1.30	
Bottle gourd (on fence) (kg)	18.5	
Brinjal (kg)	82.30	
Fenugreek (bundles) (kg)	46 bundles (14 kg)	
Vegetables in field (300 m^2) (February- April 2016)		
Fenugreek (Approx. 300 g/bundle)		193 bundles (58 kg)
Tomato (kg)		40.35
Brinjal (kg)		49.00
Lablab (kg)	-	2.00
Bhendi (kg)	-	12.50

6.7.4.7 Agroforestry

Agroforestry was initiated with various tree species. The details on tree species, date of planting are presented in the table below.

	Common Name	Botanical Name	Date of Planting	Number of trees
1.	Malaivembu	*Melia dubia*	15.12.2014	9
2.	Pungam	*Pongamiapinnata*	16.12.2014	1
3.	Perumaram	*Ailanthus excelsa*	16.12.2014	2
4.	Neem	*Azadirachtaindica*	16.12.2014	1
5.	Kumil	*Gmelinaarborea*	17.12.2014	2

The tree species are fertilized with vermicompost, bio-fertilizers and bio-agents.

6.7.4.8 Border plants - Banana and Annual Moringa

Out of 9 banana plants, a total of 86.6 kg bunch yield was recorded. Annual moringa was planted along the borders in between the banana plants to generate additional revenue. The crop is in flower initiation stage.

6.7.4.9 Pest repellant cafeteria

Pest repellant cafeteria with plants such as castor, kalluruvi, aloe, sarpaganthi, avarai, karpooravalli, adathoda, vilvam and nochi has been planted in between the trees maintained in agroforestry.

6.8 CHALLENGES

A key challenge of such a multi-faceted system is the diversity of the skills required, particularly following natural disasters, where different things need to be fixed. On the other hand, by diversifying their skills, the farmers empowered themselves and improved their self-confidence. Meanwhile, it is important to recognize that the stable access to natural resources, land and water on the farm facilitates its success. A fool proof winning attitude from the family farmers definitely appears to be another critical factor for success. The major obstacles in practicing pure organic agriculture have been identified as limited technological options, large marginal costs and risk in shifting to a new system from the conventional farming, low awareness about the organic farming system, lack of marketing and technical infrastructure and added cost by way of inspection, certification.

6.9 PROSPECTS OF ORGANIC FARMING

Deficiencies of at least five out of the critical soil nutrients are widespread in Asia due to imbalance in application of fertilizers and very limited use of organic manures. Organic techniques alone can help to regenerate the degraded soils and ensure sustainability in crop production.

Soil organic matter is the life source of dynamic soil. The decline in soil organic matter in the recent times in Indian soils often associated with crop yield loss of about 30 per cent and organic manures alone can sustain the productivity of the soil. There is an increase in crop yield by 12 % for every 1% increase in organic matter.

As organic farming is attracting worldwide attention, and there is a potential for export of organic agricultural produce, this opportunity has to be tapped with adequate safeguards so that the interest of small and marginal farmers is not harmed.

Organic farming may be practiced in crops, commodities and regions where the country has comparative advantage. To begin with, the practice of organic farming should be for low volume high value crops like spices, medicinal plants, fruits and vegetables.

Besides the identification of regions suitable for the adoption of organic farming, the crops and their products should also be identified which are amenable for production through organic ways and have the potential to fetch a premium price in the international organic market.

Organic farming should not be confined to the age old practice of using cattle dung, and other inputs of organic/biological origin, but an emphasis needs to be laid on the soil and crop management practices that enhance the population and efficiency of belowground soil biodiversity to improve nutrient availability. Performance of cultural techniques for weed control and that of bio-pesticides for pest management need to be evaluated under field conditions, preferably under cultivators.

Indian agricultural activity results in abundant crop residues. The residue turnover is 273.63 mt and the nutrient potential is 5.67 mt of NPK. Proper residue recycling can serve as effective substitute for inorganic fertilizers. Large potential of organic resources remain untapped in India. Nearly 750 mt cow dung and 250 mt of buffalo manures are available.

Crop rotation including pulses / green manures, which fixes atmospheric nitrogen and leave root nodules in the soil and help in improving residual nitrogen content thereby economizing nitrogen use.

Use of forest leaf litters, in places of availability (For example: Andaman and Nicobar Islands) greatly improves the soil organic matter and in turn soil organic carbon status.

Integration of traditional knowledge with scientific non chemical inputs and methods brings sustainability if farming.

Although, commercial organic agriculture with its rigorous quality assurance system is a new market controlled, consumer-centric agriculture system world over, but it has grown almost 25-30% per year during last 10 years. In spite of recession fears the growth of organic is going unaffected. The movement started with developed world is gradually picking up in developing countries. But demand is still concentrated in developed and most affluent countries. Local demand for organic food is growing. India is poised for faster growth with growing domestic market. Success of organic movement in India depends upon the growth of its own domestic markets.

India has traditionally been a country of organic agriculture, but the growth of modern scientific, input intensive agriculture has pushed it to wall. But with the increasing awareness about the safety and quality of foods, long term sustainability of the system and accumulating evidences of being equally productive, the organic farming has emerged as an alternative system of farming which not only address the quality and sustainability concerns, but also ensures a debt free, profitable livelihood option.

6.10 SOLVABLE PROBLEMS OF ORGANIC FARMING

- It is true that sudden conversion of lands from conventional to organic farming results in decline in yields in irrigated lands. But in the long run, organic farming has resulted in spectacular increase in the productivity of several farmlands. In traditional rainfed agriculture with low external inputs, organic agriculture has shown greater potentials to increase the yield whereas in intensive modern agriculture yield decline is witnessed in the initial years of conversion but with a steady and sustainable increase on continuous organic farming.
- Organic farming had been an integral component of crop cultivation in the past. Application of organic manures is now limited owing to the non-availability of organic manures in sufficient quantities, higher cost, flimsiness in application and transportation expenses.
- The availability of organic manures in adequate amounts and at costs affordable by the farmers is a major problem. The increased mechanization has further reduced the availability of manures with the farmers and this problem will become more acute in future. In such circumstances, postharvest residues should be exploited to partly supplement plant nutrient needs of the organic farming systems.
- Changing cropping patterns with area under legumes is going down, shrinking area under green manures due to economic considerations

and reduced availability of lopping's from forests seriously restrict wide scale use of green manures. Inclusion of legumes in intensive cereal-cereal production systems as short duration grain or forage crops, as substitute to one of the cereals or as break crops needs to be promoted which can cater to the nutrient demands of crops under organic farming system.

- Organic manures are bulky and there is great difficulty in transporting and handling organic manures. However, composting of organic manures can reduce their bulky nature.
- Due to differential availability of nutrients in manures, there is difficulty in standardization.
- In India the relative lack of national rules, regulations and specific standards relating to organic input and organic food production, inadequate certifying agencies, unrecognized 'green' marketing and retailing channels are preventing the farmers to exploit the export advantages of organic production.

6.11 BENEFITS OF INTEGRATED ORGANIC FARMING

- *Productivity:* IOFS provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.
- *Profitability*: Use waste material of one component at the least cost. Thus reduction of cost of production and form the linkage of utilization of waste material and elimination of middleman interference in most inputs used. Working out net profit/ BC ratio is increased.
- *Potentiality or Sustainability*: Organic supplementation through effective utilization of byproducts of linked component is done thus providing an opportunity to sustain the potentiality of production base for much longer periods.
- *Balanced Food*: Components of varied nature are linked to produce different sources of nutrition. Environmental Safety: In IOFS waste materials are effectively recycled by linking appropriate components, thus minimize environment pollution.
- *Recycling*: Effective recycling of waste material (crop residues and livestock wastes) in IOFS. Therefore, there is less reliance to outside inputs – fertilizers, agrochemicals, feeds, energy, etc.
- *Income Rounds the year*: Due to interaction of enterprises with crops, eggs, milk, mushroom, honey, cocoons silkworm, it provides flow of money to the farmer round the year. There is higher net return to land and labour resources of the farming family.

- *Adoption of New Technology*: Resourceful farmers (big farmer) fully utilize technology. IOFS farmers, linkage of dairy/mushroom / sericulture / vegetable. Money flow round the year gives an inducement to the small/ original farmers to go for the adoption of technologies.
- *Saving Energy*: To identify an alternative source to reduce our dependence on fossil energy source within short time. Effective recycling technique the organic wastes available in the system can be utilized to generate biogas. Energy crisis can be postponed to the later period.
- *Meeting Fodder crisis:* Every piece of land area is effectively utilized. Plantation of perennial legume fodder trees on field borders and also fixing the atmospheric nitrogen. These practices will greatly relieve the problem of non – availability of quality fodder to the animal component linked.
- *Solving Fuel and Timber Crisis*: Linking agro- forestry appropriately the production level of fuel and industrial wood can be enhanced without determining effect on crop. This will also greatly reduce deforestation, preserving our natural ecosystem.
- *Employment Generation*: Combing crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problems of under employment to a great extent. IOFS provide enough scope to employ family labour round the year.
- *Agro – industries*: When one of produce linked in IOFS are increased to commercial level there is surplus value adoption leading to development of allied agro – industries.
- *Increasing Input Efficiency*: IOFS provide good scope to use inputs in different component greater efficiency and benefit cost ratio.

6.12 USEFULNESS OF ORGANIC FARMING IN THE CONTEXT OF SYSTEM APPROACH

- Organic manures improves soils physico-chemical and biological properties and produces optimal condition in the soil for high yields and good quality crops
- Reduces cost of purchased inputs
- Farm wastes and residues are effectively recycled thus reducing environmental pollution and can be used to regenerate degraded areas.
- Organic farming allows bio diversity which is vital for ecological balance

- Helps to prevent environmental degradation.
- Increases soil organic carbon
- Enhances soil microbial population
- Carbon sequestration and stock in soil

Organic farming in the cropping system perspective will be a viable avocation to address the sustainability aspects. Effective input management, water and plant protection is possible if organic production techniques are followed on system basis. Restoration of soil fertility under intensive organic farming situations could be possible through the inclusion of legumes/green manures in the cropping system. Under certified organic agriculture, cropping system based production strategies alone will minimize the cost of production and maximize the net profit through optimum resource utilization. Sustainable organic agriculture relies on resource conservation, which is best possible under cropping system mode.Integrated farming systems offer unique opportunities for maintaining and extending biodiversity. The emphasis in such systems is on optimizing resource utilization rather than maximization of individual elements in the system. The wellbeing of poor farmers can be improved by bringing together the experiences and efforts of farmers, scientists, researchers, and students in different countries with similar eco-sociological circumstances i.e. through Integrated Farming System.

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Chapter 7

RELEVANCE OF GOOD AGRICULTURAL PRACTICES (GAPS) IN ORGANIC PRODUCTION SYSTEMS

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7.1 INTRODUCTION

Over the years, the world agricultural scenario has undergone sea change altering significantly its global picture and the transformation of some of the countries, from mere subsistence farming to commercially oriented scientific crop cultivation like India in a short span has very few parallels in the world. Few agriculturally backward countries now grows food and non-food crops in adequate quantity to meet the growing needs of burgeoning population and have emerged as a strong agricultural force which once were viewed as a market for food and other agricultural products by the agriculturally developed western world. This self-reliance of such countries in the field of agriculture and their place in global agriculture had been the result of application of science in agriculture supported by conscious, sustained and meticulous planning and research efforts by the scientists along with untiring efforts of the extension workers in transferring of relevant farm technologies. But now a days the global emphasis on safe and secure food has increased in milieu of food scams and health hazards in developed world. The global emphasis on safe and secure food supplies must be seen against a backdrop of an increasing number of immuno-compromises people (i.e. HIV / AIDS) as well as increased outbreaks of diseases such as cholera and typhoid, particularly in developing countries, which are result of inadequate sanitary measures and contaminated drinking water. With respect to developed countries such as the European Union, the importance of food safety was emphasized by the recent outbreaks of BSE (Mad Cow disease) and Food and Mouth disease as well as traditional concerns with environmental pollution, particularly pesticides and the issues surrounding Genetically Modified Organisms (GMO).

Pesticide consumption in some of the major countries, like USA (7.0 kg/ha), Europe (2.5 kg/ha) Taiwan (17 kg/ha), Japan (12 kg/ha), Korea (6.6 kg/ha), India (0.5 kg/ha) is much higher than permissible limits. Much bigger is the problem of pesticide residue in food products, which mainly percolate from fruit and agriculture crops wherein pesticides are used to kill pests. Giving reasons for more pesticide residue in food products in India *vis-a-vis* other countries, representative of CSE (Centre for Science and Environment) 1998 during her evidence before the Committee stated that other countries were using degradable pesticides. Pesticides used by them are not persistent. However in India due to more use of persistent pesticide, their residues remain in food products. The problem of persistence of pesticide residues in food and agricultural products is due to lack of awareness on the part of farmers with regard to judicious use of pesticides, the other reasons are:

- Indiscriminate use of chemical pesticides
- Non-observance of prescribed waiting periods
- Use of sub-standard pesticides
- Wrong advice and supply of pesticides to the farmers by pesticide dealers
- Continuance of banned pesticides in Public Health Programmes and other uses.
- Effluents from pesticides manufacturing units
- Wrong disposal of left over pesticides and cleaning of plant protection equipment
- Pre-marketing pesticides
- Treatment of fruits and vegetables

Microbial Food Safety Concern and Changing Food Safety Standards has resulted in increased public awareness due to outbreaks, activism and availability of information, advances in scientific knowledge, increased and improved surveillance, value-added opportunities, rapid domestic and import trade and land use and waste management conflicts. Changes in consumption patterns towards increased consumption of "riskier" foods like uncooked produce, salad bars, minimally processed/pre-prepared, imported foods (year round availability) and also the increased popularity of "riskier" produce in the form of green onions, Cilantro (16% positive Salmonella and Shigella) mesculun / spring mix, seed sprouts, unpasteurized juices and melons has been the driving force regarding the food safety and its quality. Potential contamination sources considered include; Irrigation water, manure (intentional and incidental), inadequate field sanitation during production and harvest process, wash water, handling, cross contamination during processing and ice, inadequate sanitation during distribution of the food products.

7.2 THE ORGANIC PRODUCTION VIS A VIS SUSTAINABLE FOOD PRODUCTION

The organic food industry is booming. Demand for organic food is higher than ever, according to the Organic Trade Association's recent report. American's spent a whopping $43.3 billion on organic food in 2015, an 11 per cent increase over last year's record. And yet 5.6 billion pounds of pesticides are used around the world each year (Organic Trade Association's 2016 Organic Industry Survey). Global organic food market is projected to register a CAGR of over 16% during 2015 – 2020. The share of land under organic farming is abysmally low (1.1% of total agricultural land). Out of this 45% of the worlds' organic agricultural land is in Australia (Oceania) and 99% of it is under grazing land. Organic food is made without; synthetic fertilizers and pesticides, genetic engineering, sewage sludge, radiation and preservatives. Organic agriculture is often described as an "alternative" agriculture; an alternative to conventional or industrial agriculture which has emerged over the past 100 years as the dominant agricultural system in most places across the world. Thus, the two methods are often contrasted with one another with organic agricultural operations portrayed as small-scale, mixed crop production and conventional agriculture portrayed as large-scale mono-cropping. In relation to environment, organic agriculture refers to a farming system that enhance soil fertility through maximizing the efficient use of local resources, while foregoing the use of agrochemicals, the use of Genetic Modified Organisms (GMO), as well as that of many synthetic compounds used as food additives. Organic agriculture relies on a number of farming practices based on ecological cycles, and aims at minimizing the environmental impact of the food industry, preserving the long term sustainability of soil and reducing to a minimum the use of non-renewable resources (Gomiero et al, 2011)) .Organic agriculture comprises a set of management practices aimed at environmentally friendly production by avoiding the use of synthetic fertilizers and pesticides and by strong reliance on closed on-farm nutrient cycling, including biological nitrogen fixation and crop rotations, to support soil fertility by enhancing soil organic matter content. Organic agriculture often strives to protect soil fertility which include crop rotation, intercropping, polyculture, cover crops, and mulching (Gomiero et al, 2011,). Further soil can be understood as an ecosystem or food web which is a series of conversions of energy and nutrients that occur as one organism eats another (Ingham, 2000). Another consideration is soil organic matter, which according to Pimentel, *et al*. (1995) facilitates the formation of soil aggregates, increases soil porosity, and thereby improves soil structure, water infiltration, and ultimately overall productivity. In addition, organic matter increases water infiltration, facilitates cation exchange, enhances root growth, and stimulates the proliferation of important soil biota. About 95% of the nitrogen and 25 to 50% of the phosphorus is contained in organic matter. Thirdly, the relationship between soil, food and human health can not be ignored. According to Quayson, *et al.* (1997) what people and animals eat determines to a large extent their health status. What the soil lacks in nutrients, the crops will also lack, as will, ultimately, human beings and animals. A. M. Mayer (1997) suggests that the cumulative effects of ongoing synthetic fertilizer applications to the soil might affect the food grown in it. Some of the studies have demonstrated that the content of certain vitamins, minerals and secondary nutrients (e.g., antioxidants) are higher in certain organically grown produce. There is also evidence that some nutrients are more persistent; that is, some organically grown vegetables retained more of particular nutrients after a period of storage than conventionally grown produce. Evidence suggests that these higher levels of vitamins, minerals and secondary nutrients may be a result of organic soil management through practices such as the application of organic (as opposed to synthetic) fertilizer (Nowatschin, 2013).

After the fascinating discussion on organic agriculture let us try to understand other side of the coin focusing organic agriculture's link with sustainability. What does "sustainable" really mean, and how does it relate to organic methods of food production. An extension professor defines that a sustainable agriculture must be economically viable, socially responsible and ecologically sound. The economic, social and ecological are interrelated, and all are essential to sustainability and the three must be in harmony (John E. Ikerd, 2001). Organic food production appears to be natural, but agriculture is in no way natural. Food produced using agricultural means is not produced in harmony with nature, whether it is grown by organic or conventional methods. According to the Worldwatch Institute, "Organic farming has the potential to contribute to sustainable food security by improving nutrition intake and sustaining livelihoods in rural areas, while simultaneously reducing vulnerability to climate change and enhancing biodiversity." On the other hand Dahan *et al* 2014 concluded that commercial farms that rely on compost as the main fertilizer source, as commonly practiced in organic agriculture, result in substantial down-leaching of nitrate compared with farms that rely on fertigation methods, as commonly practiced in conventional agriculture hence increased groundwater pollution potential in organic agriculture and composting generated significant amount of greenhouse gases.

Organic food can only be produced using manure and other organic nutrient sources , among other requirements. Mineral fertilizers, also called chemical fertilizers, are not allowed, nor are chemical pesticides. Grønlund (2016) says that most agree that sustainable food consumption means that people eat more vegetables, less meat, and waste less food. "If we do this, there will be fewer animals and (consequently) less organic fertilizer. Can a production system be sustainable if it relies on a consumption pattern that is not sustainable?" Organic food is not inherently safer and has the same risk as nonorganic foods for food-borne bacteria contamination. Fresh produce of all varieties are prone to listeria, *E. Coli, salmonella*, and other bacteria. A British meta-analysis published in the Journal of Environmental Management (2012) addressed the question whether organic farming reduces environmental impacts. It identified some of the stresses that were higher in organic, as opposed to conventional, agriculture: "ammonia emissions, nitrogen leaching and nitrous oxide emissions per product unit were higher from organic systems," as were "land use, eutrophication potential and acidification potential per product unit." The low yields of organic agriculture impose various stresses on farmland and especially on water consumption. In a meta-analysis study of 316 studies comprising 34 different crops, it has been observed that the yield reduction may range from 4% to 34% with an average of 25% in organic farming (Seufert *et al* 2012). Lower organic crop yields typically 20%-50% percent lower than conventional agriculture are largely inevitable in organic agriculture, which have the implication for the conversion of more land to farming and on water supplies, both of which are serious environmental issues. Another issue challenging sustainability of organic agriculture pertains to absolute exclusion of "genetically engineered" plants whereas the resistance to some disease/insect pest, higher yield and other desired characteristics are results of one or another technique of genetic engineering.

Regarding health benefits of organic foods, the results of one of the largest study conducted by Dangour *et al* (2010) suggested an association of reported consumption of strictly organic dairy products with a reduced risk of eczema in infants, but the majority of the remaining studies (8 reports of human studies, including 6 clinical trials, 1 cohort study, and 1 cross-sectional study, and 4 reports (of studies in animals or human cell lines or serum) showed no evidence of differences in nutrition-related health outcomes that result from exposure to organic or conventionally produced foodstuffs. Bradberry, et al (2014) studied the impact of organic versus non organic food on incidence of cancer and concluded that there was little or no decrease in the incidence of cancer associated with consumption of organic food except possibly for non-Hodgkin lymphoma, on the basis of 0.6 million women. In a meta-analysis, examining the safety and quality of organic vis- a-vis traditional farm produce, it was observed that there is no proof to support such a claim that organic food is tastier, safe and qualitatively better compared to traditional food (Spangler et al 2012). The Study conducted by All India Network Project for Pesticide Residues with 26 centers in the country shows that concentration of pesticides above MRL (Maximum Residue Limit) has been detected only in 2-3 per cent of samples tested in the last five years. Sreekumar (2017) advocates ensuring food security, safe food and nutritional security and farm income without deteriorating the natural resources like soil, water and biological resources. Scientifically fine-tuned agriculture has long term applications for agricultural sustainability as the basic premise of modern scientific agriculture is to address shortcomings through science and there is scope for continuous improvement.

7.3 GOOD AGRICULTURAL PRACTICES (GAPS) : THE ALTERNATIVE APPROACH FOR SAFE FOOD PRODUCTION

For the farmers who make a living out of agriculture and see it as an enterprise, GAP (Good Agricultural Practices) based farming, Integrated Nutrient Management and Integrated Pest Management (IPM) with more emphasis on biological methods of control, soil test based nutrient application, increasing nutrient use efficiency, adoption of precision farming technologies and use of pest and disease resistant varieties, etc. seems to be a viable solution. It has the potential to address the concerns of different stakeholders (governments, food retailing industries, farmers and consumers) about food production and security, food safety and quality, and the environmental sustainability of agriculture. GAP offers means to help reach those objectives. It leaves scope for the farmers to understand the nature of different chemicals (pesticides, fertilizers) used in farming and also on the safe use and disposal of pesticides.

The pesticides sustain food production and control vector bornediseases, hence, regarded as social need. Thus, the option of safe use of pesticides by recommending good agricultural practices based on supervised field trials; to recommend waiting period/pre-harvest interval so that the residues in the food commodities remain well within the prescribed safe limits; and monitoring of pesticide residues in agricultural produce has to be adopted. Some steps have already been taken to minimise pesticides residues and enforced the provisions of Insecticides Act, 1968. India has already initiated educating farmers about ill effects of pesticides, need-based use of chemical pesticides, use of recommended dosage, correct application techniques, observance of prescribed waiting period, and practices of Integrated Pest Management (IPM) and benefits of organic farming. As a result Pesticides consumption has been substantially reduced in rice and cotton which are main pesticide-consuming crops. The consumption of chemical pesticides reduced from 65,462 MT during 1994-95 to 47, 020 MT during 2001-02 and an increase in use of bio-pesticides from 219 MT during 1996-97 to 902 MT during 2001-02.

Microbial Food Safety Concern and Changing Food Safety Standards has resulted in increased public awareness due to outbreaks, activism and availability of information, advances in scientific knowledge, increased and improved surveillance, value-added opportunities, rapid domestic and import trade and land use and waste management conflicts.

The challenge of globalising markets is nowhere greater than in the primary food sector. GLOBAL GAP (earlier known as EUREPGAP) has established itself as a key reference for Good Agricultural Practices (GAP) in the global market place, by translating consumer requirements into agricultural production in the context of a rapidly changing and globalising food economy and the concerns and commitments of a wide range of stakeholders about food production and security, food safety and quality, the environmental sustainability of agriculture. Besides these it has social impacts as it takes cares about workers health, safety and welfare. GLOBALGAP is a private sector body that sets voluntary standards for the certification of agricultural products around the globe. It is a pre-farm-gate standard, which means that the certificate covers the process of the certified product from farm inputs like feed or seedlings and all the farming activities until the product leaves the farm. It is a business-to business label and is therefore not directly visible to consumers. GLOBALGAP includes annual inspections of the producers and additional unannounced inspections and consists of a set of normative documents. These documents cover the GLOBALGAP General Regulations, the GLOBALGAP Control Points and Compliance Criteria and the GLOBALGAP Checklist. The list of countries adopting GlobalGAP, in exchange of food products is rapidly growing– currently more than 100 on every continent. The EUREP GAP Protocol describes essential elements and develops best practice for global production of fresh agricultural produce which includes horticultural products and all crop bases. It demonstrates to customers a commitment and ability to produce safe and quality food, under an exhaustive system verified by an internationally recognized independent third party. It mainly focuses reducing risks associated with the use of pesticides, taking into account public and occupational health, environmental and safety considerations. EUREPGAP started in 1997 as an initiative by retailers belonging to the Euro-Retailer Produce Working Group (EUREP). British retailers were the driving forces. They reacted to growing concerns of the consumers regarding product safety, environmental and labor standards and decided to harmonize their own often very different standards. The development of common certification standards was also in the interest of producers. EUREP started working on harmonized standards and procedures for the development of Good Agricultural Practices (G.A.P.) in conventional agriculture including highlighting the importance of Integrated Crop Management and a responsible approach to worker welfare. Over the next ten years a growing number of producers and retailers around the globe joined in with the idea as this matched the emerging pattern of globalize trading EUREPGAP began to gain in global significance. The decision was announced in on 7th September 2007 at the 8th global conference in Bangkok. EUREP (Euro Retailer Produce Working Group), represents leading European food retailers and use GAP (Good Agricultural Practice) as a framework for verification. It is designed specifically for businesses in the fresh produce supply chain. It offers a means of incorporating Integrated Crop Management (ICM) and Integrated Pest Management (IPM) practices within the framework of commercial agricultural production. It demonstrates a commitment and ability to produce safe and clean food, under an exhaustive system (HACCP) verified by an internationally recognized independent third party.

7.4 EVOLUTION OF GAP

The concept of GAP has evolved in recent years in the context of a rapidly changing and globalizing food economy and as a result of the concerns and commitments of a wide range of stakeholders about food production and security, food safety and quality, and the environmental sustainability of agriculture. To improve the quality of the agricultural products, monitoring of cultivation, harvesting and processing of the plant material the GAP come into existence. The main aim of GAP is to ensure that the plant material meets the demand of the consumers and the standards of high quality. It describes general principles and provide technical details for cultivation along with quality control measures . The participants of the production process from primary producer to the traders are required to comply with the guidelines voluntarily and to elaborate practical measures in order to realize them. The stakeholders include governments, food processing and retailing industries, farmers, agricultural workers, and consumers, who seek to meet specific objectives of food security, food quality, production efficiency, livelihoods and environmental benefits in both the medium and long term. The term GAP connotes different meanings and implications. For example, GAP is formally recognised terminology used in the international regulatory framework and associated codes of practice to minimize or prevent the contamination of food. Good Agriculture practices (GAP) are Practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products. The unique grower-to-consumer relationship of farmers markets sets it apart from traditional food retailers. The casual observer may not realize that achieving and maintaining this grassroots relationship requires a lot of behind-the scenes management, time, work, and, of course, money. Providing the funding needed to keep a farmers market going week after week, year after year, can be as complex and labor-intensive as running the physical market itself.

7.5 CODIFICATION OF GAP

- Existing food safety standards like HACCP, ISO found to be inadequate
- Started as a voluntary effort by some leading food processors and retailers,
- Campbell Soup, Nestle, Unilever etc. develop their own codes of Good Agricultural Practices
- European retailers develop EUREPGAP requiring documentation in some 15 categories of compliances for fresh horticultural products. It becomes mandatory for imports into Europe
- Many countries and national agencies develop codes for Good Agricultural Practices and certification systems
- FAO sets of an Expert Consultation Group in November, 2003
- APEDA prepares a concept paper and BIS circulates a draft standard for India Gap

7.6 RELEVANCE OF GAP IN INDIA

India's basic strength lies in agriculture. But its vast potential has not been fully exploited. This market potential can be realized by reforming agriculture and making its produce internationally competitive in quality and food safety. To enable farm produce to be internationally competitive, innovative farming practices incorporating the concept of globally accepted Good Agricultural Practices (GAP) within the framework of commercial agricultural production for long term improvement and sustainability is important. Implementation of GAP would promote optimum utilization of resources such as pesticides, fertilizers, water and eco-friendly agriculture. It also takes care in integrating pre & post-harvest handling and other logistics. GAP is important in the areas where appropriated control measures need to be strengthened and farms producing raw materials to ensure sustained supply of produce of their desirable quality.

7.7 OBJECTIVES OF GAP

- Ensuring safety and quality of produce in the food chain
- Capturing new market advantages by modifying supply chain governance
- Improving natural resources use, workers health and working conditions, creating new market
- Opportunities for farmers and exporters in developing countries
- International Competiveness
- Environmental Control
- Farmers' Health
- Sustainable Development

As such the Basic Elements include; clean hand, clean soil, clean water and clean surface. The major concerns in this respect are;

- Prevention of problems before they occur
- Risk Assessment
- Commitment to food safety at all levels
- Mandatory employee education program at the operational level
- Field & equipment sanitation
- Integrated pest and crop management
- Oversight and enforcement
- Communication throughout the production chain
- Verification through independent, third-party audits

GAPs includes Soil, Water, Crop & Fodder Production, Crop Production, Animal Production, Animal Health & Welfare, Harvest and On-farm Processing & Storage, Energy & Waste Management, Human Welfare, Health & Safety, Wildlife & Landscape as the components.

7.7.1 Expected Benefits of adoption of GAP

- Development of basic infrastructure at the field level,
- Build up culture for good agricultural practices by the farmers,
- Uniform approach across farms regardless of their sizes
- Increased awareness among the farmers as well as the consumers about the need for consumption of good quality and safe food,
- Traceability through complete integration of food chain,
- Improvement in the environment as well as soil fertility
- Worker safety and welfare.
- Reputation in the international market as a producer of good quality and safe produce, and removal of Technical Barriers to Trade (TBTs) faced by exporters of agro products.
- Promotes sustainable production
- On-farm management improvement
- Value addition of products
- Integrity of global accreditation system
- Market access for small holders
- Harmonize buyer requirements
- Ensures retailers and consumers confidence through responsible and sustainable production
- Complies to the minimum standard acceptable to leading retail groups
- Incorporates IPM and ICM in commercial agricultural production
- Supports HACCP principles
- Making Food Safe and Sustainable for buyer and his Family
- GLOBALG.A.P. is a business-to-business standard for safe and sustainable food production.

- Consumer demands are what drive our improvement and development efforts. It promotes to know what you want.
- A consumer awareness campaign to inform regarding sustainable agriculture, workers' welfare and safety, animal welfare and the environment.

Beyond the Certificate and the benefits to farms it help in improvement of Traceability system (Traceability is the ability of a system to track the movement of food products and to record information about related attributes from Farm to Fork or to trace the same from Fork to Farm. It facilitates the withdrawal/recall of affected food products from the supply chain in a fast, accurate and efficient manner), Input control, Record keeping, Reduced theft of inputs, Promotes farming as a business, Agronomic practices, Increased export yields, Price premiums and improved negotiation skills. It is designed and marketed for global adoption through modular approach, it permits single "integrated farm assurance" engaging end users and simplifying control systems targeting commodity production systems (oil palm, sugar, cocoa) for future expansion.

7.7.2 Certification options for GAP certification

Applicants can apply for certification under any of the 2 options (individual or group certification). The options are based on the constitution of the legal entity applying for certification. The following options shall be available for certification:

7.7.3 Option 1 Individual Certification

Individual producer applies for certification and gets certification. *The producer is defined as a person (individual) or a business (individual or producer group) who is legally responsible for production of products and who has the legal responsibility for the products sold by that farming business.*

7.7.4 Multisite without implementation of QMS (Quality Management Systems)

Individual producer or one organization owns several production locations or Production Management Units (PMU's) that do not function as separate legal entities applies and gets certification without implementation of Quality Management Systems (QMS)

7.7.5 Multisite with implementation of QMS

Individual producer or one organization owns several production locations or Production Management Units (PMU's) that do not function as separate legal entities applies and gets certification with implementation of Quality Management Systems (QMS) (*Details of certification process for QMS implementation is given in IGAP -03)*

7.7.6 Option 2 Group certification

A producer/farmer group applies for group certification and the farmer group, as legal entity gets certification. (*Details of group certification is given in Group Certification process (IGAP 03).* The Scheme is open to all farmers/producers or organizations engaged in IndGAP implementation who are legal entities in India. The information on how to obtain certification for Good Agricultural Produce is also available on the website of QCI (www.qcin.org). The certification shall be carried out by the Certification Bodies (CBs) duly accredited for the certification scheme as per ISO/IEC Guide 65/ISO IEC 17065 by NABCB OR approved by QCI. To operate under the Scheme, the CBs will require an extension of scope within the accreditation for ISO/IEC Guide 65/ISO IEC 17065.

7.7.7 Compliance levels for certification

The producer is required to comply with three types of compliance criteria set out in the GAP standard. These are Critical, Major and minor, which must be fulfilled in all respects before certification. Compliance is indicated with a “Yes” (for compliant), “No” (for not compliant) on the checklist. Evidence/comments should be provided for each control criteria- these shall enable the audit trail to be reviewed after the event, and will include details of references taken during the evaluation. It is, however, obligatory to give evidence /comments for all the critical and major compliance criteria inspected in all external evaluation, self-assessments, and internal evaluation.

The level of compliance shall be established based on the following:

a) Critical- 100% compliance of all applicable critical control points

b) Major- 90% compliance of all applicable (missing)major control points is compulsory

c) Minor-75% of compliance of all applicable minor control points is compulsory.

Certification Body shall maintain records of all certification activities- application registration, documents provided by applicant, on site evaluation report and evaluation and review of reports for grant of certification.

7.7.8 Fee

A fee shall be charged to the client for various activities of the scheme, without any discrimination between units, geographical location, size of the unit. The CB's fee structure shall be publicly accessible and also be provided on request. CB shall notify and obtain consent to its fee structure from the clients prior to grant of certification. As and when the fee undergoes a change, the same shall be communicated to all applicants and clients certified under this scheme of certification for their acceptance.

7.7.9 Growing and targeting commodities

BIS IndiaGAP certification shall be as prescribed under the provisions of Bureau of Indian Standards Act, 1986 and Rules and Regulations framed there under. The details of the conditions under which the license may be granted to producer (individual producer and/or member of a producer group) may be obtained from the Bureau of Indian Standards.

7.8 CONTROL POINTS & EVALUATION CRITERIA

7.8.1 Crops

Site Record , Land, Grower Record, Seeds & Plants,Nursery, Cultural Practices, Transplantation, Manures & Manuring, Irrigation, Drainage System, Crop Protection, Crop Manuring, Harvesting, Post Harvesting Handling, Packaging, Loading & Transport

General (working conditions etc.), Environmental Issues, Complaint Procedures

7.8.2 Dairy & Animal Husbandry

Legal Registration

Feed

Housing & Facilities

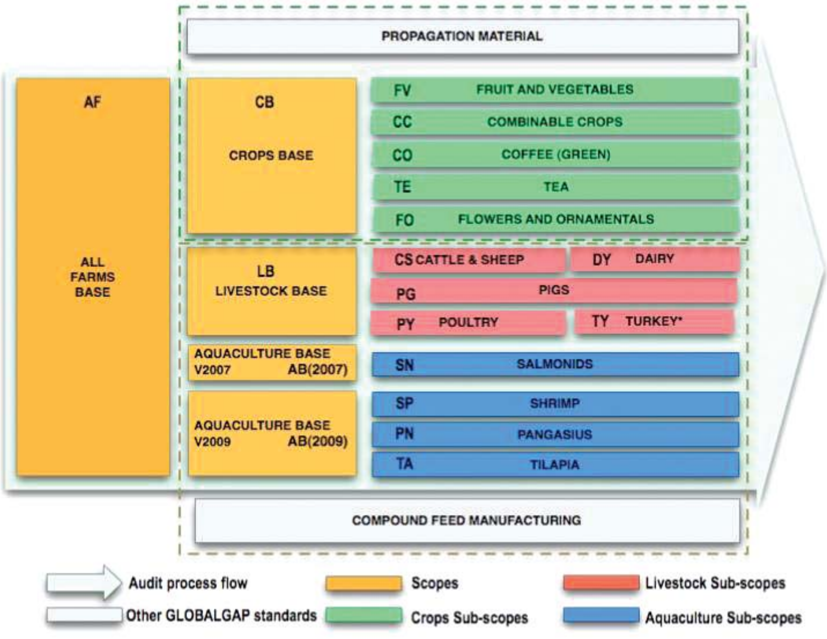
Dairy Health

Milking

Milking Facilities

Hygiene

Cleaning Agent & other chemicals



7.8.3 Fruits and vegetables module

Propagation material

Soil & substrate management

Irrigation/fertilization

Harvesting

Post-harvest handling

The detail of compliance criterion and control points can be downloaded from the website of QCI (www.qcin.org)

7.9 EXTENSION CONCERN OF GAP

- Methodologies for impact monitoring with particular respect to environmental impacts of agriculture.
- Social and environmental certification and labelling in crop and livestock production, fisheries and forestry; analysis of transaction costs for compliance with food safety and quality standards and production; value-chain analysis; how to reduce costs and the institutional innovations to reduce them.

- Training of trainers and institutional capacity building to ensure safety and quality of agricultural produce in particular for fresh foods and vegetables, coffee and other commodities; development of adequate laboratory facilities for product quality, lab quality assurance and control procedures; efficiency of sampling processing, etc.
- Methodologies and approaches to support farmers experiential learning to improve their technical and managerial capacities, in particular by supporting Farmers Field Schools, participatory technology development and Knowledge Attitudes and Practices approaches.
- Capacity to provide comparative experiences through knowledge management systems and support.
- Conflict management approaches and facilitation of multi stakeholder negotiations; building alliances with private sector and NGOs.

The acceptance of OA in developed countries is increasing slowly. Organic agriculture (OA) currently occupies 0.3% of agricultural land, mostly in developed countries. The increased area under Organic will increase competition for limited organic nutrients and in turn will reduce the beneficial impact of OA on the low-input component of agriculture and increased disadvantage of OA in developed countries. Gap offers potential to minimize the use of chemical pesticides by applying IPM practices such that pesticides are only used as a last resort, at the minimum rate and toxicity for an effective control of the pest. Where possible, substitute chemical pesticides with bio-pesticides or employ natural and physical methods to control pests and diseases. There is much emphasis to improve fertilizer formulations and use site-specific application methods, timing and amounts to optimise fertilizer use for production and environment. We need to clearly communicate to farmers that fertilizers are not poisons when used at the recommended rate or concentration. Lower cost of cultivation in organic farming is not factual, if major and secondary nutrients are to be provided by organic means alone, it will be costlier than traditional farming. Extension personnel need to be logical in their approach according to science. Extension system need to work to enhance the ability of farmers to understand the nature of different chemicals (pesticides, fertilizers) used in farming and also on the safe use and disposal of pesticides. The adoption of GAP in farming offers opportunities for safe and sustainable food production.

Good Agricultural Practices Focus on Prevention and Redundant Reductions "Guide to Minimize Microbial Food Safety Hazards for Fresh

Fruits and Vegetables" Not a regulation - guidelines only Potential to become a "de facto" standard

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Chapter 8

PHYSIOLOGICAL PARAMETERS FOR MEASURING PERFORMANCE OF CROPS UNDER ORGANIC PRODUCTION SYSTEM

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8.1 INTRODUCTION

Organic farming is one of the fastest growing sectors of agriculture worldwide. Its main objective is to create a balance between the interconnected systems of soil organisms, plants, animals and humans through the effective use of resources on the farm and natural resources.

System to regulate the nutrition regime with organic farming is based on balanced crop rotations, application of compost, green manure and organic fertilizers. In crop rotations with legumes, by submission of organic fertilizers and other plant residues in soil maintained the nutrition regime, which ensures obtaining high yields.

Organic-N fertilizer is the one of the few organic fertilizers that are used by the plant and directly participate in the construction of the plant protein, and thus realize significant energy savings for the plant itself. Therefore, plants treated with organic grow more intense look in a bush form, in green and fruit have greater weight on larger, more delicious and more brightly colored. Organic affect the microbial environment of the soil, wake up all the necessary biological functions of the plant to ensure not only good growth, but also a cleaner environment from pathogenic influences. Manure is permitted for use in organic production.

Applied organic fertilizer accelerates the vegetative growth of plants. Organic has strongly pronounced positive effect on the content of photosynthetic pigments. 30 days after the application of organic fertilizer the content of chlorophyll "a" was significantly higher compared with the control. With respect to chlorophyll “b” the same tendency was observed. The differences in the chlorophyll content between the plants treated with organic and the control plants may be due to the increased photosynthesis of the latter, on the one part, and to the stabilizing effect of the fertilizer upon the chlorophyll-protein complex, on the other part. Treatment with organic also increases the carotenoids content. It is observed that the separate pigments and photosynthetic pigments were affected equally by application of organic fertilizer.

Various researches’ indicates that organic fertilizer improves the leaf gas exchange. In the plants treated with organic fertilizer the photosynthesis rate was significantly higher compared with the control plants in both cultivars. The transpiration intensity follows the same tendency. The data about the increased photosynthesis rate correspond to those about the photosynthetic pigment content. This shows that along with the stomatal conductance, the increased pigment content is one of the reasons for the higher photosynthetic rate in plants treated with organic fertilizer.

8.2 GROWTH PARAMETERS

8.2.1 Plant Height

Plant height (cm) from basal node of the plant to the end of the shoot tip was recorded at regular time intervals till harvest.

8.2.2 Number of branches

The number of branches per plant was counted at regular time intervals till harvest and mean values of observed plants were expressed as number plant^{-1}.

8.2.3 Number of internodes plant^{-1}

The numbers of fully developed internodes plant^{-1} were recorded of the 5 tagged plants in each plot at 15 days interval till harvest.

8.2.4 No. of leaves plant^{-1}

The numbers of fully developed (opened) leaves plant^{-1} were recorded on the tagged plants in each plot at regular time intervals till harvest.

8.2.5 Shoot base diameter

The circumference of the shoot base (cm) a little below the first node was measured at regular time intervals with the help of a thread and diameter was calculated by formula

$(C = \pi r)$

Where, C = circumference, r = radius, p = 22/7

8.3 PHYSIOLOGICAL PARAMETERS

8.3.1 Leaf area / plant (dm^2 $plant^{-1}$)

This was calculated by multiplying the leaf area of upper 2^{nd} leaf with total leaf number $plant^{-1}$. Leaf area was determined by using leaf disc method at regular time intervals till harvest. Twenty leaf discs having a known diameter were collected randomly from top 4-6 fully expanded leaves of the plant. As far as possible, the mid rib was avoided. The samples (disc and remaining leaves) were dried separately in hot air oven at 80°C for 72 hours. The dry weight of leaf discs and rest of the leaves was recorded and the leaf area was calculated by using the following formula given by Vivekanandan *et al.* (1972).

$$\text{Leaf area} = \frac{a \text{ x } w}{b} X \frac{1}{100}$$

Where, a = Leaf area (cm^2) of 20 circular discs

b = Dry weight (g) of 20 circular discs

w = Dry weight (g) of rest of the leaves

8.3.2 Leaf Area Index (LAI)

It is expressed the ratio of leaf area of a plant to the land area occupied by the plant. The leaf area index was worked out as per the formula suggested by Sestak *et al.*, 1971. LAI has no unit.

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area } (dm^2)}{\text{Land area occupied by plant } (dm^2)}$$

8.3.3 Total Dry Matter production and its partitioning

Three plants were separated into leaf, stem and reproductive parts and dried in an oven at 80°C until a constant weight was obtained. Total dry matter was calculated by adding the dry weights of different plant parts and expressed as grams per plant at regular time intervals till harvest.

8.3.4 Absolute Growth Rate (AGR)

It is the dry matter production per unit time (g day^{-1}) and was calculated by using the formula of Radford (1967).

$$AGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Where, W_1 = Dry weight of the plant at time T_1

W_2 = Dry weight of the plant at time T_2

8.3.5 Crop Growth Rate (CGR, g m^{-2} day^{-1})

Crop growth rate is the rate of dry matter production per unit ground area per unit time (Watson, 1952). It was calculated by using the following formula and expressed as g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{A}$$

Where, W_1 = Dry weight of the plant (g) at time T_1

W_2 = Dry weight of the plant (g) at time T_2

$T_2 - T_1$ = Time interval in days

A = Land area (m^2)

8.3.6 Relative Growth Rate (RGR, g g^{-1} day^{-1})

It is the rate of increase in the dry weight per unit dry weight already present and is expressed as g g^{-1} day^{-1} (Blackman, 1919). Relative growth rate at various stages was calculated as follows:

$$RGR = \frac{Log_e W_2 - Log_e W_1}{T_2 - T_1}$$

Where, W_1 = Dry weight of plant (g) at time T_1

W_2 = Dry weight of plant (g) at time T_2

$T_2 - T_1$ = Time interval in days

8.3.7 Net Assimilation Rate (NAR, mg m^{-2} day^{-1})

Net assimilation rate is the rate of dry weight increase per unit leaf area per unit time. It was calculated by following the formula of Gregory (1926) and expressed as mg m^{-2} day^{-1}.

$$NAR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{Log_e L_2 - Log_e L_1}{L_2 - L_1}$$

Where, L_1 and L_2 are total leaf area at times T_1 and T_2 respectively.

W_1 and W_2 are total dry weights during the same period.

8.3.8 Leaf Area Duration (LAD - days)

Leaf area duration is the integral of leaf area index over a growth period (Watson, 1952). LAD for different growth periods was worked out as per the formula of Power *et al.*, 1967 and expressed in days.

$$LAD = \frac{L_i + L_{(i+1)}}{2} \times (T_2 - T_1)$$

Where, L_i = LAI at i^{th} stage

$L_{(i+1)}$ = LAI at $(i+1)^{th}$ stage

$T_2 - T_1$ = Time interval between i^{th} stage and $(i+1)^{th}$ stage (days)

8.3.9 Biomass duration (BMD, g day)

Biomass duration (BMD) was calculated by using the following formula and expressed in g day (Sestak *et al.*, 1971).

$$BDM = \frac{TDM_i + TDM_{(i+1)}}{2} \times (T_2 - T_1)$$

Where, $TDM_{(i)}$ = Total dry matter at i^{th} stage

$TDM_{(i+1)}$ = Total dry matter $(i+1)^{th}$ stage

$T_2 - T_1$ = Time interval (days) between i^{th} stage and $(i+1)^{th}$ stage.

8.3.10 Specific leaf weight (SLW - g cm^{-2})

The specific leaf weight indicates the leaf thickness and was determined by the method of Radford (1967) and it was expressed as g cm^{-2}.

$$SLW = \frac{Leaf\ dry\ weight}{Leaf\ area}$$

8.3.11 Specific leaf area (SLA - cm^2 g^{-1})

The specific leaf area was worked out by using the following formula determined by the method of Radford (1967) and expressed as cm^2 g^{-1} leaf weight.

$$SLA = \frac{Leaf\ area}{Leaf\ dry\ weight}$$

8.3.12 Relative Water Content (RWC)

RWC (%) was calculated using formula suggested by Kramer (1969). Data was recorded when control plants showed almost 70% RWC.

$$RWC\ (\%) = \frac{W\ -\ DW}{TW - DW} \times 100$$

Where, W – Sample fresh weight

TW – Sample turgid weight

DW – Sample dry weight.

The weight of whole upper second leaf was taken as fresh weight. Then the leaf was dipped in water for about 10-15 minutes. All the water was drained out. Water drops were wiped off from the leaf surfaces. The weight of this turgid leaf was taken. It was then dried in the room for about one week and the dry weight was taken.

8.3.13 Stomatal resistance

Carbon dioxide Diffusion rate was recorded using Porometer at 30 days interval till harvest. Readings were taken on the day time when there is no shade. The sensor head was connected to instrument and null adjustment was made.

8.3.14 Chlorophyll content

Chlorophyll content of plant is taken at peak flowering stage or at regular time intervals till harvest. Leaf sample from different treatments and replicates were taken. 0.5 g of leaf sample each was taken and ground to fine pulp by adding 5 ml of 80% acetone in mortar and then centrifuged at 5000 rpm for 5 min, the supernatant was transferred to 50 ml volumetric flask. It was repeated till all the residues were colourless. The mortar and pestle were washed thoroughly with 80% acetone and collected the clear wash in flask. The volume was made up with 80% acetone (Arnon, 1949).

$$\text{Chlorophyll 'a'} = 12.7\ (A663) - 2.69\ (A645)\ X\ \frac{V}{1000\ X\ W\ X\ a}$$

$$\text{Chlorophyll 'b'} = 22.9\ (A645) - 4.68\ (A663)\ X\ \frac{V}{1000\ X\ W\ X\ a}$$

$$\text{Total Chlorophyll} = 20.2\ (A645) + 8.02\ (A663)\ X\ \frac{V}{1000\ X\ W\ X\ a}$$

Where, A = Absorbance at specific wave lengths (645, 652 and 663 nm)

V = Final volume of the chlorophyll extract (ml)

W = Fresh weight of the sample (g)

a = Path length of light (1 cm)

8.3.15 Chlorophyll index (SPAD meter reading)

The chlorophyll intensity meter (SPAD-520, Minolta, Japan) is a high weight portable diagnostic meter (Plate 4b) which allows one to quickly read the total chlorophyll concentration of a leaf with no damage. Data collection involved placing of second leaf from top below the apex on the main axis of the plant. The procedure takes only seconds to perform. With the help of this SPAD – 520 the chlorophyll intensity of the upper second successive leaf of each treated plant was observed. A comparison of the readings obtained by chlorophyll meter (70 DAS) was done with values obtained by chemical and spectrophotometric method.

8.3.16 Nitrate Reductase Activity (NRA)

The nitrate reductase activity (NRA) *in vivo* was estimated at 30, 60 and 90 DAS following by the method of Saradhambal *et al*. (1978). Leaves were cut into small round discs, weighed and suspended in 0.1 M KNO_3 under bright light for 1 hour for complete stomatal opening. The discs were transferred to 25 ml volumetric flasks containing 5 ml of stock solution having 0.1 M phosphate buffer (pH 7.5), 0.02 M KNO_3, propanol (5%) and 2 drop of chloremphenicol (0.5 mg/ml). The flasks were incubated at 30°C for 30 minutes in dark and the reaction was stopped by adding 0.1 ml of zinc acetate (1.0 M) and 1.9 ml of ethanol (70%). The contents were centrifuged at 3000 rpm for 10 minutes and the supernatant was collected. To the supernatant, 1.0 ml of sulphanilamide (1%) and 1 ml of NNEDA (N-Naphthyl ethylene diamine dihydrochloride 0.02%) were added and incubated at room temperature for 20 minutes. The activity of nitrate reductase was determined from a standard curve of KNO_2 and expressed as n moles NO_2 formed per gram fresh weight per hour.

8.3.17 Photosynthetic rate

Photosynthesis rate was measured by IRGA instrument at 60 DAS. The rate of photosynthesis is expressed in μ mol CO_2 m^{-2} s^{-1}.

8.4 QUALITY PARAMETERS

8.4.1 Starch content (%)

The starch content (%) in roots was estimated by Anthrone reagent method (Sadasivam and Manickam, 1991).

The starch gets hydrolyzed to simple sugars in the presence of perchloric acid. After hydrolysis, free sugars can be estimated by phenol or anthrone method. The concentration of sugars obtained is multiplied with a factor of 0.9 to calculate the concentration of starch.

8.4.1.1 Reagents

1. 52 % Perchloric acid – Dissolve 52 g of perchloric acid to make the volume to 100 ml.
2. 5 % distilled Phenol – Dissolve 5 g of distilled phenol to make the volume to 100 ml.
3. Concentrated H_2SO_4
4. Standard glucose solution (100 μg/ml) – Dissolve 100 mg glucose in distilled water and make the volume to 100 ml. This will serve as stock standard solution. From the stock take 10 ml and make the volume to 100 ml distilled water to get working solution of 100 μg/ml.

Homogenize 0.1 to 0.5 g of the sample in hot 80 per cent ethanol to remove sugars. Centrifuge and retain the residue. Wash the residue repeatedly with hot 80 per cent ethanol till the washings do not give colour with anthrone reagent. Dry the residue well over a water bath. To the residue add 5.0 ml of water and 6.5 ml of 52 per cent perchloric acid. Extract at 0°C for 20 min. Centrifuge and save the supernatant. Repeat the extraction using fresh perchloric acid. Centrifuge and pool the supernatants and make up to 100 ml. Pipette out 0.1 or 0.2 ml of the supernatant and make up the volume to 1 ml with water. Prepare the standards by taking 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard and make up the volume to 1 ml in each tube with water. Add 4 ml of anthrone reagent to each tube. Heat for eight minutes in a boiling water bath. Cool rapidly and read the intensity of green to dark green colour at 630 nm. Find out the glucose content in the sample using the standard graph. This value is multiplied by a factor 0.9 to get the starch content.

8.4.2 Moisture content (%)

The moisture content of the sample is calculated using the following equation:

$$Moisture\ content = \frac{A - B}{B}\ X\ 100$$

Where: A = Weight of wet sample (g), and

B = Weight of dry sample (g)

8.4.3 Fibre content

It was estimated at the 90 DAS. 5 g of dry pod with ether or petroleum ether to remove fat (Initial boiling temperature 35-38°C and final temperature 52°C). After extraction with ether boil 5 g of dried material with 200 mL of sulphuric acid for 30min with bumping chips. Filter through muslin and wash with boiling water until washing are no longer acidic. Boil with 200 mL of sodium hydroxide solution for 30 min. Filter through muslin cloth again and wash with 25 mL of boiling 1.25% H_2SO_4, 50 mL portions of water and 25 mL alcohol. Remove the residue and transfer to ashing dish (pre-weighed dish W_1). Dry the residue for 2h at 130 ±2°C. Cool the dish in a desiccator and weigh (W_2). Ignite for 30min at 600 ±15°C. Cool in a desiccator and reweigh (W_3) (Maynard, 1970).

$$\%\ crude\ fiber\ in\ sample = \frac{Loss\ in\ weight\ on\ ignition\ (W2 - W1) - (W3 - W1)}{Weight\ of\ the\ sample} \times 100$$

Where, W_1 – Pre-weight dish (g)

W_2 – Dry weight before ignition (g)

W_3 – Dry weight after ignition (g)

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Chapter 9

ORGANIC PRODUCTION OF CYMBIDIUM ORCHIDS

D.R. Singh and L.C. De

9.1 INTRODUCTION

Cymbidium consists of 70 semi-terrestrial and epiphytic orchids of tropical and subtropical Asia. The plants are characterized by short and stout pseudobulbs ensheathed by encircling leaf bases. Leaves are long, ribbon shaped, leathery or soft and lanceolate. The flower spikes develop from the base of the pseudobulbs. The spikes are erect, arching or pendulous and arranged with 2 to 15 flowers. The individual florets are 1 cm to 12.5 cm across and are of various shades of colour. Cymbidiums are famous for its beautiful spikes derived from species and hybrids. Among the orchids, Cymbidium ranks first and in floricultural crops it accounts for 2.7% of the total cut flower production. Cymbidium hybrids are classified into three groups-Standard, Intermediate and Miniature hybrids. Standard and Intermediate hybrids produce 90 to 120 cm long spikes with 8 to 15 flowers per spike. Miniature hybrids produce green, yellow or brown coloured flowers, 30 cm tall and each spike contains 30-40 flowers of 2.5 to 8.5 cm across. Novelty or Intermediate hybrids have been evolved by crosses between Miniature and Standard hybrids.

9.2 IMPORTANCE AND USES

Cymbidiums are highly valued for genetic resources, cut flowers, hanging baskets, potted plants and herbal medicines.

9.2.1 Genetic resources for hybridization

Cymbidium iridioides, C. eburneum, C. hookerianum, C. sanderae, C. lowianum, C. tracyanum, C. insigne, C. erythrostylum, Cymbidium ensifolium, C. devonianum, C. tigrinum, Cymbidium atropurpureum, C. finalaysonianum

9.2.2 Cut flowers

Both standard and novelty hybrids are used as cut flowers.

9.2.3 Standard types

Valley Legend Staff, Soul Hunt 6, Forest King, September Sunset, Mini Moon Tiger, Golden Girl, H.C. Aurora, Levis Duke, Margaret Thatcher Perfection, Baltic Glacier Mint Ice, Break Out Flame, Black Flame, Valley Zenith Concord, Magic Kiwi Winner, Magic Kiwi Double Delight, Pure Jungle Crown.

9.2.4 Intermediate types

Ammes bury, Show Girl Cooks Bridge, Platinum Bird, Jungfrau Snow Queen, Golden Elf, PCMV, Velvet Green, Red Imperial Red Tower, Luna Pink Champion.

9.2.5 Potted types

Ice Cascade, Mini Sara Jean.

9.3 GROWING REQUIREMENTS

In India, its cultivation is limited to Sikkim and the surrounding region of West Bengal covering Kalimpong, Darjeeling and Mirik. Other North Eastern states like Nagaland and Arunachal Pradesh are also promoting this flower. Higher elevations of 1500-2000 m with cool summer night and monsoonal summer rain are ideal for cymbidium cultivation.

9.3.1 Light

A full morning sun or bright dappled afternoon shade during summer and full sun in winter is ideal. Mature plants need 50-55% shade during hot weather. During growing season they require upto 5000-6000 f.c. light whereas in flowering season upto 2000-3000 f.c. light. Foliages should be yellowish green in colour.

9.3.2 Temperature

In general, cymbidiums can tolerate as low as temperature of 7°C. In vegetative stage, plantlets grow best at temperature of 18°C at night and 24-30°C during the day. A temperature of 10-15°C is required for initiation of flower spikes. During the winter season (Late October to late February) a temperature of 7-12°C at night and 18-24°C during the day is maintained. Miniature hybrids can withstand 5°C higher temperature than standard cymbidiums.

9.3.4 Relative humidity

An optimum range of relative humidity is 50-80% and important for good growth and flowering. During hot weather, misting down the plants and the surrounding floors and benches maintain humidity. Humidity prevents from crinkling of leaves.

9.3.5 Air circulation

Fresh air and good circulation are essential for orchid production. Leaves should move gently in a light breeze.

9.3.6 Propagation

Cymibidiums are propagated sexually through seeds and asexually through division or backbulbs. Division means splitting the plants into two to three parts each with one new shoot and each will produce an individual plant. Propagation through back bulb is a slow process which will take three to four years to give a flowering size plant.

Tissue culture is the only way to produce millions of disease free and true to the type plants in shortest time. In this method, callus (amorphous masses of cells), meristems and organs (root, leaf, flower, embryo, ovary, fruit, seeds etc) are isolated and cultured aseptically in laboratory supplied with defined media containing sugars, inorganic salts, vitamins and growth regulators.

9.4 GROWING STRUCTURES

Greenhouse with all sides open is suitable for Cymbidium cultivation. In mid hills, simple bamboo/wooden structure with UV stabilized polyethylene on the top is generally used with success. However, structure with steel pipe and top covered with double layered polycarbonate and encircled with 50 mesh and iron net is suitable for Cymbidium cultivation. Greenhouse fabricated with galvanized steel pipe and covered with polyethylene is most often used for Cymbidium cultivation. Cymbidium can be grown in cost effective cooled green house with automation system of temperature, light, humidity and aeration. In India, the direction of house should be North-South to trap the maximum sunlight. The central height of greenhouse should be 5-6 m and side height atleast 4m in mid hill conditions.

9.4.1 Benches

The ideal bench should be made of galvanized iron pipe of 50 meshes with a maximum 75 cm in height and maximum 90 cm in breadth to hold the weight of sufficient number of pots. The benches can be made up of concrete or split bamboo also.

9.4.2 Pot

The most commonly used are earthen or plastic pots to hold the media. The pots must have sufficient number of holes for aeration to root zone and draining out excess water. One year old plants should be planted in 4 inches pot. Thereafter, it needs to be transferred in 6 inches pot. Smaller plants of less than 15cm should be planted in the community pots to check the mortality. The full grown bearing plants are planted in 10 to 12 inches pot.

9.5 GROWING MEDIA

A healthy growth growing media should contain leaf mould, coconut husk, tree barks or dry leaf ferns and brick pieces (1:1:1:1). The pH of the potting media should be 5-.5 to 6.5. The electrical conductivity (EC) of around 1.05 mhos/cm is good for growth.

9.5.1 Potting & Re-potting

The potting should be done during active growth phase i.e. during April to June after flowering. Crocks or brick chips should be placed at the bottom of the pot. The plant then placed centrally and sterilized media need to be placed all around the plant. Cymbidiums usually need to be repotted about every three years under normal conditions. March to June is the actual period for repotting of pot bound Cymbidiums in Indian conditions. Generally, it is best to divide the overgrown plants by breaking the rhizomes between the pseudobulbs. While dividing or repotting, a division should have one backbulb, one old bulb and one young bulb.

9.5.2 Spacing

About 30 plants can be accommodated in one to one and half year old plants in a square meter year. The spacing will be wider as a plant grows and 6 to 9 adult plants of 4-5 years age in 6 inches pot can be accommodated. However, fully grown plants require more space foe aeration and 3-4 plants can be spaced in a square meter area.

9.5.3 Organic nutrient management

Cymbidiums are heavy feeders for their robust growth of bulbs and leaves. Application of organic manure increases the water holding capacity, aeration of growing media , allows root development and modify media temperature. During potting of Cymbidium seedlings in 10-12 cm pot, application of dried poultry manure @10g/pot as basal dose and weekly drenching of vermiculture wash (1:20) will help in growth and flowering Cymbidium. Organic manure comprised of mustard oil cake, dried fish and bone meal (8 kg: 0.5 kg: 4 kg) is also beneficial for Cymbidium. It contains 3.5% nitrogen, 2.1% phosphorus, 2.7% potassium, 4.5% calcium and 1.6% Mg. The mixture is prepared by decomposing for 21 days in water followed by sun drying. 5 g of this organic mixture at 6 monthly interval and weekly spraying of vermiwash is beneficial for 2-3 years old Cymbidium.

9.5.4 Watering

In cymbidium, watering is required all the year round to keep the pseudobulbs green and smooth. The frequency of watering is given below.

Summer: 2-3 times per week

Autumn: Once or twice per week

Winter: Once per week

Spring: As Autumn season

9.6 HARVEST

The orchid flowers should be harvested at proper stage for getting quality flowers and maximum vase life. Morning is the best time for harvesting. Flowers are cut sharply with a knife or secateur and dipped immediately in a bucket of water. In most of the commercial orchids, the optimum harvesting stage is fully opened and mature flowers. A matured healthy plant in 10" pot under good management will produce about 4 – 6 flowers per year. A healthy well grown orchid will produce flowers spikes every year and a plant 10 years old can produce from 10 to 20 flower spikes.

9.6.1 Economics of cultivation

A Cymbidium grower can earn Rs. 20-25 lakhs in 10 years from an area of 500 m^2 accommodating 1500 plants after investing 10 lakhs and saling of 55000-60,000 cut spikes.

9.7 INSECT PESTS AND DISEASES

9.7.1 Insect pests

Mites, thrips, scale insects, aphids, mealy bugs, grass hoppers and shoot borers are common insect pests of Cymbidium. The all active stages (nymph and adult) of mite feed on undersurface of leaves and flowers by sucking the cell sap from epidermal layer, especially along with midrib and the base. The loss of cell sap causes yellowing of leaves. Sulphur, 3% wettable or colloidal, satisfactorily control the nymph and adults.

There are five predominant species of scale insects *viz.*, ti scale, *Pinnaspis buxi,* florida red scale, *Chrysomphalus aonidum;* lecanium scale, *Lecanium* sp; soft brown scale, *Coccus hesperidum* and boisduval scale, *Diaspis boisduvali* which cause damage on orchids round the year. Both the stages of scale insects suck the cell sap from leaves, pseudobulbs, flower buds and flowers cause yellowing of leaves, vigor loss and stunted new growth. In case of heavy infestation, infected plants become deformed, sticky honeydew excreted which attracts sooty mould on which dust particles deposited as resulted that photosynthesis rate affected. chemicals like imidacloprid 17.8 SL @ 0.003%, acephate 75 SP or carbaryl 50WP or monocrotophos 36 EC @ 0.03-0.05% can be used against aphids, scale insects and mealybug.

Two species of aphids like yellow aphid, *Macrosiphum luteus* and black aphid, *Toxoptera aurantii* mainly cause damage to orchids. The nymphs and adults suck the cell sap usually from new flower spike and foliage. They also excrete honeydew on which sooty mould developed that affect the photosynthesis. Thrips, *Dichromothrips nakahari* suck the cell sap from tender portion of plants and on leaves, it become discolored and shrivels. Both young once and adult of mealy bug (*Pseudococcus* sp) suck the cell sap from the leaves and petioles or any joint portion of plants and as a result of that plants become weakened. Grass hopper (*Hieroglyphus banian*) feed on young leaves, un-opened flower buds and flowers by cutting in irregular shape with their biting and chewing type of mouth parts and ultimately flowers quality affected.

9.7.2 Diseases

9.7.2.1 Black rot, Crown rot or heart rot (*Pythium ultimum, P. splendens, Phytophthora palmivora and P. parasitica*): Water soaked small brown spot on the aerial parts of plants, which quickly turn black. Fungicides spray viz Captan @ 2 g/l or Zineb @ 2 g/l water controls it.

9.7.2.2 Anthracnose (*Colletotrichum gloeosporioides and C. orchidacearum*): Initial symptom appears as the small oblong to circular oval, sunken and reddish brown to dark brown or gray coloured spots. Die back of leaves are also observed if the leaf tip is attacked. Spraying of Carbondazim (Bavistin) @ 1 g/ liter in 10 days interval checks the disease.

9.7.2.3 Blossom Blight (*Botrytis cinerea*): The pathogens produce numerous small dark spots on petals, especially on older flowers. Sometimes shot hole effect is found on infected flower petals. Spraying with Bavistin @ 1g/l liter or indofil Z @ 2g/liter at 7 days intervals are effective.

9.7.2.4 Bacterial soft rot (*Erwinia corotovora pv. corotovora and E. chrysanthi*): Deep grayish grey lesions on leaves. It causes leaf spot, soft rot and stem rot with fishy smell. Treating of infected plants with streptomycin or oxy tetracycline solution before planting

9.7.2.5 Cymbidium mosaic virus (Cymbidium mosaic potexvirus): The virus produces variable symptoms on different hosts. It produces mild or severe mosaic symptoms followed by necrosis. Start with certified and virus free plant material, Proper sterilization of tools used in cultural practices, proper distance among plants has to be maintained to avoid virus infection, proper sanitation. Keep growing area free from plant debris. Quarantine new plants and Control of insect vectors.

9.7.2.6 Odontoglossum ringspot virus (Tobamovirus): It produces ringspot on Odontoglossum grande, diamond mottle symptoms. Start with certified and virus free plant material, proper sterilization of tools used in cultural practices, proper distance among plants has to be maintained to avoid virus infection, proper sanitation. Keep growing area free from plant debris. Quarantine new plants and control of insect vectors are remedial measures.

9.8 POSTHARVEST MANAGEMENT

A good quality cut flower of an orchid should have the following characteristics

- Minimum eight standard blooms per stem
- Flowers must be cleaned, evenly coloured and free from physiological disorders
- Stem must have flowers evenly arranged and around the stem.
- Two third of the stem should be covered with the flowers.
- Flowers must have a firm texture and a luminescent sheen
- Stems must be firm when held up
- The minimum base diameter of the stem should be of 10 mm

9.8.1 Stage of harvest

In Cymbidium, flowers having 75% bloom stage or two buds opened stage with the spike length of 60-90 cm are harvested.

9.8.2 Grading

Cymbidium orchids are graded in the following way.

Category	Grade	Flower count	Spike length
Standard	AAA	>12	1.25 m
	AA	8	90 cm
Miniature	XL	> 15	65 cm +
	L	12-14	55-64 cm
	M	8-11	40-54 cm
	S	<5	30-39 cm

9.8.3 Packing

After harvest the flower stems are bunched into 5 or 10 and wrapped in a specialized polythene cover and at the base of the stem a slant cut is made with a sharp knife. The stem bottom is inserted in a plastic plug containing clean water. This will keep the flowers fresh during transportation. In absence of the plug moistened cotton wrapped with a piece of polythene can do the job for domestic market. After plugging or wrapping with moistened cotton, the flower stems are placed in corrugated boxes and readied for dispatch to the market.

9.8.4 Storage

0.5 to 5^{o} C for 14 days under dry.

9.8.5 Floral preservatives

In *Cymbidium* hybrid 'Red Princess' pulsing with 5% sucrose increases vase life upto 56 days followed by sucrose @ 8% (54.78 days). In *Cymbidium*, 1-MCP and AVG are superior than STS in prolonging the vase life of cut flowers. In Cymbidium hybrid, 'Red Princess', 75% open flowers with 200 ppm 8-HQS showed highest vase life along with cent percent opening. In Cymbidium 'Ensikhan' and 'PCMV', 4% sucrose + 100 ppm salicylic acid and 4% sucrose + 100 ppm $Al_2 (SO_4)_3$ are used as bud opening chemicals. 2% sucrose + 200 ppm 8-HQS is also used as holding solution.

Chapter 10

CROP RESIDUE, CHALLENGES AND ITS MODERN TECHNIQUE FOR RECYCLING

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10.1 INTRODUCTION

Plant parts used for food and fibre, and crops grown for animal feed, do not produce most of the phytomass harvested annually by the world's agriculture-crop residues. More than half of all absolutely dry matter in the global harvest is in cereal and legume straws; in tops, stalks, leaves, and shoots of tuber, oil, sugar, and vegetable crops; and in pruning and litter of fruit and nut trees. Consequently, it would not be inappropriate to define agriculture as an endeavour producing mostly inedible phytomass.

Globally, annual output of 3.5-4.0 Gt of crop residues during the mid-1990s; the most likely total, 3.75 Gt, is nearly 1.4 times the size of the annual aggregate crop harvest. Cereal stem, leaf, and sheath material accounts for two-thirds of all residual phytomass, and sugar cane tops and leaves are the second-largest contributor. Just over 60% of all residual phytomass is produced in low-income countries, and close to 45 % of it originates in the tropics. Any calculated total of residual phytomass would be substantially enlarged by the inclusion of crop processing residues, such as husks and brans (which make up approximately 13% of ripe rice, for example) or sugarcane bagasse (the fibrous residue remaining after the milling of cane stalks, which amounts to 15- 18% of the fresh weight of the cane plant). However, these forms of phytomass are readily used as either good-quality feed (in the case of grain milling residues) or as industrial fuel (in the case of bagasse in sugar refining operations) and are rarely, if ever, candidates for field recycling or other forms of disposal.

India is an agrarian economy, where a vast majority of land is used for farming and a wide range of crops are cultivated in its different agro-ecological regions. With a production of 93.9 million tons (Mt) of wheat, 104.6 Mt of rice, 21.6 Mt of maize, 20.7 Mt of millets, 357.7 Mt of sugarcane, 8.1 Mt of fibre crops (jute, mesta, cotton), 17.2 Mt of pulses and 30.0 Mt of oilseeds crops, in the year 2011-12 (MoA, 2012), it is but natural that a huge volume of crop residues are produced both on-farm and off-farm. It is estimated that approximately 500-550 Mt of crop residues are produced per year in the country. These crop residues are used for animal feeding, soil mulching, bio manure making, thatching for rural homes and fuel for domestic and industrial use.

Generation of crop residues in India the Ministry of New and Renewable Energy (MNRE, 2009), Govt. of India has estimated that about 500 Mt of crop residues are generated every year. There is a wide variability in the generation of crop residues and their use across different regions of the country depending on the crops grown, cropping intensity and productivity of these crops. The generation of crop residues is highest in Uttar Pradesh (60 Mt) followed by Punjab (51 Mt) and Maharashtra (46 Mt). Among different crops, cereals generate maximum residues (352 Mt), followed by fibres (66 Mt), oilseeds (29 Mt), pulses (13 Mt) and sugarcane (12 Mt) (Fig. 1). The cereal crops (rice, wheat, maize, millets) contribute 70% while rice crop alone contributes 34% to the crop residues (Fig. 1). Wheat ranks second with 22% of the crop residues whereas fibre crops contribute 13% to the crop residues generated from all crops. Among fibres, cotton generates maximum (53 Mt) with 11% of crop residues. Coconut ranks second among fibre crops with generation of 12 Mt of residues.

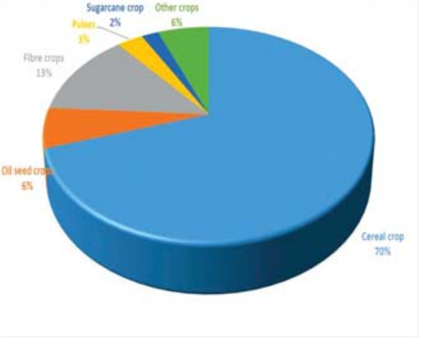

Fig. 1. Residue generation by different crops in India (calculated from MNRE, 2009)

Nevertheless, there is no doubt that a large part of the residual harvest is handled inappropriately, weakening the world's food-production capacity and contributing to undesirable biospheric change. Such malpractice is particularly common in low income countries, where inadequate amounts of residues are recycled while unacceptably large amounts of straws and stalks are burned, either in the fields or as household fuel. In this article, I deal with each of these major concerns. I begin by quantifying the world's crop residue production; next, I review the variety of off-field uses of residues; and finally, I explain the agro-ecosystem benefits of recycling this phytomass and the negative impacts of burning straws and stalks, a traditional practice that I suggest should give way to better approaches to crop residue management.

10.2 RESIDUES AS RESOURCE

i. Household fuel

ii. Feed and bedding

iii. Mushroom cultivation

iv. Building material

v. Pulp and chemicals

vi. Recycling

vii. Protecting soils against erosion and improving water retention.

viii. Recycling nutrients

ix. Enhancing soil organic matter‘

10.2.1 Utilization and on-farm burning of crop residues in India

The utilization of crop residues varies across different states of the country. Traditionally crop residues have numerous competing uses such as animal feed, fodder, fuel, roof thatching, packaging and composting. The residues of cereal crops are mainly used as cattle feed. Rice straw and husk are used as domestic fuel or in boilers for parboiling rice. Farmers use crop residues either themselves or sell it to landless households or intermediaries, who further sell them to industries. The remaining residues are left unused or burnt on-farm. In states like Punjab and Haryana, where crop residues of rice are not used as cattle feed, a large amount is burnt on-farm. Sugarcane tops are either used for feeding of dairy animals or burnt on-farm for growing a ratoon crop in most parts of the country. Residues of groundnut are burnt as fuel in brick kilns and lime kilns. The residues of cotton, chilli, pulses and oilseed crops are mainly used as fuel for household needs. The shells of coconut, stalks of rapeseed and mustard, pigeon pea and jute and mesta, and sunflower are used as domestic fuel.

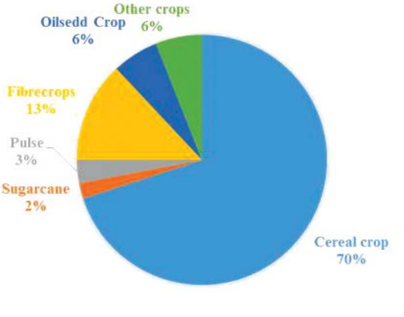

Fig. 2. The share of unutilized residues in total residues generated by different crops in India (calculated from MNRE, 2009)

The surplus residues i.e., total residues generated minus residues used for various purposes, are typically burnt on farm. Estimated total amount of crop residues surplus in India is 91-141 Mt. Cereals and fibre crops contribute 58% and 23%, respectively (Fig. 2) and remaining 19% is from sugarcane, pulses, oilseeds and other crops.

10.2.2 Burning; a challenge with crop residue

Thus crop residues are of tremendous value and use to the farmers. However, a large portion of the residues is burnt on-farm primarily to clear the field for sowing of the succeeding crop. The problem of on-farm burning of crop residues is intensifying in recent years due to shortage of human labour, high cost of removing the crop residues by conventional methods and use of combines for harvesting of crops.

The problem is more severe in the irrigated agriculture, particularly in the mechanized rice-wheat system of the northwest India (Fig. 3).

It is a paradox that burning of crop residues and scarcity of fodder coexists in this country, leading to significant increase in prices of fodder in recent years. Industrial demand for crop residues is also increasing.

Fig. 3. Burning of rice residues, a prevalent practice in northwest India (Pathak S. *et al*. 2012)

Out of 82 Mt surplus residues from the cereal crops, 44 Mt is from rice followed by 24.5 Mt from wheat, which is mostly burnt on-farm. In case of fibre crops (33 Mt of surplus residue) approximately 80% of the residues are from cotton and are subjected to on-farm burning. It is worth mentioning here that large uncertainties as well as variability exist in the estimates of generation, utilization and on-farm burning of crop residues. Pathak et al. (2004) had estimated that annually 523 Mt crop residues were generated in India, out of which 127 Mt was surplus. According to MNRE (2009), the amount of crop residues generated was 500 Mt and surplus was 141 Mt. Crop-wise the annual surplus crop residues of cotton stalk, pigeon pea stalk, jute and mesta, groundnut shell, rapeseed and mustard and sunflower were estimated to be 11.8 Mt, 9.0 Mt, 1.5 Mt, 5.0 Mt, 4.5 Mt, and 1.0 Mt, respectively. According to the estimates of Sardar Patel Renewable Energy Research Institute (2004), about 72 Mt crop residues are burnt on-farm. Recently, Pathak et al. (2010) have estimated that about 93 Mt of crop residues are burnt on-farm in the country.

10.2.3 Reasons behind on-farm burning of crop residues

Crop residue burning is not an isolated practice. In the weeks following a harvest, flames and dense smoke can be seen above the wheat fields of the Canadian Prairies and the US Great Plains and in the sugarcane fields of Latin America. Consequently, rice straw is burned in the monsoonal paddies of Southeast Asia, in Italy's Piemonte, and in huge, aerially seeded fields around Sacramento, California (Jenkins et al. 1992).

The practice is also common in rice and wheat growing areas, where modern, high-yielding cultivars produce as much as 6-7 t/ha of straw and where the residue is not needed to protect soils against wind and water erosion in flat and wet fields. The most common justifications that farmers give for burning are to get a seedbed that is easy to work and will not impede the growth of a new crop and to rid the fields of phytomass that can harbor pests and diseases waiting to reduce the next harvest.

Farmers and policy makers are well-aware of the adverse consequences of on-farm burning of crop residues. However, because of increased mechanization, particularly the use of combine harvesters, declining numbers of livestock's, long period required for composting and unavailability of alternative economically viable solutions, farmers are compelled to burn the residues. The number of combine harvesters in the country, particularly in the Indo-Gangetic Plains (IGP) has increased dramatically from nearly 2000 in 1986 to over 10000 in 2010. The north-western part (Punjab, Haryana and Western Uttar Pradesh) of the IGP has about 75% of the cropped area under combine harvesting. Combine harvesters are used extensively in the central and eastern Uttar Pradesh, Uttarakhand, Bihar, Rajasthan, Madhya Pradesh and in the southern states as well for harvesting rice and wheat crops. Major reasons for rapid increase in the use of combines are labour shortage, high wages during harvesting season, 9 ease of harvesting and thrashing and uncertainty of weather.

On using combine harvesting; about 80% of the residues are left in the field as loose straw that finally ends up being burnt on farm.

There are some other reasons also behind intentional burning of crop residues. These include clearing of fields, soil fertility enhancement, and pest and pasture management. On farm burning traditionally provides a fast way to clear the fields off the residual biomass, thus, facilitating land preparation and sowing/planting. It also provides a fast way of controlling weeds, insects and diseases, both by eliminating them directly or by altering their natural habitat. The time gap between rice harvesting and wheat sowing in north-west India, for example, is only 15-20 days. In this short duration, farmers prefer to burn the rice straw on-farm instead of harvesting it for fodder or any other use. The latter options also involve a huge transportation cost. On-farm burning is also perceived to boost soil fertility, although burning actually has a differential impact on soil fertility. It increases the short term availability of some nutrients (for example P and K) and reduces soil acidity, but ultimately leads to a loss of other nutrients (for example N and S) and organic matter.

Although these claims have some validity, none can justify blanket burning of residues. Mechanical difficulties in tilling residue-laden fields can be managed either by using a straw chopper and dispersing the residues as evenly as possible or, preferably, by choosing an appropriate reduced-tillage operation. An-other set of UK tests with winter barley straw found that, although the burnt areas were less infested with fungi initially, by summer they had more severe problems with net blotch (Pyrenophora teres) and leaf blotch (Rhynchosporium secalis) than the plots with incorporated straw (Jenkyn et al. 1995). Early short-term studies did not find any reduction in grain yields or soil organic matter contents with residue burning. However, more re-cent long-term appraisals indicate accelerated loss of soil carbon and reduced microbial activity in soils where straw has been burned for more than 20 years (Rasmussen and Collins 1991). Emissions from crop residues. Andreae (1991) put the worldwide burning of agricultural residues at 2020 Mt per year, accounting for almost a quarter of his estimate of all biomass combustion; he also assumed the standard 45% carbon content and 90% combustion efficiency to calculate the release of approximately 800 Mt of carbon as carbon dioxide. Both of his assumptions appear to be on the high side. Because of the relatively high mineral content of some straws and stalks, the carbon share of residues is often substantially less than 45%-even as low as 30% (Ilukor and Oluka 1995). And smouldering fires-which convert only approximately 50% of phytomass car-bon to carbon dioxide, compared to conversion rates of 85-97% during the flaming phase-are common when field residues are burned, particularly in tropical settings. The United Nations Environmental Programme and other organizations (UNEP et al. 1995) estimated that in low-income countries, approximately 25% of all residues are burned; the corresponding share in affluent nations is just 10%. The actual rate in low-income countries is almost certainly higher than 25%, especially when the use of residues for fuel is included. Even the rate in affluent nations is most likely higher because data on average burn fractions indicate regionally much higher burn rates both for field and orchard crops (Jenkins et al. 1992). Mini-mum global emissions from the burning of crop residues could be estimated by assuming that one-third of all residues in low-income countries and 15% of all residues in affluent nations are burned (either in field or as fuel). The most likely maximum burning rates would be 45% in low-income countries and 25% in affluent nations. The resulting range of 1000-1400 Mt of burned residual phytomass would, given the average carbon content of 35-40%, result in annual emissions of 350-560 Mt of carbon, considerably lower than Andreae's (1991) estimate. However, the extreme variability of emission rates precludes an accurate calculation of total fluxes of major combustion gases. Key variables affecting the rate and composition of emissions are the chemical composition of the residues, their moisture content, the degree of fuel packing, and the surface area-to-volume ratio. Actual fluxes measured both in laboratories and in the field indicate that most (85-90%) of the 95% of phytomass carbon that is released in gaseous compounds (the remaining 5% being particulate carbon) is emitted as carbon dioxide; the rest is emitted mainly as carbon monoxide, with a small percentage emitted as methane and nonmethane hydrocarbons (Laursen et al. 1992, Nguyen et al. 1994a, Scholes 1995). Annual carbon dioxide emissions from the burning of crop residues thus range between 1.1 and 1.7 Gt. However, as is the case with more massive savanna burning, these emissions do not result in a net long-term tropospheric increase of carbon di-oxide because an equivalent amount of gas (or, as the harvest increases, a slightly larger volume) is taken up by the next season's or the next year's crops. Annual emissions of carbon monoxide are most likely between 50 and 100 Mt, and they clearly contribute to the carbon monoxide-rich plumes detected repeatedly by satellites above parts of Africa, Asia, and Latin America that are located far from any industrial or urban sources of the gas (Newell et al. 1989). Emissions of methane are most likely between 5 and 7 Mt. Burning of crop residues also re-leases nitrogen as both NOx (NO and NO2) and ammonia; in addition, 30-40% of the nitrogen present in the phytomass is converted during flaming combustion directly into nitrogen gas (Kuhlbusch et al. 1991). Finally, combustion of residues is also a significant source of carbonyl sulfide (Nguyen et al. 1994b).

10.2.4 Effects of burning

Although residue burning may give farmers fields that are easier to seed and sometimes, perhaps, less pest infested, it is, in an overwhelming number of cases, an undesirable practice because it weakens the local capacity of the agroecosystem services, ranging from protection of soils against erosion to recycling of nitrogen. At the same time, residue burning contributes significantly to the build-up of tropospheric methane, a greenhouse gas that is approximately 60 times more effective than carbon dioxide in absorbing outgoing infrared radiation. Indeed, current methane emissions from crop residues may be equivalent to at least one-tenth of all methane emissions from the combustion of fossil fuels. Carbonyl sulfide has a long residence time in the atmosphere and the highest natural background concentrations of any sulfur compound. However, after reacting with hydroxyl radicals, most of it ends up eventually as tropospheric sulfate, which counteracts global warming by supplying condensation nuclei. Seasonal burning of residues also has adverse regional health effects. These effects are most severe when stationary high-pressure cells still winds, limit atmospheric mixing, and cause overnight temperature inversions. For example, during the first week of October 1992, burning of wheat straw in southern Manitoba produced smoke concentrations high enough to activate residential and institutional detection devices in Winnipeg, caused severe health problems for people with respiratory problems, and made driving dangerous in the worst-affected areas (EMO 1993). The Emergency Measures Act was invoked to ban stubble burning within 100 km of the capital, and subsequent regulation forbade any residue burning during the night. Public pressure stemming from health concerns has been the main reason for bans or limitations on crop residue burning. In the United Kingdom, where some 600,000 ha of cereal residues were burned annually in the early 1980s, a ban was imposed in 1992 (Prew et al. 1995). Currently, the most controversial attempt to eliminate straw burning is unfolding in California, where, according to the Rice Straw Burning Reduction Act of 1991, the area burned annually was to be reduced by 50% by the year 1998. By the end of 1997, only a 33% reduction had been achieved; furthermore, rice growers would actually like to see a re-expansion of burning because it is the easiest way to dispose of the large volume of rice straw (Air Re-sources Board 1998). Burning of crop residues leads to release of soot particles and smoke causing human and animal health problems. It also leads to emission of greenhouse gases namely carbon dioxide, methane and nitrous oxide, causing global warming and loss of plant nutrients like N, P, K and S. The burning of crop residues is wastage of valuable resources which could be a source of carbon, bio-active compounds, feed and energy for rural households and small industries. Heat generated from the burning of crop residues elevates soil temperature causing death of active beneficial microbial population, though the effect is temporary, as the microbes regenerate after a few days.

Repeated burnings in a field, however, diminishes the microbial population permanently. The burning of crop residues immediately increases the exchangeable NH4 +-N and bicarbonate- extractable P content, but there is no build up of nutrients in the profile. Long-term burning reduces total N and C, and potentially mineralizable N in the upper soil layer.

The burning of agricultural residues leads to significant emissions of chemically and radiatively important trace gases such as methane (CH4), carbon monoxide (CO), nitrous oxide (N2O), oxides of nitrogen (NOX) and sulphur (SOX) and other hydrocarbons to the atmosphere. About 70%, 7% and 0.7% of C present in rice straw is emitted as carbon dioxide, carbon monoxide and methane, respectively, while 2% of N in straw is emitted as nitrous oxide upon burning. It also emits a large 8 amount of particulates that are composed of a wide variety of organic and inorganic species. One ton of rice straw on burning releases about 3 kg particulate matter, 60 kg CO, 1460 kg CO2, 199 kg ash and 2 kg SO2 (Gadi, 2003). Besides other light hydrocarbons, volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), SOx and NOx are also emitted. These gases are of major concern for their global impact and may lead to increase in the levels of aerosols, acid deposition, increase in tropospheric ozone and depletion of the stratospheric ozone layer. These may subsequently undergo trans-boundary migration depending upon the wind speed/direction, reactions with oxidants like OH , leading to physic chemical transformation and eventually wash out by precipitation. Many pollutants found in large quantities in biomass smoke are known or suspected carcinogens and could be a major cause of concern leading to various air-borne/lung diseases.

10.3 MANAGEMENT OR RECYCLING OF CROP RESIDUES

Maintenance of highly productive cropping requires effective protection of soils against erosion, conservation of relatively high amounts of soil organic matter, provision of optimum conditions for soil biota, and, to prevent undesirable environ-mental effects of high-level fertilizer applications, the highest possible rate of recycling of plant nutrients. At the same time, minimizing the human impacts on tropospheric chemistry requires lower emissions of green-house and other gases, and avoiding serious health hazards posed by smoke necessitates severe restrictions, or outright elimination, of all unnecessary phytomass burning. Appropriate field management of crop residues can help to achieve all of these goals. Residues in excess of carefully determined recycling requirements can make a major difference at both the local and regional levels in producing high-quality animal and fungal protein or fibre. Better ways of compacting residues would lower their transportation costs and improve their nutritional value, making their off-field use for feed, fibre, or substrate more economical. Perhaps the best way to promote these rational ways of dealing with straws, stalks, and leaves is to see them not as residues-as often undesirable left over of much more highly prized crops-but as valuable resources that provide irreplaceable environmental services and assure the perpetuation of productive agro-ecosystems and sustainable food production.

Extensive long-term experiments at the Rothamsted and Woburn Ex-perimental Stations in the United Kingdom that compared burning of winter wheat straw with various re-cycling methods showed that incorporating straw into soil (by chop-ping, followed by cultivators or plowing) had no adverse effects on the subsequent harvest (Prew et al. 1995). Decay rates were satisfactory (i.e., 1 year after incorporation, the straw was decomposed to such an extent that it did not impede seedbed preparation, and after 2 years it was fully fragmented), toxins produced during degradation had no notice-able effect on subsequent plant establishment, yield was unaffected, and pests were not a problem.

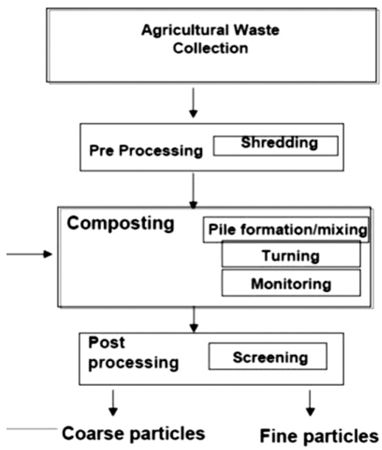

Fig. 4. Flow diagram showing operations for a typical agricultural waste facility

10.4 COMPOSTING

Composting refers to the bio-oxidation process of transforming wastes into a stabilized form and compost refers to the resulting product: stabilized organic matter. A complete definition of composting as stated by many authors (Gray, Sherman and Biddlestone, 1971; De Bertoldi, Vallini and Pera, 1983; Diaz, Savage, Eggerth, et al., 1993) is: "the controlled exothermic bioxidative decomposition of organic materials by indigenous micro-organisms in a moist warm aerobic environment, leading to the production of carbon dioxide, water and a stabilized organic matter, defined as compost". Today a variety of composting processes exist that can be used for any scale of organic waste management. Systems range from simple to sophisticated technology. Passive piles, windrows, aerated static piles and in-vessel composting systems are being used worldwide to treat different types of organic waste. Currently, there is more emphasis on compost maturity, quality and sustainability, which are key traits in the acceptance and use of the final product.

Compost feedstock is a complex mix of organic material, ranging from simple sugars and starches to more complex or resistant molecules such as cellulose and lignin. The composting process is shown in Fig. 5.

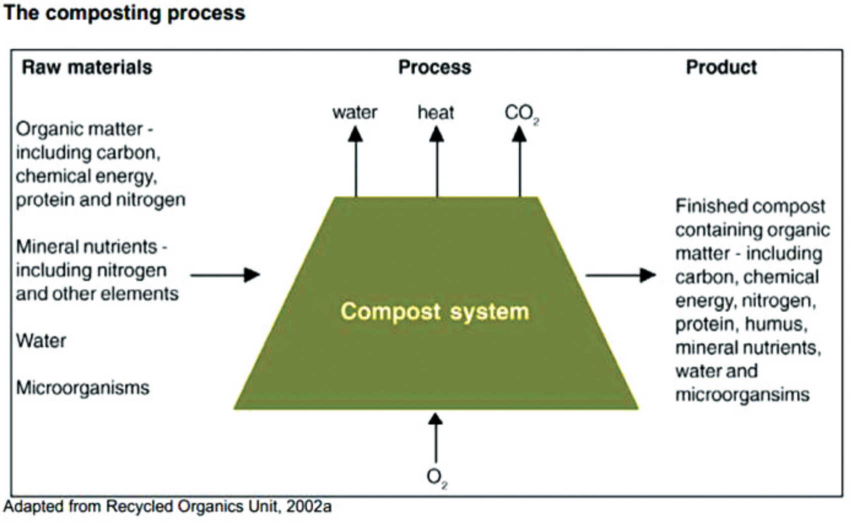

Fig. 5. The composting process

10.4.1 STAGES IN THE COMPOSTING PROCESS

The composting process has three main phases:

10.4.1.1 Pre-processing
10.4.1.2 Active composting
10.4.1.3 Curing

10.4.1.1 Pre-processing

Pre-processing or preparation of feedstock usually is necessary to create suitable conditions for bacterial action. It consists of three separate types of operation:

- Separation or removal of oversize and dangerous materials and materials that cannot be composted; size reduction through chipping, grinding or shredding to create small particles;

- Blending to adjust the carbon/nitrogen ratio, moisture content or structure of the materials to be composted. Fig. 5. The composting process

10.4.1.2 Active composting:

Active composting begins as soon as appropriate materials are piled together. Heat is given off, the temperature rises and other groups of micro-organisms develop. Some composting systems can more effectively deal with specific types of organic materials. For example, highly odorous material such as food organics are more easily processed in systems with forced aeration. The most common form of composting is the turned windrow system. This system is adequate for a large range of organics but requires more maintenance and a higher degree of process control.

10.4.1.3 Curing

By the end of rapid phase of composting, a significant proportion of the easily degradable organic material has decomposed. Organic materials remaining after the active phase decompose slowly and microbial activity continues at a slower rate. This second phase, called curing, usually takes several weeks to months. During curing, after temperatures have gone down, fungi and actinomycetes re-invade the compost and decompose the more resistant materials. The curing phase is important to reduce the presence of phytotoxic compounds normally present in immature compost. Generally, curing uses passive aeration with occasional turning. As the pile cures, the micro-organisms generate less heat, the pile begins to cool. Small-scale technology is applicable to composting small amounts of waste, normally less than 500 kg, while the range for large-scale technology is between hundreds of kilograms and thousands of tonnes. Large-scale technology can be classified further into four categories: passive pile, windrow, aerated static pile (ASP) and in-vessel composting. The technologies vary in the method of air supply, temperature control, mixing/turning of material and time required for composting. In this section, technologies have been grouped as large scale and small scale. Supporting technologies for composting include pre-processing of waste substrates and post-processing of compost.

10.4.1.4 Composting technologies

Composting technology can be classified as open or closed, batch or continuous and small-scale or large-scale. Open or closed methods refer to composting in the open or in closed reactors, batch or continuous methods refer to the frequency at which the waste materials are composted while small scale and large-scale methods refer to the quantity of material to be composted at one time. The amount of waste is a major consideration when deciding the method to use.

10.5 SMALL-SCALE TECHNOLOGIES

Small-scale composting systems adapted for households include heaps in and above the ground, pits, boxes, bins, garbage cans, drums and barrels, which can be outdoors or indoors. Each method has its advantages, but when choosing composting method, factors such as space availability, neighbours, type of material and available construction facilities have to be taken into account. A summary of small-scale methods is given in Table 10.1.

Table 10.1. Small scale composting systems at household level

Small-scale systems	Turning	Heat generation	Vectors	Duration
Heap	Easy	Rapid	Present	6 months - 1 year
Cage type + circular bins	Easy	Moderate	Present	6 months - 1 year
Block/brick bin	Easy	Moderate	Present	6 months – 1 year
Drums	Very easy	Very rapid	Present	2 - 4 months

The simplest way to compost material is to build a heap. A small compost heap can be either in a stack above the ground or in a pit dug in the ground. A heap can be of any size but a manageable heap is 1 to 2 m wide and 1 to 1.5 m high, although considerable heat losses occur with small heaps. This method is appropriate for gardeners or farms that have plenty of space, ample materials, sufficient time and no nearby residents. The composting time is quite long, up to one year.

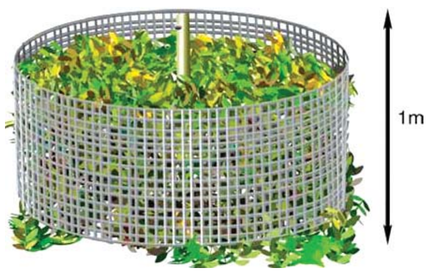

Fig. 6.Circular pen Adapted from Martin, Gershuny and Minnich, 1992

Bins and pens the most common compost structures. The bins are made of concrete, brick, wood or masonry and pens made of wire or hardware cloth. Pens (Fig. 6) have the advantage of allowing air circulation;

however there is free circulation of flies and rodents. It is quite difficult to trap heat in a compost pen and therefore high temperature composting may not develop.

Bins are more stable and have a protecting structure. Pens and bins are classified as holding units while barrels and drums as turning units. Turning units produce compost more quickly than holding units because of the turning process.

10.5.1 Holding units

Cage type bin (Fig. 7) is a circular or rectangular structure made of wooden pallets and hardware cloth. Usually it is applicable for yard waste composting and is about 1 m^3 in size.

Fig. 7. Cage type bin

Fig. 8. Block and brick bin

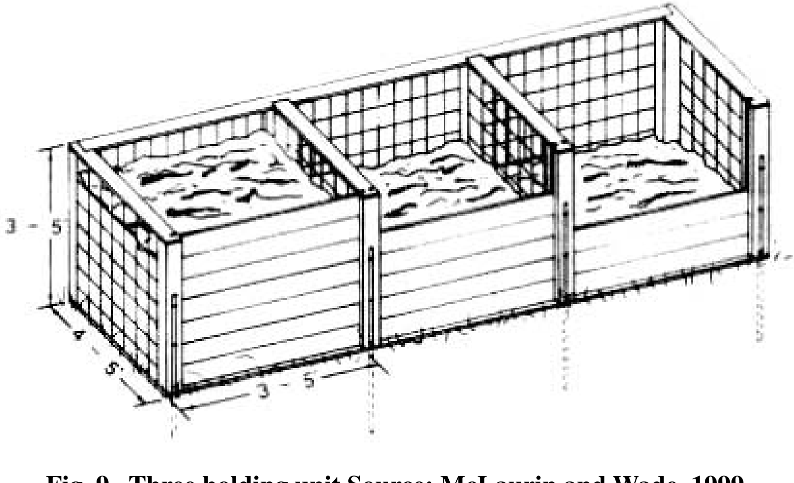

Fig. 9. Three holding unit Source: McLaurin and Wade, 1999

10.5.2 Block and brick bin

These are permanent structures (Fig. 8) used to compost wastes. Blocks are lined in such a way as to allow for proper air circulation. Three holding unit A turning unit also can be three holding units placed side by side (Fig. 9). Each unit is approximately $1m^3$ (1 m * 1 m * 1 m). One bin is full at a time and its contents are turned into the empty adjoining bin every week or two. The final bin provides the space for curing while new batch of compost is started in the first bin. Average composting time is around two months. Commonly, the three holding unit is used to compost horse wastes on farms.

10.5.3 Drums

Drums are very effective for composting kitchen waste. They can be used for households with small yards. Drums are waterproof. There are two types of drum compost systems:

- Vertical drums (Fig. 10), which are not turned themselves, but materials can be turned using a fork.

Fig. 10. Vertical drum Adapted from McLaurin and Wade, 1999

- Horizontal rotary drums, which allow for easy turning. Rotary horizontal drums can be rolled on the ground or fixed to a support. When fixed to a support they are easy to turn and as the drum is above the ground it is easier to empty.

10.6 LARGE- SCALE COMPOSTING TECHNOLOGIES

Several large-scale composting methods are suitable for farms. The method chosen depends on available labour, resources, time, land and raw materials. The main large-scale composting systems are

a. Passive piles,

b. Windrows,

c. Aerated static piles

d. In-vessel systems.

A summary of large-scale methods is given in Table 10.2.

Table 10.2. Comparison of large-scale composting system

Large-scale composting systems Parameter	Passive pile	Windrow	Passive windrow	Aerated static pile
Process time (month)	12-24	6-12	6-12	3-6
Process control/ management	Minimal	Moderate	Minimal (turning)	High
Potential for odour generation	High because of anaerobic pockets	Moderate only when turning	Minimal (odour absorbed in top layers)	Minimal (with sucked air)
Capital investment	Low	Low	Moderate	High
Operation cost	Low	High (labour)	Low	High
Compost quality	Poor	Moderate	Low to moderate	Good
Important parameters	Porosity/ structure	Porosity/ structure	Porosity/ structure	Porosity/ moisture (Pile can settle)
Materials targeted	Leaves/ yard trimmings	Mixed wastes, manure most widely used by farmers	Manure, seafood wastes	Sludge, mixed wastes, manure

10.6.1 Passive composting piles

The passive composting pile method involves forming mixtures of raw material into a pile (Fig. 11). Typical dimensions are 2 m high and 3 m wide. Aeration is accomplished through the passive movement of air through the pile. However, the pile must be small enough to allow for passive air movement, otherwise anaerobic pockets will form.

Fig. 11. Passive composting pile
Source: Vogel and Block, 1998

Since no turning and moisture adjustment is made during the composting period, special attention should be given to the mixing of raw materials and their porosity and structure.

Minimal labour and equipment is needed with passive composting and therefore it is the least expensive large-scale composting method. It is very appropriate for leaves and yard trimmings and when compost is not needed quickly. Composting is slow, taking up to two years to stabilize the waste material.

10.6.2 Windrow composting

In the windrow composting method the organic wastes are piled in elongated rows that are turned regularly. Raw materials can be mixed as part of pile formation. Windrow shapes and sizes vary, depending on climate, equipment and the material used.

Typically windrows are 2 to 3 m high, 4 to 5 m wide and up to 30 to 40 m long. Frequent turning of the material (at least once a week) provides aeration, mixes the material, helps to control temperatures and redistributes moisture.

Windrows can be either left in the open or covered, depending on the climate and the moisture content of the material. If left in the open, the top part of the windrow in dry climates must have a concave shape to collect water to maintain pile moisture or in wet climates a triangular shape to allow water to run off (Fig. 11). Large amounts of heat are lost from small windrows, especially when they are turned. The turning schedule during composting varies from operation to operation, depending on the pile temperature, season, labour availability and the desired compost quality.

The time required to complete the composting process ranges from five to ten weeks, depending on the type of material being composted and the turning frequency.

10.6.2.1 Passive aerated windrows

Passive aerated windrows are windrows that are not turned. They are used commonly for composting manure with straw or woody shavings and seafood wastes with peat moss. Aeration is solely by the passive movement of air through perforated pipes in the pile base.

The windrows are built on top of a base layer, typically composed of straw, finished compost or bagasse. This layer must be porous so that air coming through the pile is distributed evenly. Aeration pipes are placed on top of the peat/compost base with their holes oriented downwards to minimize plugging and allow condensate to drain. A top layer, composed of peatmoss and/or finished compost, is used to cover the windrow. The main functions of the top layer are to retain odours, moisture, and ammonia and to insulate the pile. Also, it deters flies. As in passive pile composting, it is important to have a mix with good porosity and structure to allow for adequate aeration. Typically, passive aerated compost systems are 1 to 2 m high and about 3 m wide. The bottom and top layers should be about 100 - 150 mm thick. The average composting time is six to ten weeks.

10.6.3 Aerated static pile

Waste materials are arranged in long rows, in a similar way to windrows. Air is introduced via a network of perforated pipes in the base layer of the pile (Fig. 12). An aerated static pile differs mainly from a passive aerated windrow in that it uses fans to either suck air out of, or blow air into the pile.

Aeration fans not only provide oxygen, but also cooling. Fans can be run continuously or at intervals and can be activated either at set times or based on compost temperature. Fan aeration with temperature control allows for greater process control than windrow turning (National Engineering Handbook, 2000). A forced aerated static pile (ASP) has a base layer of porous material, such as wood chips and/or bagasse and a top layer similar to the passively aerated windrow. The use of forced aeration technique requires calculations on aeration rates, size of the fan and number, length, diameter and types of pipes. Aeration rates vary

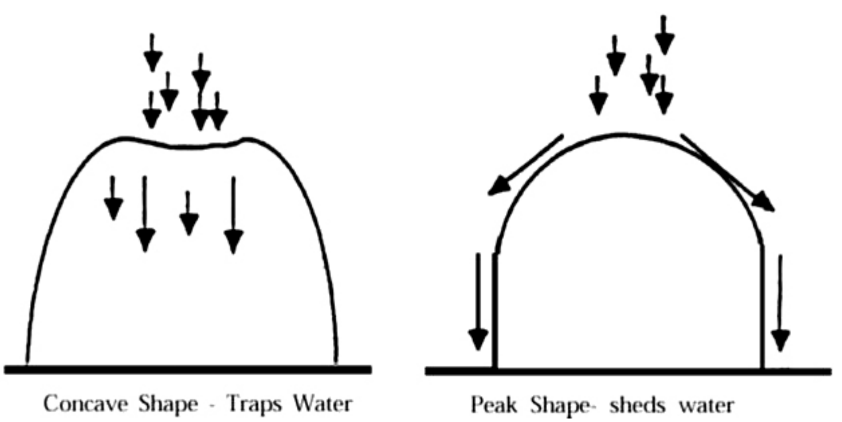

Fig. 12. Shape of windrows

according to the materials being composted and whether aeration is used to provide oxygen, remove heat or aid drying (Haug, 1993). Batches of 10 tonnes of horse manure may require around 432 m^3/day of air (Nardeosingh, 2003) while a similar amount of yard waste trimmings would need 200 m^3/day (Eustasie, 2003). Quick composting can be achieved with an ASP, the active composting period being completed in approximately three to five weeks. The length of an ASP is limited by air distribution in the aeration pipes. If the pile is too long, air might not reach the far end. Typical pile lengths are 12 to 15 m. Because of the high costs of operation (energy supply) and temperature equipment for greater process management aerated static piles are not used often in farm-scale composting systems.

10.6.3.1 Extended aerated static pile

The extended aerated static pile (EASP) composting method is similar to aerated static pile except that a new cell is constructed on the flank of the preceding cell, to form a flat-topped pile that increases in width with the addition of each new cell Fig. 13. Adjoining cells are constructed by placing aeration pipes on the pad parallel to the long side of the initial cell. This process can be repeated daily for a period of around four weeks, thereby forming an extended pile. At the end of active composting, the cells are broken down separately in the same order that they were constructed.

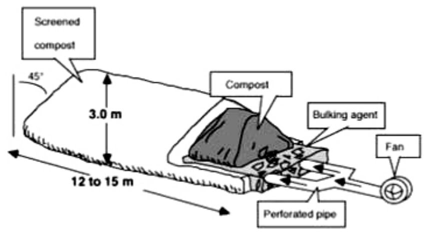

Fig. 13. Aerated static pile

The EASP method requires four to five times less area than turned windrow method and because of large mass of composting material the method is self-insulating. By converting the system from a turned windrow to an EASP method of composting, the area required for composting is decreased by a factor of four (Moon, 1997). This has added benefit of significantly decreasing the volume of leachate needing to be collected, stored and treated, all of which decreases the cost of operation. The amount of bulking agent or finished compost required for covering the pile is reduced also.

10.7 BIOCHAR PRODUCTION

Fig. 14. Low-cost pyrolysis klin for preparation of biochar (Courtesy: T.J. Purakayastha, IARI, New Delhi)

Biochar is a high carbon material produced through slow pyrolysis (heating in the absence of oxygen) of biomass (Fig. 14). It is a fine-grained charcoal and can potentially play a major role in the long-term storage of carbon in soil, i.e., C sequestration and GHG mitigation. However, with current level of technology, it is not economically viable and cannot be popularized amongfarmers. However, once all the valuable products and co-products such as heat energy, gas like H2 and bio-oil are captured and used in the biochar generation process, it would become economically-viable. There is a need to develop low cost pyrolysis kiln for the generation of biochar to utilize surplus crop residues, which are otherwise burnt on-farm.

10.8 CONSERVATION AGRICULTURE

Indian agriculture has made significant progress in the last five decades. However, for past some years it is facing various challenges with stagnating net sown area, reduction in per capita land availability, climate change effect and deterioration of land quality. The root cause of degradation of agricultural land is its low soil-carbon content that disrupts many important soil-mediated ecosystem functions. Conservation agriculture, with the following three core inter-linked principles, is a viable option for sustainable agriculture and is an effective solution to check land degradation (Kassam, 2011). To manage the residues in a productive and profitable manner, conservation agriculture (CA) offers a good promise. With adoption of conservation agriculture-based technologies these residues can be used for improving soil health, increasing crop productivity, reducing pollution and enhancing sustainability and resilience of agriculture. The resource conserving technologies (RCTs) involving no or minimum tillage, direct seeding, bed planting and crop diversification with innovations in residues management are the possible alternatives to the conventional energy and input-intensive agriculture.

The gravity of situation demands that an appropriate policy should be evolved to promote multiple uses of crop residues in the context of conservation agriculture and to prevent their on-farm burning. Under this scenario this bulletin aims to (i) quantify the amount of crop residues generated in the country every year and the extent of their on-farm burning, (ii) assess the environmental impacts of on-farm burning of crop residues, (iii) identify competing uses of crop residues and their adoption potential, (iv) assess the potential of using crop residues for conservation agriculture and constraints involved therein, (v) develop a model plan for managing crop residues at the local and regional scales, and (vi) identify research and policy issues for safe and sustainable management of crop residues for productive, rofitable and sustainable agriculture.

i. Minimizing mechanical soil disturbance and seeding directly into untilled soil to improve soil organic matter content and soil health.

ii. Enhancing organic matter cover on soil using cover crops and/or crop residues. This protects the soil surface, conserves water and nutrients, promotes soil biological activity and contributes to integrated pest management.

iii. Diversification of crops in associations, sequences and rotations to enhance system resilience these principles can be integrated into most of the rainfed and irrigated production systems, including horticulture, agro forestry, organic farming, rotational farming and integrated Crop-livestock systems to strengthen ecological sustainability. Worldwide about 105 Mha land is under conservation agriculture and it is increasing with time (Fig. 15). However, USA, Brazil, Argentina, Canada and Australia occupy about 90% of the area under conservation agriculture in the world. The conservation agriculture, which is advocated as alternative to the conventional production system, has been adopted by the Food and Agriculture Organization (FAO) of the United Nations as a lead model for improving productivity and sustainability.

Recent estimates have revealed that conservation agriculture-based resource conserving technologies (RCTs) that include laser assisted precision land levelling, zero/reduced tillage, direct drilling of seeds, direct seeding of rice, unpuddled mechanical transplantation of rice, raised bed planting and crop diversification are being practised over 3 Mha in South Asia. The RCTs with innovations in residue management avoid straw burning, improve soil organic C, enhance input efficiency and have the potential to reduce GHGs emissions (Pathak et al. 2011). Permanent crop cover with recycling of crop residues is a pre-requisite and integral part of conservation agriculture.

However, sowing of a crop in the presence of residues of preceding crop is a problem. But new variants of zero-till seed-cum-fertilizer drill/ planters such as Happy Seeder (Fig. 16), Turbo Seeder and rotary-disc drill have been developed for direct drilling of seeds even in the presence of surface residues (loose and anchored up to 10 t ha-1). These machines are very useful for managing crop residues for conserving moisture and nutrients as well as controlling weeds in addition to moderating soil temperature.

Domestic fuel, at least some parts of the stubble should be left in the fields to contribute to soil organic C. This technology has been successfully applied in several experiments at Bidhan Chandra Krishi Viswavidyalaya (BCKV), West Bengal (Fig.17). Due to less biomass productivity and competing uses of crop residues, the scope of using crop residues for conservation agriculture is limited in dryland ecosystems. Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, has shown that in

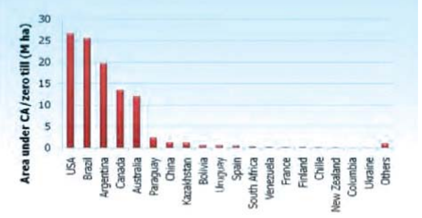

Fig. 15. Area under conservation agriculture in the world (Source: Derpsch and Friedrich, 2010)

Fig. 16. A 'Happy Seeder' for direct drilling of seeds in presence of surface residues (Courtesy: CSISA, CIMMYT-IRRI, New Delhi)

Fig. 17. Leaving of varying lengths of stubbles for enriching soil organic C content (Courtesy: B. Mandal, BCKV, West Bengal)

Fig. 18. Growing of horse gram during post-rainy season with maize residues under conservation agriculture in rainfed condition (Courtesy: Ch. Srinivas Rao, CRIDA, Hyderabad)

dryland ecosystems, where only a single crop is grown in a year, it is possible to raise a second crop with residual soil moisture by covering soil with crop residues (Fig. 18).

Crop residues are of great economic values as livestock feed, fuel and industrial raw material. These crop residues are used for animal feeding, soil mulching, bio-manure making, thatching for rural homes and fuel for domestic and industrial use. There is a wide variability in generation of crop residues and their use across different regions of the country depending on crops grown, cropping intensity and productivity of these crops residues. Nevertheless, there is no doubt that a large part of the residual harvest is handled inappropriately, weakening the world's food-production capacity and contributing to undesirable biospheric change. Such malpractice is particularly common in low-income countries, where inadequate amounts of residues are recycled while unacceptably large amounts of straws and stalks are burned, either in the fields or as household fuel. The burning practices weaken the local capacity of the agro ecosystem services, ranging from protection of soils against erosion to recycling of nitrogen. At the same time, residue burning contributes significantly to the build-up of tropospheric methane, a greenhouse gas that is approximately 60 times more effective than carbon dioxide in absorbing outgoing infrared radiation. The agro-ecosystem benefits of recycling this phytomass and the negative impacts of burning straws and stalks, a traditional practice that I suggest should give way to better approaches to crop residue management like composting, boichar preparation and conservation agriculture. Crop residues, either partly or entirely must be used as resource through recycling of residue a huge volume of crop residues are produced both on-farm and off-farm. All stakeholders viz, farmers, supply and value chain service providers, researchers, extension agents, policymakers, civil servants and consumers need to be engaged in understanding and harnessing the full potential of these valuable resources for sustainability and resilience of Indian agriculture. We believe that the research, policy and development programmes as outlined in this bulletin will serve a great deal in managing crop residues at local and regional scales.

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Chapter 11

NUTRIENT MANAGEMENT IN ORGANIC RICE FARMING – RESEARCH EXPERIENCES

Surekha K and Ravindrababu V

11.1 INTRODUCTION

Rice is the major staple food crop in India occupying around 44 million hectares and contributing about 100 million tonnes to the total food grain production. Introduction of high yielding and fertilizer responsive rice varieties with the advent of green revolution resulted in intensive rice farming leading to increased use of chemical fertilizers, pesticides and other inputs. Continuous use of chemical fertilisers has been reported to cause harmful effects on the soil environment, ground and surface water and even atmospheric pollution reducing the productivity of the soil by affecting soil physical, chemical and biological properties (Altieri, 2000). The reported occurrence of widespread soil fatigue in intensively cultivated irrigated rice lands has led to the use of 40 per cent more N to increase rice yield obtained 10 years ago has further accentuated the problem (Lampe, 1993). Likewise, indiscriminate and increased use of pesticides is leading to soil pollution, entry of toxic compounds into food chain, death of natural enemies of insect pests and development of resurgence and resistance to pesticides (Chandra Mohan, 2001). Outbreaks of insect pests have occurred frequently due to over use of insecticides. Numerous reports have indicated that spraying insecticides could cause serious decrease in natural enemies of insect pests and consequently lead to the out break of brown plant hopper, *Nilaparvata lugens* (Wang *et al.* 1994 and Gu *et al.* 1997). Continuous monoculture of rice has also led to the degradation of soil resource base. Hence, enhancement and maintenance of system productivity and resource quality is essential for sustainable agriculture.

It was felt that organic farming can solve the above mentioned problems as this system is believed to maintain soil productivity and pest control by enhancing natural processes and cycles in harmony with nature.

Organic farming may promote natural control of some pests and diseases, reduce soil quality deterioration by improving soil organic matter (SOM) and soil microbial activity. Organic farming reduces the entry of toxicants in the form of pesticides in food chain and minimises the accumulation of toxic residues in the soil thus leading to production of "clean" foods. There is a growing demand worldwide, especially in the European region and other parts of Western world for organically grown food products. There is a scope for minimising the economic and environmental costs under organic farming system as compared to conventional farming in the long run by preventing environmental damage and protection of natural eco-systems. Organic farming is considered as one of the keys for sustainable agriculture.

11.2 DEFINITIONS OF ORGANIC FARMING

Organic farming (OF)/organic agriculture (OA) is defined as a production system which largely excludes or avoids the use of fertilisers, pesticides, growth regulators, preservatives and livestock feed additives and totally rely on crop residues, animal manures, legumes, green manures, off-farm wastes, mechanical cultivation, mineral nutrient bearing rocks and biological pest control to maintain soil health, supply plant nutrients and minimise insects, weeds and other pests.

An alternative definition offered for OA is that it is a system approach of crop production, observing the rules of the nature, targeted to produce nutritive, healthy and pollution free food, protecting the entire system of the nature, maximizing the use of on-farm resources, minimizing the use of off-farm inputs and avoiding the use of chemical fertilizers and pesticides.

11.3 PRINCIPLES OF ORGANIC AGRICULTURE

The four main principles of organic agriculture as given by the International Federation of Organic Agriculture Movement (IFOAM 2002) are as follows:

11.3.1 Principle of health

Organic Agriculture should aim at sustaining and enhancing the health of soil, plant, animal, human and planet as one and indivisible.

This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health and well being of animals and people. Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health.

The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and biota from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes towards preventive health care and well-being through avoidance of use of fertilizers, pesticides, drugs and food additives that may have adverse impact on health of natural living systems, live stock and human beings.

11.3.2 Principle of ecology

Organic Agriculture should be based on promoting the ecological systems and natural cycles, work with, emulate and help sustain them.

This principle connects organic agriculture within natural ecological systems and thus stipulates that production is to be based on ecological processes, and recycling of plant nutrients. For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment.

Organic farming, pastoral and wild harvest systems should fit the cycles and ecological balances in nature. These cycles are universal but their operation is site-specific. Organic management must be adapted to local conditions, ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources.

Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.

11.3.3 Principle of fairness

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties - farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty. It aims to produce a sufficient supply of good quality food and other products.

This principle insists that animals should be provided with the conditions and opportunities of life that suit to their physiology, natural behavior and well-being.

Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

11.3.4 Principle of care

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken to protect the eco systems leading to sustainable agriculture.

This principle states that precaution and responsibility are the key concerns in development, management and technology choices in organic agriculture. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge may also offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adopting appropriate technologies and negating unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

Basic principles in organic farming

1. Avoidance of synthetic fertilisers, insecticides and fungicides
2. Production and use of organic manures and residue management
3. Minimising use of introduced or off-farm inputs
4. Choice of appropriate cropping systems including crop rotation and crop mixing for organic matter generation and maintenance, nutrient recycling and non pesticidal methods of weed, insect pest and disease management
5. Use of mechanical and traditional methods for weed, pest and disease management
6. Use of biofertilisers and biocontrol agents

Main principles of organic agriculture

11.4 OBJECTIVES AND BENEFITS OF ORGANIC FARMING

11.4.1 Objectives

- To work with natural systems rather than dominating them
- To encourage and enhance the biological activity and nutrient recycling
- Production of safe food of better quality free from toxicants and harmful chemicals
- Maintenance of soil organic matter and soil fertility on long term basis

- Sustain and continuously promote soil health and prevent environmental degradation

11.4.2 Benefits of Organic farming

- Reduces or prevents irreversible damage to environment and the ecosystem
- Prevents entry of toxicants in the food chain and promotes production of clean, healthy, nutritious and quality food
- Promotes bio-diversity and conserves natural resources
- Promotes natural control over pests by increasing populations of natural enemies
- Improves soil quality and ensures safe environment
- Fetches premium price for quality food and promotes export potential for foods, feeds and livestock products
- Reported to increase shelf life of perishables
- May benefit small and marginal farmers through decrease in cost of cultivation and increase in profits due to premium prices for the organic products

Suggested practices of Orthodox Organic farming

1. Synthetic fertilisers are strictly prohibited
2. Use of FYM, slurry, urine, blood meal, bone meal, compost prepared from organic sources, poultry waste, vermi-compost, slaughter house waste etc. are permitted
3. Use of basic slag, soil amendments like lime, gypsum, magnesium rock, naturally occurring potassium minerals, natural phosphates, trace elements, sulphur, mineral materials like clay, silicate are permitted
4. Use of bio - fertilisers is permitted
5. Use of synthetic insecticides, fungicides, herbicides, genetically modified organisms (GMOs) etc. is prohibited
6. Use of crop protection and growth regulator materials of plant and animal origin are permitted
7. Use of fungal and bacterial preparations, release of parasites, predators, viral preparations, biodynamic preparations, use of traps, barriers, repellents are permitted

11.5 GLOBAL SCENARIO OF ORGANIC FARMING

Based on the global survey on organic farming carried out in 2016 by the Research Institute of Organic Agriculture (FiBL), the International Federation of Organic Agriculture Movements (IFOAM) and Foundation Ecology & Agriculture (SOEL), organic agriculture is gaining ground and popularity and is now practiced in more than 161 countries of the world (FiBL and IFOAM 2017). Its share of agricultural land and farms continues to grow in many countries. According to the latest survey on global organic farming, about 51 million hectares of agricultural land is managed organically in the year 2015 by about 2.4 million producers.

The regions with the largest areas of organically managed agricultural land are Oceania (22.8 million hectares), Europe (12.7 million hectares) and Latin America (6.7 million hectares) [Table 11.1]. The countries with the most organic agricultural land are Australia, Argentina, USA and China (Table 11.2). The countries with the highest number of producers are India (585,200), Ethiopia (203602), Mexico (200,039) and Uganda (190,670). More than three quarters of the producers are located in Asia, Africa and Latin America. On a global level, this is an increase of more than 162000 producers compared with 2014, or 7 per cent. (FiBL and IFOAM 2017).

About one-third of the world's organically managed agricultural land (12 million hectares) is located in developing countries. Most of this land is in Latin America, with Asia and Africa in second and third place. Almost two-thirds of the agricultural land under organic management is grassland (22 million hectares). The cropped area (arable land and permanent crops)

Table 11.1: Organic agricultural land and farms by continent

Continent	Organic agricultural land area (ha)	Share of global organic agricultural land (%)	Organic wild collection area (m. ha)
Africa	1,683,482	3.0	11.9
Asia	3,965,289	8.0	5.52
Europe	12,716,969	25.0	17.66
Latin America	6,744,722	13.0	4.22
North America	2,973,886	6.0	0.05
Oceania	22,838,513	45.0	-
Total	50,919,006	100.0	39.4

Source: FiBL and IFOAM Survey 2017

Table 11.2: Land area of major countries under organic agriculture

S.No.	Name of the Country	Area under organic agriculture (ha)	% of total agricultural land	Number of organic producers
1	Australia	22,690,000	5.6	1876
2	Argentina	3,073,412	2.1	1074
3	USA	2,029,327	0.6	14871
4	Spain	1,968,570	7.9	34673
5	China	1,609,928	0.3	9990
6	Italy	1,492,579	11.7	52609
7	France	1,375,328	5.0	28884
8	Uruguay	1,307,421	9.0	4
9	***India***	***1,180,000***	***0.7***	***585200***
10	Germany	1,088,838	6.5	25078
11	Canada	944,558	1.4	4267
12	Brazil	750,000	0.3	10323
13	Mexico	584,093	0.5	200039
14	Poland	***580,731***	***3.8***	***22277***
15	***Austria***	553,570	21.3	20976
	World total	**50,919,006**	**1.1**	**2,417,414**

Source: FiBL Survey 2017

constitutes 8.2 million hectares, which represents a quarter of the organic agricultural land.

In Asia, the total organic area is 4.0 million hectares and this constitutes 8% of the world's organic agricultural land. The leading countries are China (1.61 million hectares) and India (1.18 million hectares)

Global demand for organic products has remained robust, with sales increasing every year. The global market for organic products reached 81.6 billion US dollars in 2015 (approximately 75 billion euros). The United States is the leading market with 35.9 billion euros, followed by Germany (8.6 billion euros), France (5.5 billion euros), and China (4.7 billion euros). In 2015, most of the major markets showed double-digit growth rates. The highest per capita spending was in Switzerland (262 Euros), and Denmark has the highest organic market share (8.4 per cent of the total food market). (FiBL and IFOAM 2017).

11.6 INDIAN EXPERIENCE OF ORGANIC FARMING

Organic Agriculture (OA) is not a new concept to India. Traditionally Indian farmers had practiced OA and gradually converted to chemical based cultivation since 1950's and chemicals were increasingly applied with the advent of Green Revolution. Though the adoption of Green Revolution agricultural technology in the 1960's reached the main production areas of the country, there were still certain areas especially hilly and tribal areas that did not adopt the use of agro-chemicals. Therefore, some areas can be classified as *organic by default* though their significance and extent has been rather overemphasized. However, an increasing number of farmers have consciously abandoned agro-chemicals and foods organically, as an alternative to Green revolution agriculture. Total area brought under organic certification process state wise during 2013-14 is given in Table 11.3.

Currently, India ranks ninth in terms of total land under organic cultivation and first in number of organic producers in the world. The total area under organic certification is 5.71million ha (2015-16). This includes 26% cultivable area with 1.49 million Hectare and rest 74% (4.22 million ha) forest and wild area for collection of minor forest produces. India produced around 1.35 million MT (2015-16) of certified organic products which includes all varieties of food products namely Sugarcane, Oil Seeds, Cereals & Millets, Cotton, Pulses, Medicinal Plants, Tea, Fruits, Spices, Dry Fruits, Vegetables, Coffee etc. The production is not limited to the edible sector but also produces organic cotton fiber, functional food products etc.

Among all the states, Madhya Pradesh has covered largest area under organic certification followed by Maharashtra and Rajasthan. The total volume of export during 2015-16 was 263687 MT. The organic food export realization was around 298 million USD. Organic products are exported to European Union, US, Canada, Switzerland, Korea, Australia, New Zealand, South East Asian countries, Middle East, South Africa etc. Oil seeds (50%) lead among the products exported followed by Processed food products (25%), Cereals & Millets (17%), Tea (2%), Pulses (2%), Spices (1%), Dry fruits (1%), and others (APEDA 2017).

Table 11.3: State wise area under organic certification process (including wild harvest) during 2013-14

Sl. No.	State	Area under organic certification (ha)
1	Andhra Pradesh	12325.03
2	Arunachal Pradesh	71.49
3	Assam	2828.26
4	Andaman&Nicobar	321.28
5	Bihar	180.6
6	Chhattisgarh	4113.25
7	Delhi	0.83
8	Goa	12853.94
9	Gujarat	46863.89
10	Haryana	3835.78
11	Himachal Pradesh	4686.05
12	J & K	10035.38
13	Jharkhand	762.30
14	Karnataka	30716.21
15	Kerala	15020.23
16	Lakshadweep	895.91
17	Manipur	0
18	Maharashtra	85536.66
19	Madhya Pradesh	232887.36
20	Mizoram	0
21	Meghalaya	373.13
22	Nagaland	5168.16
23	Orissa	49813.51
24	Puducherry	2.84
25	Punjab	1534.39
26	Rajasthan	66020.35
27	Sikkim	60843.51
28	Tripura	203.56
29	Tamilnadu	3640.07
30	Uttar Pradesh	44670.10
31	Uttarakhand	24739.46
32	West Bengal	2095.51
	Total	**723039.04**

Source: NPOF (National Project on Organic Farming). Committee on estimates 2015-16

11.7 ORGANIC RICE CULTIVATION

India has tremendous potential to become a major exporter of organic rice in the International market. Agricultural and Processed Food Products Export Development Authority (APEDA) made efforts to produce and export basmati rice, aromatic rice and other rice varieties by establishing model farms in states like Punjab, Haryana and Uttar Pradesh. Rice is the major crop that receives maximum quantity of fertilizers (40%) and pesticides (17-18%) and these practices pose major challenges in organic rice farming for nutrient and pest management. All possible organic nutrient sources and how these sources can effectively and efficiently be managed for achieving higher productivity are discussed in detail in this section.

11.7.1 Nutrient management in organic rice production

The success of organic farming depends on the availability of organic resources for recycling of plant nutrients. The animal dung, crop residues, green manures, bio-fertilisers, poultry manure, vermi compost, agro-industrial wastes, food processing waste and urban solid waste are some potential organic sources of nutrients. In addition, the organic farmers are using a wide range of other local products of plant extracts and animal wastes not only to supplement the crop nutritional requirement but also to protect them against pests, with a good measure of success.

The organic nutrient management techniques that can be followed in nursery and main field are described in detail giving several options to the farmers who are willing to practice organic rice cultivation.

11.7.1.1 Nursery management

Seed bed preparation: During seed bed preparation, organic manures such as FYM, Compost, vermi-compost can be used @ 5t/ha

Seed treatment: Seed treatment is very important as it helps to improve the germination potential, vigour, hardening against drought, environmental shocks and resistance to pests and diseases. The recommended seed treatment techniques using bio-fertilisers are:

1. Seed treatment with Azospirillum and/or phosphorus solubilizing bacteria (PSB) or phosphorus solubilising micro organisms (PSM) @ 10 g each/kg seed.
2. Seedling root dipping in Azospirillum and/or PSB/PSM suspension prepared with 600 g of culture for seedlings sufficient to transplant in a hectare of land. Some other popular seed treatment methods

followed by farmers are treating with cow urine, cow milk, wood ash and hot water treatment.

11.7.1.2 Main field management

In the main field, only organic manures/crop residues/green manures are to be utilized to supply plant nutrients based on soil test recommendations of the location. Nutrient concentrations and moisture content of organic manures, their contribution to plant uptake and crop nutrient requirement are to be evaluated to estimate the quantity of organic sources. Rice requires 16 - 21 kg N, 5 – 9 kg P_2O_5 and 20 – 25 kg K_2O to yield a ton of paddy. During land preparation and puddling, 10 tons of FYM/ha along with 5 tons paddy straw and 10 tons of *insitu* grown dhaincha/sunhemp green manure/ha needs to be incorporated. In the last puddle, vermi-compost @ 2 t/ha may be applied (optional). Through these organics, approximately 150 kg N, 40 -50 kg P_2O_5 and 100 – 120 kg K_2O can be supplied which take care of crop NPK needs to a large extent depending on their mineralization and release of nutrients. In addition to NPK, these organics supply micronutrients also in required quantities.

Bio-fertilizers such as Azospirillum or PSB/PSM @ 2 – 3 kg culture/ha can be mixed with 25 kg FYM or vermi-compost and applied to the soil just before planting. Blue green algae @ 10 kg/ha, 10 days after planting is also recommended. If possible, Azolla @ 1 t/ha can be added 7 – 10 days after transplanting and incorporated after 3 weeks. Azolla can also be used as a green manure @ 6 t/ha and incorporated before transplanting. All these bio-fertilizers may add 30 – 40 kg N on an average. Bio-fertilisers, in addition to improving the availability of major nutrients like N and P are also known to produce various growth promoting substances and the nutrients release will be staggered and made available slowly to the plants over an extended period of time thus minimizing nutrient losses through leaching, volatalisation and competition from weeds.

11.7.1.3 Important organic sources for nutrient management

1. Organic manures, 2. Crop residues, 3. Green manures, 4. Bio-fertilisers, 5. Inclusion of Legumes, 6. Agro industrial wastes, 7. Multi variety seed sowing (Dabholkar method), 8. Organic solutions and preparations.

11.7.1.3.1 Organic manures

Organic manures constitute an important component of organic farming. The benefits of organic manures include: slow release of N and other nutrients; they are sources of almost all the plant nutrients and also effectively solubilise nutrients from mineral components in soil; improve the soil structure and other soil physical properties. They generate high levels of biological activity of soil microorganisms and also reduce the toxic effects of agri-chemicals and other heavy metals. Organic manures include: Farm yard manure (FYM), compost, vermi-compost, coirpith compost, other organic wastes like urban solid and human wastes (bio solids), poultry litter, sheep and goat manure, slaughter house waste, animal and fish wastes and several edible and non-edible oil seed cakes. Efficient live stock waste management would not only cut down the pollution, but also provide farmers with a useful source of less costly organic fertilizers. Many long term fertilizer experiments have revealed the beneficial role of FYM by increasing crop yields over the years besides improving soil physical and chemical properties.

Method of application: To derive maximum benefit, the organic manures should be immediately spread and mixed into the soil without leaving them in small piles in the fields for a long period. Under tropical climatic conditions existing in India, organic matter is quickly lost and hence fresh applications are necessary to obtain increased yields and maintain soil fertility.

FYM

Vermicompost

Poultry manure

Coirpith compost

11.7.1.3.2 Crop residues

Crop residues can be recycled into the soil by different methods such as incorporation, mulching, composting and partial burning which will eventually improve the chemical, physical and biological properties of the soil resulting in higher crop productivity. Substantial quantities of crop residues (about 330 m.t.) are produced in India every year. Half of these are used as cattle feed and the rest 50% can be recycled for their beneficial effects on soils and plants. Cereal straws/residues on an average contain 40-45% C, 0.5-0.8% N, 0.1-0.2% P, 1.0-1.5% K and 5-10% Si. Thus, 1 ton of rice straw contains approximately 400-450 kg C, 5-8 kg N, 1-2 kg P, 10-15 kg K and 50-100 kg Si. Legume residues have much higher potential qualitatively as they are readily decomposed.

Method of application: Crop residues can be recycled by methods such as incorporation, mulching, composting and burning. Incorporation is better way of application. Immobilisation of N is usually associated with high C/N cereal straws and by mixing them with green manures of narrow C/N ratio (in 1:2 proportion), temporary immobilization can be avoided and N release can be accelerated. Another way is by delayed planting (1-2 weeks) after incorporation. In mulching, though decomposition is a slow process, its biomass and C/N ratio during the course of one crop season is appreciably reduced and this facilitates its easy incorporation in next season. Mulch helps in controlling weeds and conserving moisture. Though burning facilitates easy and quick disposal of residues and promotes partial sterilization of soil, the draw back is, it causes energy and nutrient losses and atmospheric pollution besides killing soil biota which is not a desired practice in organic farming.


Paddy straw and its incorporation along with green manure

11.7.1.3.3 Green manures

Green manures (GM) play a major role in integrated nutrient management (INM) especially if they are grown in off season utilizing either early monsoon showers or where good irrigation facilities are available. Dual purpose grain legumes like green gram and cow pea are most promising as they offer immediate economic benefit through their grain (4-5 q/ha) and can be incorporated into the soil before transplanting *kharif* rice. Among the sole green manure crops, dhaincha (*Sesbania aculeata*) and sunnhemp (*Crotalaria juncea*) are most suitable as they put up sufficient biomass (22-40 t/ha) in a minimum required period of 45-60 days. They add on an average 60-80 kg N/ha in addition to other nutrients. They also recycle sub soil nutrients and improve soil physical condition. Further, they contribute to the active pool of soil organic matter consisting of microbial biomass/enzymes and other secretory products from soil biota contributing to soil quality improvement.

Method of incorporation: The GM crops are grown up to 8 weeks in the field and then incorporated into the soil before they start seeding. In case of grain legumes, after taking the economic end product that is grain, the residues can be incorporated into the soil. The important caution to be exercised is that transplanting of rice should be done with in 1 or 2 days of incorporation since 50% of N is known to be released within 3 weeks which may be prone to severe losses in the absence of absorbing roots in case of delayed planting practiced traditionally across the country.

Sunnhemp

Cowpea

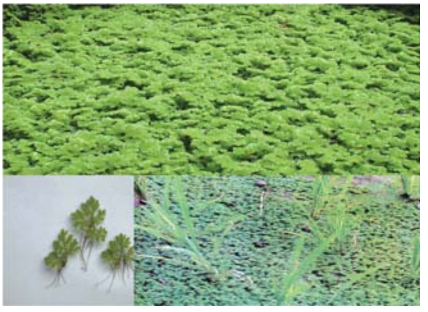
Dhaincha

Incroporation of green manures

Different green manure crops and their incorporation

11.7.1.3.4 Biofertilizers

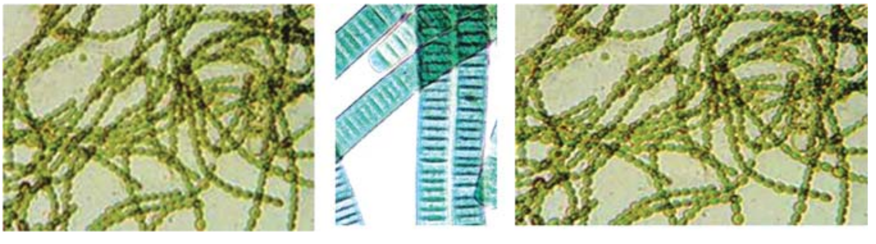
Biofertilizers, also known as microbial inoculants, contain actively living cells of micro organisms which are proven as efficient nitrogen fixers or perform other functions such as phosphate and other mineral solubilisation which beneficially affect plant growth and yield of crops. N and P are the main nutrients that can be supplemented by bio fertilizers to rice. Azolla, blue green algae (BGA) and Azospirillum for N and phosphate solubilising microorganisms for P are important to rice.



Azolla

a) Azolla: Azolla is an aquatic fern (non seeding plant) widely distributed in water bodies and harbours a blue green algae, *Anabaena*. N fixed by azolla in association with anabaena becomes available to the rice plant after the decomposition of azolla, which is therefore comparable to green manuring. Inoculation of Azolla either as a green manure @ 3-4 t/ha 15 days before transplanting or as a dual crop 1-2 weeks after transplanting and incorporating after 2-3 weeks is reported to contribute 10-50 kg N/ha/crop.

b) Blue green algae (BGA): BGA occur abundantly in soils and can fix atmospheric N by non-symbiotic N fixation. Besides N fixation, BGA synthesise and excrete several growth promoting substances like auxins and ascorbic acid. Inoculation of BGA @ 10 kg/ha adds about 30 kg N/ ha.



Blue green algae

c) Azospirillum: This organism, a bacterium fixes atmospheric N by the process, associative symbiosis in association with the root tissues using the root exudates. It is also known to produce growth promoting substances such as Indole acetic acid (IAA), Gibberellic acid (GA) etc. Azospirillum inoculation @ 600 g/ha in nursery and 2 kg/ha in the main field are reported to contribute on an average 20-30 kg N/ha.

d) Phosphate solubilising micro organisms: They are a group of heterotrophic micro organisms (bacteria and fungi) which have the ability to solubilise/mineralise insoluble inorganic/organic P sources to forms available to the plant. Inorganic P is solubilised by the production of organic acids like citric, fumaric, malic etc. by the microorganisms whereas organic P is mineralized through production of phosphatases. Inoculation of 5-6 kg PSB/ha as soil application is generally recommended.

Phosphate solubilising bacteria (PSB)

11.7.1.3.5 Inclusion of Legumes

Rice monocropping is not a sound nutrient management practice as it leads to mining of same soil horizons repeatedly. Rice-rice system (anaerobic-anaerobic) is known to build up phenol rich difficultly decomposable organic matter and in the process, a lot of N is locked in through immobilisation. Legumes are considered as soil builders and rice-legume cultivation system is more ideal in terms of nutrient addition, especially N and also helps regenerate disturbed rice soil structure (on account of puddling) through their favourable rhizosphere effects. Similarly, in upland rice-chick pea system, the legume component improves P availability by acidifying its rhizosphere due to its acidic root exudates like citric acid. This supplies P in addition to N to the succeeding upland rice which lacks advantage of flooding. Inclusion of legumes in the cropping sequence gives a lot of scope to economise on certain nutrients.


Field Bean+red gram


Red gram


Chickpea


Green gram


Groundnut

11.7.1.3.6 Agro – Industrial wastes

Agro-industries are based not only on crops such as rice, sugarcane, jute, tea, coffee, fruits and vegetables but also based on forest products (non edible oil seeds, wood, lac etc.), marine products (prawns, fish, frogs and sea weeds) and slaughter house wastes and dead animal carcases. Recyclable agro-industrial products like rice husk, bran, bagasse, pressmud, coir pith, sewage sludge, seed cakes and wastes from marine industry are not put to use and if properly used, they help in reducing the off-farm inputs


Pressmud


Bagasse


Cotton cake


Groundnut cake

needed. However, much work has not been done on the use of these wastes in improving the yields and soil quality particularly with respect to spread of parasites and pathogens adversely affecting human and animal health.

11.7.1.3.7 Multi variety seed sowing (Dabholkar method)

This method has been developed by a mathematician by training Mr. Dabholkar from Maharashtra state who did a lot of experiments on soil fertility and organic farming (Dabholkar 2001). This method is similar to green manuring. But, in this method, 20-30 diverse, short duration crops involving cereals (jowar, bajra, ragi, korra etc.), pulses (black gram, green gram, Bengal gram, cowpea etc.), oil seeds (sesame, sunflower, groundnut, castor etc.), legumes (pillipesara, dhaincha, sunnhemp, subabul etc.), and spices (coriander, jeera, mustard, fenugreek etc.) will be grown *in situ* and incorporated into the soil after 30-40 days. The seed rate recommended is 50-60 kg/ha. For normal soils of moderate or optimal fertility, this process is recommended once in between two main crops. If the soil fertility is very poor and in case of problem soils, same process has to be repeated for a period of 60 days and then the crops have to be incorporated. This process has to be repeated for the third time for a period of four months (120 days) and then the crops have to be incorporated. By this way, the degraded soil will regain its fertility and sustain the productivity of the main crop.

The philosophy behind this method is that different crops take up varying quantities of nutrients from various depths due to their rooting depth differences and their need and deposit them on the top layers when they are incorporated into the same soil. In this process, the soils become highly fertile and all the plant nutrients, including micro nutrients will be made available to the succeeding rice crop.

11.7.1.3.8 Organic solutions

"Panchagavya" and "Amruthajalam" are organic solutions and alternatives to chemical fertilizers (Vijayalakshmi *et al.* 2004 and MOFF 2006). Some of the farmers practicing organic farming and system of rice intensification (SRI) cultivation used these organic solutions in their crop and reported good results.

Panchagavya: For this, 5 kg cow dung+ 5 litres cow urine+ 2 litres cow milk+ 2 litres cow butter milk+ 500 g cow ghee + 500 g jaggery are required. Initially, dung and ghee are mixed and kept in a pot for 4 days and on the 5th day, the remaining ingredients are added and allowed to ferment for 15 days. The contents are stirred three times daily in the morning, afternoon and evening.

Method of application: 250 ml panchagavya mixed with 10 litres water can be sprayed on the crop. Depending on the crop growth, 200-300 litres/ acre can be sprayed 2 – 3 times during active growth period of the crop.

Amruthajalam: 1 litre cow urine + 1 kg cow dung+250 g jaggery+ 10 litres water are required for preparing this. All these contents are mixed and allowed to ferment for one day.

Method of application: To 1 litre of amruthajalam, 10 litres water is mixed, filtered and the filtered solution can be sprayed on the crop @200-300 litres/acre, 2 – 3 times during active growth period of the crop.

Any easily available and local organic source (preferably on-farm) should be efficiently utilized rather than going for scarce organic manures at higher price. Based on the nutrient concentration, moisture content and C/N ratio, a combination of different organic sources can be used in a balanced proportion to avoid excess build up of only certain elements.

11.8. INDIGENOUS TECHNICAL KNOWLEDGE (ITK)

Indigenous Technical Knowledge (ITK) is the knowledge that people of a particular community have acquired from their ancestors or developed from their personal experience. It is based on experience, often tested over long period of use, adapted to local culture and environment, dynamic and changing, and lay emphasis on minimizing risks rather than maximizing profits. This traditional knowledge evolved from the experiences of farmers is found to possess practical utility in solving some of the farmer's problems under their own conditions. Most of these ITKs can be efficiently utilized in organic rice farming as they have been verified scientifically and found effective in improving soil fertility and managing pests. Some important ITKs (Muthuraman *et al.* 2009) that can be adopted in organic rice farming for soil fertility management are listed here:

11.8.1 Soil fertility management

- Mixing of rice husk with excreta of poultry birds, cattle, pigs and ash and its application to soil
- Collection of soil from the base of the pond and its application to the main field during summer
- Sheep and goat penning in the field
- Water hyacinth compost
- Walking in the rice field and/or using a weeder for better aeration to control iron toxicity
- Application of wild indigo (*Wrightia tinctoria*) and *Pongamia pinnata* leaves
- Left over material of animal feed on the bedding along with urine and excreta of animals

> *ITKs that are locally and easily available, proved effective without having any side effects and have been in practice for hundreds of years of adoption may prove a low cost ideal tool for sustainable organic rice farming.*

11.9 RESEARCH EXPERIENCE ON ORGANIC RICE FARMING AT IIRR

Field experiments were conducted spread over five years (2004-05 to 2009-10) covering ten rice cropping seasons [five wet (WS, *kharif*) and five dry (DS, *rabi*)] on a deep black clayey vertisol (Typic pellustert) at the ICAR-Indian Institute of Rice Research (IIRR) farm, Rajendranagar, Hyderabad to compare the influence of organic and conventional farming systems on productivity of super fine rice varieties, BPT 5204 (WS) and Vasumati (DS), pest dynamics, grain quality and soil health. The experimental soil characteristics were: slightly alkaline (pH 8.2); non-saline (EC 0.71 dS/m); calcareous (free $CaCO_3$ 5.01%); with CEC 44.1 C mol (p+)/kg soil and medium soil organic carbon (0.69%) content. Soil available N was low (228 kg/ha); available phosphorus was high (105 kg P_2O_5 /ha);

FIELD LAYOUT

available potassium was high (530 kg K_2O /ha) and available zinc was also high (12.5 ppm).

The organic sources used were: green manure, dhaincha (*Sesbania aculeata*) + paddy straw during wet seasons (WS) and poultry manure + paddy straw during dry seasons (DS). The local recommended dose of inorganic fertilizers were given to conventional system @ 100-40-40 kg N, P_2O_5, K_2O/ha during WS and 120-40-40-10 kg N, P_2O_5, K_2O and Zn /ha during DS through urea, single super phosphate, muriate of potash and Zinc sulphate, respectively. Nitrogen was applied in three equal splits at basal, maximum tillering and panicle initiation stages while P, K and Zn were applied as basal doses only. Through organics, N dose was adjusted to recommended level based on their moisture content and 'N' concentration on dry weight basis. Organic fertilizers were incorporated one day before transplanting rice.

The results pertaining to grain yield trends, grain quality parameters, pest incidence and parasitism, impact on soil microbial and nematode communities, soil quality parameters, pesticide residue analysis and economics of the study are presented and discussed here.

11.9.1 Grain yield trends

During *kharif*, grain yields in the inorganic fertilizer applied plots were near stable ranging from 5.2-5.5 t/ha and superior to organics during the first two years (2004-06) by 15-20% which improved with organics (4.8-5.4 t/ha) in the later years to comparable levels with inorganics (Table 4). However, During *rabi*, inorganics were superior to organics for four years and both were at par in the fifth year. This could be due to mismatch of nutrient release from organic sources and crop demand as influenced by seasonal conditions in the initial years and once the soil fertility was built up sufficiently, organic system also produced equal yields as conventional system. Thus, slow and gradual release of nutrients from organics during the initial years of conversion to organic farming could not result in increased yields. But, repeated application of organics over the years may build up, stabilize and improve soil fertility by improving soil biological activity.

Table 11.4: Grain yield (t/ha) as influenced by nutrient sources

Year	Wet season (*kharif*) –BPT5204		Dry season (*rabi*) - Vasumati	
	Inorganics	Organics	Inorganics	Organics
2004-05	5.47a	4.68b	3.79a	3.52b
2005-06	5.35a	4.59b	3.74a	3.10b
2006-07	5.20a	4.85a	3.81a	3.14b
2008-09	5.33a	5.23a	3.76a	3.27b
2009-10	5.23a	5.36a	4.18a	3.98a

Figures within the same row with different letters in a particular season differ significantly (p=0.05)

Under organic farming, productivity would increase on a long-term basis due to improvement in overall soil environment.

11.9.2 Grain quality parameters

Physical grain quality parameters- milling%, hulling%, head rice recovery (HRR), L/B ratio; cooking quality parameters- amylose content and elongation ratio were not influenced by the nutrient sources even after 4 years of study. However, in the fifth year, there was an improvement in HRR by 9.5% with organics over inorganics (Tables 5 and 6). Similarly, there was an improvement in elongation ratio by 4.1% with organics over inorganics. Whereas, moderate improvement in nutritional quality parameters such as protein, phosphorus and potassium contents was recorded with organics compared to inorganics and brown rice recorded higher values (by 5-16%) than polished rice (by 1-6%).

11.9.3 Pest incidence and parasitism

Observations on pest and preponderance of natural enemies of pests were recorded on 20 randomly marked hills in each plot. Number of dead hearts and white ears in case of stem borer, silver shoots in case of gall midge, number of damaged leaves in case of foliage feeders such as whorl maggot and leaf folder were recorded. Stem borer egg parasitism, larval parasitism, gall midge larval parasitism was observed by collecting the stem borer eggs, dead hearts, white ears and galls respectively. BPH nymphs / adults were artificially released in the polythene cages kept in the field. Observations were recorded on the number of BPH / hill, number of predators such as mirid bugs (*Tytthus parviceps* and *Cyrtorhinus lividipennis*), spiders, coccinellids, and % hopper burn.

Table 11.5: Grain quality parameters as influenced by nutrient sources (5th year)

	Physical quality								Cooking quality			
Treatments	Hulling %		Milling%		Head rice recovery %		L/B ratio		Elongation ratio		Amylose %	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Inorganics	79	77	68	64	28	51	4.26	2.68	2.05	1.69	25.7	24.2
Organics	77	77	66	64	25	56	4.22	2.66	2.09	1.76	26.0	24.0
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.039	0.041	NS	NS

Table 11.6: Grain quality (nutritional) parameters as influenced by nutrient sources(5th year)

Treatments	Protein %				Phosphorus (g/kg)				Potassium (g/kg)			
	BR		WR		BR		WR		BR		WR	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Inorganics	8.55	8.31	8.16	7.56	1.7	3.2	1.0	1.0	1.7	2.3	1.0	1.0
Organics	8.58	8.71	8.14	7.76	2.0	3.3	1.1	1.2	1.9	2.5	1.1	1.2
CD(0.05)	NS	NS	NS	NS	0.25	0.32	0.08	NS	0.11	0.15	NS	NS

BR-Brown rice; WR- white rice; DS- Dry season; WS- Wet season

The mean values of five years data are reported in Figures 1 and 2. Stem borer damage recorded as dead hearts ranged from 4.5% to 10.6% during the vegetative stage and 0.4% to 4.5% (white ears) in the pre-harvest stage in *kharif* season. In the *rabi* season, during vegetative stage, the stem borer incidence ranged from 6.5% to 20.9% (dead hearts) and 2 to 17% (white ears) in the reproductive stage. There was a slight difference in the stem borer incidence in the organic and inorganic treatments during *rabi* and *kharif* seasons. The mean dead hearts % was same in orgainic (8.4%) and inorganic (8.3%) treatments. Whereas, the white ears were slightly more in inorganic treatment (2.8%) compared to organics (2.5%) in the *kharif* season. In the *rabi* season, dead hearts were less (13.6%) and white ears were more (7.7%) in the organic treatment compared to inorganic treatment where dead hearts and white ears were 14.7 % and 6.9 %, respectively (Surekha *et al*. 2010).

Stem borer egg mass parasitism ranged from 91.2 to 97.6% during *kharif* season and in *rabi* season it was 69.2 to 86.7%. Significant differences were not observed in the parasitism between organic (94 .6%) and inorganic treatments (94.1%) in the *kharif* season whereas parasitism was more in inorganics (86.7%) compared to organics (69.2%) in the *rabi* season. The predominant egg parasitoid was *Tetrastichus schoenobii*, among the three parasitoids observed viz., *T. schoenobii*, *Telenomus* dignus and *Trichogramma japonica*. Gall midge damage ranged from 0.4% to 7.6% (silver shoots) in the *kharif* season and it was not observed during *rabi* season and the damage was same both in organic (5.9% silver shoots) and inorganic (5.8% silver shoots) systems. Gall midge larval parasitism due to *Platygaster oryzae* ranged from 14.5 to 61.2% and overall mean parasitism was more in the organic treatment (40.9%) compared to inorganics (30.3%). Leaf folder damage ranged from 0.4 to 4.8% and significant differences were not observed between organics (2% and 0.7% LFDL in *kharif* and *rabi*, respectively) and inorganics (2.1% in *kharif* and 7% LFDL in *rabi*). In case of BPH where insects were

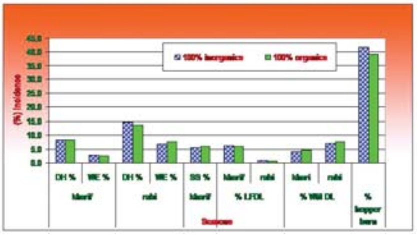


Fig. 1. Incidence of insect pests in inorganic and organic rice systems

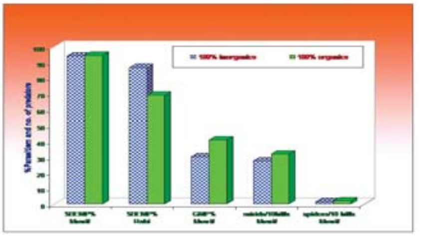


Fig. 2. Incidence of natural enemies in inorganic and organic rice systems

released artificially in the confined cages (one m^2 area), hopper burn was 42% with inorganics as compared to 39% with organics. Mirid bugs and spiders, the predaors were more in the organic treatment compared to inorganics.

The reason for non-significant differences between organic and inorganic treatments in the present study could be due to the application of recommended dose of nutrients in both systems that prevented the build up of pest pressure to reach economic threshold (ET) levels in inorganic system which otherwise happens normally with increased/indiscriminate use of fertilizers. No major disease incidence was observed throughout the experiment in both organic and inorganic production systems.

11.9.4 Soil quality parameters

Changes in soil quality parameters were monitored at the end of five years and presented in Table 11.7. There was a significant improvement in soil physical (bulk density and penetration resistance), fertility (organic carbon and available N, P and K) and biological properties (soil respiration and enzyme activities viz., glucosidase, phosphatase and dehydrogenase) with organics compared to inorganic fertilisers. Compared to inorganics, there was an increase in soil organic carbon (SOC), available N, P and K by 58, 14, 17, and 8 % with organics, respectively, at the end of five years. Paddy straw being rich in potassium and poultry manure with high phosphorus content are the possible factors responsible for the observed increase in soil P and K values in treatments where these two organic sources were used. A further reason for the SOC increase may be the slow decomposition of applied and native soil organic matter due to

Table 11.7: Soil quality parameters after five years under organic and conventional rice cultivation systems

Trts.	Physical parameters		Fertility indicators				Biological parameters			
	BD Mg/m^3	PR kg/cm^2	SOC %	N kg/ha	P2O5 kg/ha	K2O kg/ha	SR	Bg	AP	DH
Inorganics	1.48	11.8	0.64	225	157	548	0.173	140	458	1352
Organics	1.30	7.7	1.01	256	184	592	0.208	162	563	1623
CD (0.05)	0.07	1.45	0.12	NS	14	41	0.024	20	77	32

BD- Bulk density; PR- Penetration resistance; SOC- Soil organic carbon; SR-Soil respiration in mg CO_2/24h/g; Bg- Beta glucosidase and AP- Alkaline phosphatase in µg p-nitrophenol/g/h; DH- dehydrogenase in µg Triphenyl formazon/g/24h

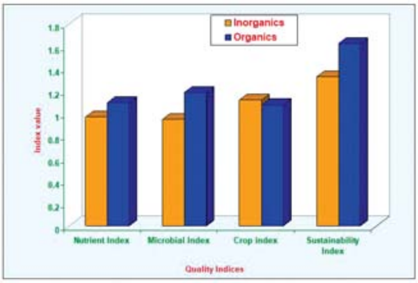


Fig. 3. Soil quality indices in organic and inorganic rice cultivation systems

prevailing anoxic conditions and formation of difficultly decomposable SOC under rice-rice system (Ponnamperuma 1984).

Soil enzyme activities in soil were also influenced by different treatments. Enzymes catalyse the biochemical reactions involved in nutrient cycling in soils. â - glucosidase, involved in carbon cycling; alkaline phosphatase, that plays a major role in the mineralization of organic phosphorus substrates and dehydrogenase, which is an indicator of total microbial activity were significantly higher with organics compared to inorganics. Soil respiration, another important indicator of soil biological activity was also significantly higher with organics over inorganics. Addition of organic sources provide a stable supply of C and energy for micro-organisms and cause an increase in the microbial biomass pool, thereby increasing rate of soil respiration.

Soil quality, as measured by different indices viz., nutrient index (NI), microbial index (MI) and crop index (CI) indicated maximum nutrient (1.10) and microbial (1.19) indices with organics and inorganics recorded 0.97 & 0.95 NI & MI values, respectively (Figure 3). Whereas, the crop index was maximum with inorganics (1.12) compared to organics (1.08). The sustainability index (SI) of the soil system, measured from above three indices was maximum with organics (1.63) and inorganics recorded 1.33, which was just above the minimum sustainability index of 1.30. Kang *et al.* (2005) reported that long-term application of organic manures in rice–wheat cropping system increased the sustainability index value (2.20) due to improved values of nutrient index, microbial index and crop index of soils as compared to the chemical fertilizers alone that resulted in poor sustainability index of 1.16.

11.9.5 Pesticide residue analysis

Though overall pesticide consumption in our country is very low compared to that of developed countries, still the problem of residues in food and feed is much higher under conventional farming. Despite very low consumption, the reasons for higher pesticide residues are: indiscriminate use; non-observance of waiting period; use of sub-standard pesticides; continuance of DDT and other persistent pesticides in public health programmes; pesticide use in storage and transit and treatment of fruits and vegetables with pesticides. There are frequent reports of rejection of consignments of Indian agricultural products for export by the US and EU countries due to detection of pesticide residues and non-compliance with phytosanitary and sanitary standards.

Reducing dietary exposure to pesticide residues is an important goal of public health and environmental protection officials, farmers and other segments of the food industry, and consumers. Though not much study has been made in this direction, organic agriculture, with its strictures against the use of synthetic chemical inputs, seems to offer a low-residue alternative to conventionally-grown produce.

Pesticide residue analysis was done in grain, straw and soil samples (11.8). Most of the residues were below detectable limits (BDL) in grain, brown rice and white rice with an exception in a few samples where BHC (CHC compound), dimethioate and chlorpyriphos (OP compounds), butachlor (herbicide) were detected. But, all these residues were below permissible limits. Very low levels of residues are recorded mainly as drift from conventional farming and from the persistent chemicals used over the past few decades.

- Chlorinated hydrocarbons (CHC) or organo chlorine (OCs) and organo phosphate (OPs) group of pesticide residues are detected in plant and soil samples. CHCs are more than OP residues in general in plant and soil. Among CHCs, residues of BHC are detected in more number of samples than endosulfan and DDT with higher residue levels in straw than in grain.
- Whole grain and brown rice detected more residues and polished rice has negligible and BDL values as most of them are removed during processing.
- Among OPs, Chlorpyriphos is the only OP compound used in the experiment that was detected in plant and soil samples. OP residue levels are also slightly higher in straw than in grain. OPs are in BDL in polished rice.
- Herbicide residues were detected in a few grain and straw samples and were in BDL in soils.
- No clearcut differences were noticed in pesticide residue accumulation between organic and inorganic production systems.

In the present study, the residues of pesticides recommended for use in conventional system were not detected in grain and straw at harvest

Table 11.8: Pesticide Residues detected* (ppm) in organically and conventionally cultivated Rice

Residues	Grain		Straw		Brown rice		White rice		Soil	
					CHC(OCs)					
	Inorganics	**Organics**	**Inorganics**	**Organics**	**Inorganics**	**Organics**	**Inorganics**	**Organics**	**Inorganics**	**Organics**
BHC	BDL-0.02	BDL-0.02	0.05-0.09	0.01-0.03	0.01-0.011	0.005-0.01	BDL-0.005	BDL-0.001	BDL-0.006	BDL-0.018
Endosulfan	0.025-0.04	BDL-0.005	0.06-0.08	0.05-0.07	BDL-0.05	BDL-0.02	BDL	BDL-0.008	BDL	BDL
DDT	BDL-0.07	BDL-0.01	0.06-0.07	0.014-0.04	BDL-0.012	BDL-0.01	BDL-0.003	BDL-0.002	BDL-0.009	BDL-0.008
					OPs					
Dimethioate	BDL-0.065	BDL-0.056	0.04-0.130	BDL-0.06	0.037-0.039	0.02-0.04	BDL	BDL	BDL-0.024	BDL-0.005
Methyl parathion	BDL-0.013	BDL-0.011	BDL-0.245	BDL-0.08	BDL-04	BDL-0.02	BDL	BDL	BDL	BDL
Fenitrothion	BDL-0.008	BDL-0.001	BDL-0.06	BDL-0.04	BDL-0.09	BDL-0.002	BDL	BDL	BDL	BDL
Malathion	BDL-0.186	BDL-0.08	BDL	BDL	0.073	0.06	BDL	BDL	BDL	BDL
Chlorpyriphos	BDL-0.03	BDL-0.02	0.024	0.023	0.033-0.049	0.02-0.04	BDL	BDL	0.219	BDL-0.01
					Herbicide					
Butachlor	BDL-0.002	BDL-0.001	BDL-0.086	BDL-0.009	BDL	BDL	BDL	BDL	BDL	BDL

* Range of 8 values of 4 seasons; BDL- Below detectable limits

since all these new molecules are easily biodegradable and are not persistent. However, some of the pesticide residues pre-existing in soil (eg: BHC and DDT) were detected in grain, straw and soil at harvest both in organic and conventional systems indicating their long term persistence in soil. Most of the residues in organic foods can readily be explained as the unavoidable results of environmental contamination by past pesticide use, or by "drift" (sprays blown in from adjacent non-organic farms).

Persistence of pesticide residues in grain is also detrimental to the rice exports, which are planned to be stepped up in future

11.9.6 Economics of organic and conventional rice cultivation systems

Rice produced in transition to organic cultivation from chemical cultivation cannot be sold as organic and therefore cannot take advantage of potential organic pricing premiums. Pricing premiums for organic commodities are dependent on market demand as well as the amount of production in any given year and are fragile in nature.

Total cost of cultivation, gross returns, net returns and benefit :cost ratio were calculated at the end of first and fifth years of study under inorganic and organic production systems (Table 11.9). In the first year, net returns were calculated without price premium for the organic rice. Benefit cost ratio was less with organics (1.09:1) compared to inorganics (1.37:1) in the first year which improved with organics (1.99:1) over inorganics (1.75:1) by fifth year.

Table 11. 9: Cost of Cultivation and net returns/ha/annum under organic and conventional systems of rice cultivation

Treatments	**Year 1 (2004-05 [*kharif+rabi*])**			
	Total cost (Rs.)	Gross returns (Rs.)	Net returns (Rs.)	B:C ratio
Inorganics	35,045	48,152	13,107	1.37:1
Organics	38,950	42,640	3,690	1.09: 1
	Year 5 (2009-10 [*kharif+rabi*])			
Inorganics	50,995	89,395	38,400	1.75:1
Organics	58,600	1,16,750	53,480	1.99:1

High cost of certification had always been a matter of concern for small and marginal farmers. But with increasing competition, more number of producers and introduction of Grower Group Certification (GGC) system, per farmer costs have been reduced substantially. The costs which were ranging from 1.5 to 2.0 lakh per individual project and Rs. 500 to 2500 per farmer in groups have come down to Rs. 45,000 to 75,000/- in case of individual projects and Rs. 100-150/- per farmer in groups. Recently, initiatives taken up by Government of India to promote State Government bodies as certification agencies has further reduced the prices.

Organic farming is more profitable due to low input cost and a premium price on the organic produce. Unlike conventional agriculture, there are no diminishing returns due to continued use of production inputs under organic regime.

11.10 FARMERS' PERCEPTION AND FEED BACK ON ORGANIC RICE FARMING

Farmers' perception and feed back was collected from a model organic village, "Enabavi" and provided in Table 11.10. In general, all the farmers expressed their satisfaction over organic farming as they could reduce the cost of cultivation and lead a better and healthy life.

Table 11.10: Farmers' Perception and Feed back on organic farming

S.No.	Perception/Feed back	% of farmers
1	Improved soil quality	87 %
2	Reduced cost of cultivation	83 %
3	Good seed quality & taste	83 %
4	More head rice, more grain weight & less brokens	83 %
5	No health problems & health Improvement	33 %
6	Higher price in local market	33 %
7	Followed by farmers of near by village	33 %
8	Less chaff and more filled grain	27 %
9	Crop withstands well under drought	17 %
10	Reduced environmental pollution	17 %
11	To provide marketing facility to get higher price	83 %
12	More organic sources should be available at cheaper price	33 %
13	Fertilizer companies should manufacture organic manures	17 %
14	More knowledge, information & guidance to be provided.	17 %

Interaction meeting with farmers

Farmers in their fields

11.11 GENERAL CONCLUSIONS BASED ON RESEARCH DATA OF IIRR AND THE ENABAVI EXPERIENCE

Global demand for organically grown foods is increasing and organic agriculture is growing fast in recent years. As a result, the area under organic farming and the number of countries practicing it are also increasing every year. India is not an exception with considerable land area under organic farming and most of the North Eastern States have been declared as organic though by default.

From the present research study at IIRR, it can be concluded that organic system of rice production needs more than two years period to stabilize rice productivity and bring about perceptible improvement in soil quality, sustainability indices and economic returns under intensive, irrigated rice-rice system in vertisols of tropical climate.

Hence, resorting to the use of available local natural resources, organic farming can be practiced with a view to protect/preserve/safeguard natural resources and environment for a fertile soil, healthy crop and quality food and let our future generations enjoy the benefits of non-chemical agriculture. Organic farming should not look at yields alone but also at replenishment of resources, especially, soil fertility. Given the same profitability, organic farming is more advantageous than conventional farming considering its contribution to health, environment, and sustainability.

> *In reality, yield can not be looked at in a narrow sense and defined as the grain produce alone; yield in real sense should include improvement to soil fertility factor and for all the by-products from the main crops*

11.12 MAJOR PROBLEMS/CHALLENGES IN ORGANIC RICE FARMING

- Lack of availability of organics in large quantities to meet exact crop nutrient requirements at appropriate time.
- Lack of knowledge/know how on organic rice cultivation and limited access to advanced knowledge and technology for efficient use of organic inputs.
- Lack of knowledge for preparation of good quality organic inputs as standardized procedures for their preparation are not available
- Non availability of good quality organic manures, bio fertilizers, botanicals and bio pesticides and lack of artificial rearing methods for inundative release of biological control agents.
- High cost of organic manures and bio pesticides, more transportation and labour costs for procuring and spreading the manure if purchased from out side leads to high cost of cultivation
- Standardisation of package of practices is difficult because the practices successful at one farm under certain situations may not be applicable else where and location specific practices for efficient use of various organic sources are not available.
- Decomposition of organic manures/crop residues may be a problem under very low temperatures
- Under certain situations, use of huge quantities of organics in rice production may increase the emission of green house gases from the wet land soils
- Wrong perceptions among the farmers that yields are low in organic cultivation which is not true under all situations though initial yield reduction is possible under certain conditions
- Difficulties in the certification procedures in terms of cost, accessibility, cumbersome nature and lack of guidance
- Lack of marketing facilities for selling organic produce in most of the areas
- Lack of interest among the farmers when no price premium is offered for un-certified produce

11.13 FUTURE THRUST AND SUGGESTIONS FOR PROMOTING ORGANIC RICE FARMING

- Promotion of research on various organic nutrient sources, bio control of pests and diseases etc. to arrive at crop specific recommendations
- Production and promotion of standard quality manures and organic pesticides in sufficient quantities and at reasonable prices
- Creation of awareness among farmers about organic farming
- Provision of subsidies and financial support to help marginal and small farmers for initial expenses of converting to certified organic farms
- Reduction of certification costs to make them accessible to small farmers without diluting standards
- Improvement of infra structure such as roads, transportation, storage facilities etc.
- Encouragement to develop domestic market for organic products
- Development of strong linkages between growers and consumers, with minimum influence of middlemen.

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APPENDIX

Products for Use in Fertilising and Soil Conditioning

[Source: National programme for Organic Production (NPOP), Dept. of Commerce, Ministry of commerce and Industry, New Delhi, 2005]

In organic agriculture the maintenance of soil fertility may be achieved through the recycling of organic material whose nutrients are made available to crops through the action of soil micro-organisms and other biota. Many of these inputs are restricted for use in organic production. In this appendix "restricted" means that the conditions and the procedure for use shall be set by the certification programme. Factors such as contamination, risk of nutritional imbalances and depletion of natural resources shall be taken into consideration.

Matter Produced on an Organic Farm Unit

• Farmyard & poultry manure, slurry, urine	Permitted
• Crop residues and green manure	Permitted
• Straw and other mulches	Permitted

Matter Produced Outside the Organic Farm Unit

• Blood meal, meat meal, bone meal and feather meal without Preservatives	Restricted
• Compost made from any carbon based residues (animal excrement including poultry)	Restricted
• Farmyard manure, slurry, urine (preferably after control fermentation and / or appropriate dilution) "factory" farming sources not permitted.	Restricted
• Fish and fish products without preservatives	Restricted
• Guano	Restricted
• Human excrement	Not allowed
• By-products from the food and textile industries of biodegradable material of microbial, plant or animal origin without any synthetic additives	Restricted
• Peat without synthetic additives (prohibited for soil conditioning)	Permitted

• Sawdust, wood shavings, wood provided it comes from untreated wood	Permitted
• Seaweed and seaweed products obtained by physical processes, extraction with water or aqueous acid and/ or alkaline solution	Restricted
• Sewage sludge and urban composts from separated sources which are monitored for contamination	Restricted
• Straw	Restricted
• Vermicasts	Restricted
• Animal charcol	Restricted
• Compost and spent mushroom and vermiculate substances	Restricted
• Compost from organic household refuse	Restricted
• Compost from plant residues	Permitted
• By products from oil palm, coconut and cocoa (including empty fruit bunch, palm oil mill effluent (pome), cocoa peat and empty cocoa pods)	Restricted
• By products of industries processing ingredients from organic agriculture	Restricted

Minerals

• Basic slag	Restricted
• Calcareous and magnesium rock	Restricted
• Calcified seaweed	Permitted
• Calcium chloride	Permitted
• Calcium carbonate of natural origin (chalk, limestone, gypsum and phosphate chalk)	Permitted
• Mineral potassium with low chlorine content (e.g. sulphate of potash, kainite, sylvinite, patenkali)	Restricted
• Natural phosphates (e.g. Rock phosphates)	Restricted
• Pulverised rock	Restricted
• Sodium chloride	Permitted
• Trace elements (boron, Fe, Mn, molybolerum, Zn)	Restricted

• Woodash from untreated wood	Restricted
• Potassium sulphate	Restricted
• Magnesium sulphate (Epsom salt)	Permitted
• Gypsum (calcium sulphate)	Permitted
• Stillage and stillage extract	Permitted
• Aluminum calcium phosphate	Restricted
• Sulphur	Restricted
• Stone mill	Restricted
• Clay (bentonite, perlite, zeolite)	Permitted
Microbiological Prepararations	
• Bacterial preparations (biofertilizers)	Permitted
• Biodynamic preparations	Permitted
• Plant preparations and botanical extracts	Permitted
• Vermiculate	Permitted
• Peat	Permitted

"Factory" farming refers to industrial management systems that are heavily reliant on veterinary and feed inputs not permitted in organic agriculture.

Chapter 12

INSECT PEST MANAGEMENT PRACTICES IN ORGANIC PRODUCTION SYSTEM

G. Singh

12.1 INTRODUCTION

The big challenge of the 21st century is the need to feed a fast growing population. There are other challenges like improving the productive capacity of agricultural ecosystems, and the health and integrity of surrounding environments for future generations. Organic farming is gaining popularity worldwide as it minimizes dependence on chemical inputs, thus safe the natural resources and environment. In organic farming, insect pests are the greatest challenge since genetically modified crops and synthetic chemical pesticides are not allowed in organic agriculture. The principle of integrated pest management (IPM) under organic production involves application of ecologically sound strategies. Major emphasis should be give on integration of various tactics and their incorporation into cropping systems should be done to prevent damage from insect pests.The key strategies of IPM of organic farming are selection of resistance/tolerance varieties, planting trap crops, following crop rotation, conservation and use of biological agents to manage the pest below economic injury level (EIL). In such situations, augmentative release of helps in rapid suppression of insect pests. Since no single practice is effective for all insect pests of the crop, a combination of such practices (IPM) is necessary to maintain pest population below the EIL. These practices when used in a compatible manner could make organic ecosystem unattractive to pest species.

Organic agriculture production and Integrated Pest Management can work together to address these challenge. Organic is wholly compatible with advanced, biologically based IPM and most IPM principles and tactics will work in organic systems. Our goals include illuminating ways that organic cultivation and IPM should work together to Sustainable organic production.

The insect pest management in organic farming involves understanding of basic ecological principles using in an agricultural ecosystem. The insect pests management in organic farming depends on preventive methods of control rather than curative methods which are based on ecologically safer management methods. The priority should be given to maintain health of the ecosystem thus plants should be resistance to attack by insect pests. Sound management of ecosystem through little modification in the cultural practices such as trap crop, sowing time, crop rotation, soil quality management through the addition of organic materials constitute the first defense against the attack of insect pests followed by use of the curative methods like use of predators, parasitoids, plant products and ecologically safer chemicals forms the next line of defense against the insect pests.

12.2 INSECT PEST MANAGEMENT STRATEGIES

12.2.1 Modification of cultural practices

Cultural practices are among the oldest techniques used for pest suppression, and many of the preventive practices used in conventional and organic farming today have their roots in traditional agriculture. Slight modification in cultural practices will have an impact on the whole ecosystem. The practices such as crop rotation, intercropping, soil management with addition of organic amendments will enhance agricultural biodiversity and thus have a greater role to play in the management of insect pests as well as the pathogens. The insect pests which have an obligate relationship with host plants can be controlled by adopting crop rotation. Use of resistant host plants forms another cultural method to reduce the damage caused by insect pests. Trap crop and intercrops will reduce the incidence of insect pests on the main crop that help in reducing the pest damage. These methods have certain limitations *viz.*, have to be planned well in advance and these are preventive in nature thus not helpful in case of a severe outbreak of insect pests.

12.2.2 Conservation of natural enemies

Many pest populations can be managed by enhancing the efficacy and augmenting local abundance of existing natural enemies through modification of the environment or existing practices, a practice known as conservation biological control. This practice is of immense importance in case of organic farming thus natural regulation of pest population can be obtained through enhancement of the activity of already existing natural enemies in the production system. The practices such as provision of the nectar providing plants as hedge rows and shelter belts will improve the efficacy of parasitoids and predators in controlling the insect pests. The production strategies such as intercropping and trap cropping also reported to augment natural enemies by providing alternative host as well as source of chemical cues that enhance the activity of biological control agents in cropping system. The planting of perennial flower bearing plants around field has been found to be beneficial in increasing activity of the natural enemies in plantation crops. Shelter belts increase survival percentage of natural enemies in the absence of natural host by providing alternate habitat.

12.2.3 Use of biological control agents

Inundative and inoculative release or applying biological control agents such as insect predators, parasitoids and bio-pesticides (insect pathogens) have a greater role to play in controlling the insect pests in an insecticide free environment. These agents can be used as curative control methods in case of sudden outbreak in insect population. Some of commonly used and potential biological control agents and bio-pesticides for pest management in organic crop production are listed below:

12.2.4 Bio-agents

12.2.4.1 Predators

They are free living, and are usually as big as or bigger than their prey. They consume several too much prey over the course of their development. Some predators, including certain syrphid fly and the common green lacewing, are predaceous only as larvae. Other predators are found in the field in different cropping systems are lady beetle, rove beetle, damsel fly, dragon fly, mired bug, ground beetle, and praying mantis, *Conobertha,* spiders, etc.

12.2.4.2 Parasitoid

Parasitoid means parasite like. Although parasitoids are similar to true parasites, which are generally much smaller than their hosts. As they develop, parasites usually weaken but parasitoids really kill their host.

Egg parasitoids: *Trichogramma* spp.,*Tetrasticus* spp., *Telenomus* spp.,*Ooenocytus pyrillae, Epiricania melanoleuca*)

Larval parasitoids: *Bracon hebetor, Apanteles* spp., *Stenobracon* spp.

Pupal parasitoids: *Xenothopimpla* spp.

Trichogramma spp.

***Trichogramma spp.* On host eggs**

These are small size insects which use eggs of different borers and leaf folder insects as a host. The adult female wasp her eggs inside host eggs and completes all stages in it. From parasitized eggs adult wasp emerges and searches the host eggs to complete her life cycle. One adult female wasp can damage 100 host eggs. This parasitoid available as trichocard bears 18000-20000 eggs per trichocard.

Table 12.1. Use of different *Trichogramma spp.* against different crop insect pests

S.No.	Insect pests	*Trichogramma spp.*	Releasing time and quantity
1	S. cane Top borer	*T. japonicum*	Start after 60 days after planting or occurrence of insects, 100000-150000 eggs per ha. 4-6 time at 10 days interval
2	Rice stem borer	*T. japonicum*	Start after 30 days of transplanting
3	Rice leaf folder	*T. japonicum*	or occurrence of insects, 100000 eggs per ha. 6 time at 8- 10 days interval
4	Bhindi shoot and fruit borer	*T. japonicum*	Start after 30 days of transplanting sowing or occurrence of insects,
5	Pod borer of veg.pea	*T. Chilonis*	100000 eggs per ha.4- 6 time at 8 days interval
6	Maize stem borer	*T. Chilonis*	Start after 15 days of sowing or occurrence of insects, 100000 eggs per ha.4- 6 time at 8 days interval

7	S. cane Early shoot borer	*T. Chilonis*	Start after 45 days of planting or occurrence of insects, 100000-150000 eggs per ha. 6-10 time at 10 days interval
8	S. cane Stalk borer	*T. Chilonis*	Start after 90 days of planting or occurrence of insects, 100000-150000 eggs per ha. 6-10 time at 8
9	S. cane inter node borer	*T. Chilonis*	
10	S. cane gurdashpur borer	*T. Chilonis*	days interval
11	American boll worm	*T. Chilonis*	Start after 45 days of sowing or occurrence of insects, 100000-
12	Pink boll worm	*T. Chilonis*	150000 eggs per ha. 6time at 8
13	Spoited boll worm	*T. Chilonis*	days interval
14	Tomato fruit borer	*T. bressiliensis*	Start after 45 days after transplanting or occurrence of insects, 100000 eggs per ha. 6 time at 8 days interval
15	Diamond back moth	*T. bressiliensis*	Start after 20 days after transplanting or occurrence of insects, 100000 eggs per ha.4-6 time at7- 8 days interval

Note : Trichocard should be cut in to 10 pieces before adult wasp emergence and stapled at lower surface of leaf.

Trichocard

Using methods

12.2.5 Bio-pesticides

Biopesticides are certain types of pesticides that are derived from natural materials like plants (Botanical origin), bacteria, fungi and virus (Microbial origin) and certain minerals. When used as a component of Integrated Pest Management (IPM) programs these bio-pesticides can greatly decrease use of conventional pesticides, while crop yields remain high. Bio-Pesticides control pests selectively or with broad spectrum approach. Bio-pesticides are usually inherently less toxic than conventional pesticides. Bio-pesticides are generally target specific and affect only the target pest and closely related organisms.

12.2.5.1 Bacteria

***Bacillus Thuringiensis* (*B.t.*):** Bt is a ubiquitous gram positive soil bacterium. It has been isolated from soil, stored grain, insect cadavers and the phylloplane. Thus, 3 prevailing niches of *B.t.* can envisaged:

(i) entomopathogen

(ii) phylloplane inhabitant

(iii) soil microorganism

B.t. is recognized by its parasporal body that is proteinaceous in nature and possesses insecticidal properties. It is a bacterium which infected the insect and produced disease. When *B.t.* treated crop is ingested by insects the *B.t.* produce a protein i.e. endo-toxin at mid gut (High pH-9.0). With in minute the toxin binds with specific receptors in mid gut wall. With in hours mid gut wall broken down and allowing spores to enter in the body cavity (Hemocoel). After 1-2 days larvae die from septicemia. Affected larvae become inactive – stop feeding – regurgitate or watery excrement

***B.t.* infected larvae**

Head capsule become large than body size and larvae become flaccid & die. Body content turn towards black as they decompose

Use of *B.t.* species:

- Lepidoptera (*B.t. Kurstaki* & *aizawai*)
- Coleoptera (*B.t. tenebrionis)*
- Diptera (*B.t. israeliensis*)

Table 12.2: Crop wise application and dose against different insect

Crop	Insect	Dosage (Kg/ha)
Cauliflower and Cabbage	DBM, Cabbage butterfly	1.0-1.50
Brinjal	Stem borer, Fruit borer	0.5-1.50
Tomato, Okra Chickpea, Cotton and Sunflower	Fruit borer	1.0-1.50
Cauliflower, Cabbage and Cotton	Tobacco cater pillar	1.00

12.2.6 Fungi

*Beauveria bassiana (*White muscardine fungus*)*

*Metarhizium anisopliae (*green muscardine fungus*)*

The entomopathogen invades insect body. The fungal hypha secretes enzymes and attached to the insect cuticle and offer germination, the hyphae penetrate cuticle and proliferate in insect's body. Once inside, the fungus replicates and consumes the insect's internal organs and blood like fluid, the haemolymph. After the insect dies, an antibiotic (oosporein) is produced that enables the fungus to out compete intestinal bacteria. When conditions are favourable the fungus grow through the softer parts of insect body, producing characteristic 'White bloom' appearance. High humidity or free water is essential for conidial germination and infection establishes between 24 and 48 h. The infected insect may live for 3 to 5 days after hyphae penetration and after death the conidiophores bearing conidia are produced on cadaver. The fungus is insect specific.

B. bassiana is used as foliar spray. Application rates depend upon the crop and the pests to be controlled. The normal application rate on commodity crop is 750 to 1,000 ml of product per hectare. Formulation should contain conidia *of B. bassiana* at a conc. of 2.3 x 10^7 spores/ml or

~ 5 x 10^8 spores/g. The formulation may be kept up to one year if stored below 20 ^oC. The product may be used alone or tank mixed with other product such as sticking agents, insecticidal soaps. Not used with fungicide and if used then 48 h is awaited before applying fungicide.

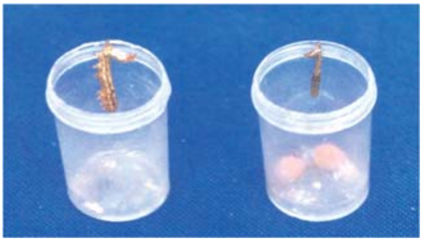
Table 12.3: Use of different entomophagous fungi against different crop insect pests

Fungi	Dose	Crop	Insects
Beauveria bassiana (White muscardine fungus)	Soil- 5-7 kg/ha. with 25-50 kg FYM Foliar- 5-7 g/lit water along with jaggary Drenching- 2 kg in 400 lit of water/acre along with jaggary	Chick pea, Pigeon pea, Cotton, Tomato, Rice, Cabbage	Fruit borer, Tobacco cater pillar, Semilooper, Termite, BPH, Grass hopper, Leaf folder, DBM, Aphid
Metarrhizium anisopliae (Green muscardine fungus)	Soil- 5-7 kg/ha. with 25-50 kg FYM Foliar- 5-7 g/lit water along with jaggary Drenching- 2 kg in 400 lit of water/acre along with jaggary.	Sugarcane, Cotton, Pigeon pea. Tomato	Pyrilla, Fruit borer, Grasshopper, Pod borer, Rice bug

12.2.7 Virus

12.2.7.1 Nuclear Polyhedrosis Virus (NPV)

Infection of baculovirus generally occurs by ingestion of occluded or free virion. Ingested virion infect mid gut – occluded bodies dissolve by protease enzyme and free virion reach hemocoel, circulatory system and respiratory system and attack there. Symptoms: occur after 5-7 days of infection Gradual change in colour (infected larvae change light to dark brown) heamolymph turns cloudy and milky Larvae become less active and losses appetite Shortly before dying larvae move away from food and climb on elevated location to hang. Prior to death integument fragile and easily torn when handled and it is typical system of NPV.

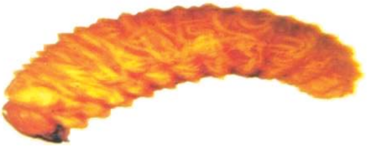


NPV infected larvae

At least 250 larval Equivalent (L.E.) of NPV is recommended for every hectare. It contains $1x10^9$ PIB per ml. NPV may be mixed with water along with jaggry and soap powder. It is sprayed in infested crop preferably in evening. The caterpillars while feeding on plant ingest the virus. The virus multiplies rapidly within the body of caterpillars and kills them within 6 days. The spray should be done during evening hours on 1^{st} and 2^{nd} larval stage of insects.

12.2.7.2 Entomopathogenic Nematodes (EPN)

These nematodes enter in the body of insects and kill them which causes disease in insects called Entomopathogenic Nematodes. The two genera of EPN *i.e.* Steinernema and Heterorhabditis carry Xenorhabdus and Photorhabdus bacteria respectively. Nematode relies on bacterium for killing insect host and creating suitable environment for its development by producing antibiotics that suppress competing econdary microbes. Breakdown of host tissues into usable nutrients Serve as a food source for nematodes. Bacterium requires nematode for protection from external environment and penetration into host haemocoel. It also inhibit the host's antibacterial proteins. EPN of the genus *Steinernema* and *Heterorhabditis* are symbiotically associated with bacteria *Xenorhabdus* and *Photorhabdus*, respectively. They are lethal obligatory parasites of insects, yet pose no threat to plants, vertebrates and many invertebrates.This has generated intense interest in the development of these nematodes for use against insect pests. Therefore, EPN are promising biocontrol agents alternative to chemical insecticides. It can provide effective control of



EPN infected larva

some of the agriculturally important lepidopteran, coleopteran and dipteran pests.

For spraying of EPN 2.5-5.0 x 10^9 IJs per hectare are used three times against insects on crops. The 2.5-5.0 x 10^9 IJs per hectare are used for soil application and followed by irrigation.

These biological control agents will be useful when there is a sudden outbreak in the pest population unlike the earlier control measures which are to be planned well in advance.

However, slow mode of action, susceptibility of these bio agents to environmental conditions and in ability to control the pest below the economic threshold level will hinder the large scale use of bio control agents in organic farming.

12.2.7.3 Use of botanicals and other bio-chemicals

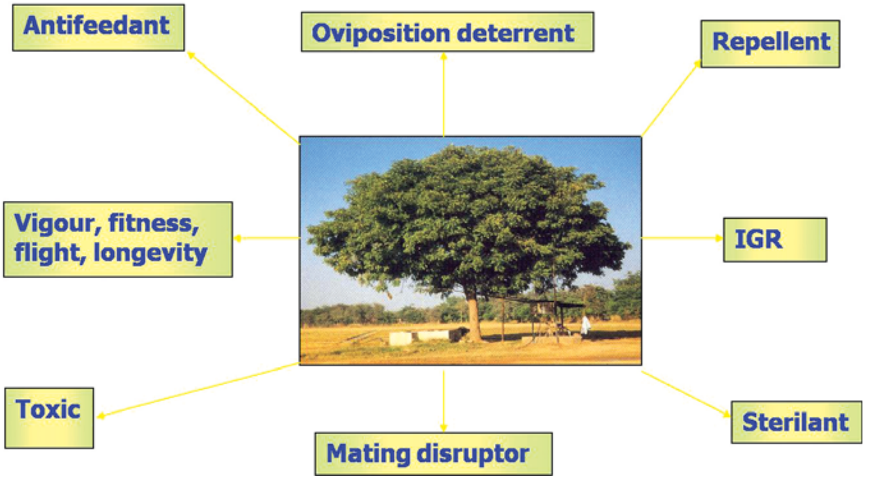
The use of botanicals and other insecticides of mineral origin for the control insect pests and application of pheromone traps for monitoring, mass trapping and mating disruption were used as last options in the organic agriculture if all the earlier methods have been failed. Strict regulation of the chemicals that are allowed for pest management in organic cultivation is monitored by NPOP (National programme for organic production) for India and similar organizations existed in different countries to look after registration of chemicals for use in organic cultivation of the crops.

The crude extracts as well as commercial formulations from plants like neem, pongamia, and tobacco that showed efficacy in conventional agriculture for the management of insect pests were allowed in organic farming because of their less residual action and ecological safety.

12.2.7.4 Neem

Neem is a ever green shade tree grown in all parts of india. It bears flowers in Feb-April and its fruit mature after four months (generally 3rd week of May-mid of August).

All plant parts (stem,bark,leaves,twings,flowers and fruits) are important and use for different purposes. About 40 seed of the seed weight consists of the kernel which cotains 25-35 per cent oil and 65-75 per cent neem cack. One neem tree gives 50-100 kg of seeds per year.



Plant products have been found to have insecticidal, fungicidal, bactericidal, and antiviral properties. Plant products play an important role in evolving an ecologically sound and environmentally safe insects and diseases management system. They are safer to non target organisms also.

Pass a heavy roller over dried neem seed. Winnow and separate kernel from the seed coat. 5 kg or 3 kg kernel of neem seed is required to prepare 100 lit. of spray fluid. Grind 5 kg or 3 kg of kernel with 20 lit of water to get a fine paste. This fine paste is kept for 12 hours and repeatedly filtered and squeezed through a rough cloth and made up to 100 lit, which is used for spraying. About 800-1000 liters of spray solution is required to spray one hectare of different crops.

The microbial based insecticides such as spinosad 45 SC was also approved for use in organic agriculture in USA and UK. A broad array of pest-repellent products, including homemade herbal teas, plant extracts, and fermentation products, and industrial clay and rock powder products (e.g., kaolin) are authorized for use in organic agriculture: Nevertheless, the use of homemade products has declined in recent years because of the Commercialization of standardized industrial products.

Dashparni extract is the commonly used homemade extract used to control the insect pests in organic farming in India. It is prepared by mixing the crushed neem leaves 5 kg, *Vitex negundo* leaves 2 kg, *Aristolochia* leaves 2 kg, papaya (*Carica papaya*) 2 kg, *Tinospora cordifolia* leaves, 2 kg, *Annona squamosa* (Custard apple) leaves 2 kg, *Pongamia pinnata*

(Karanja) leaves 2 kg, *Ricinus communis* (Castor) leaves 2 kg, *Nerium indicum* 2 kg.

Calotropis procera leaves 2 kg, green chilli paste 2 kg, garlic paste 250 gm, Cow dung 3 kg and Cow Urine 5 lit in 200 lit water ferment for one month. Shake regularly three times a day. Extract after crushing and filtering. The extract can be stored up to 6 months and is sufficient for one acre.

Use of pheromone traps for mass trapping and mating disruption for the management of lepidopteron insect pests in commercial crops and coleopteran pests in plantation crops is largely encouraged in organic farming as suitable alternative for the insecticides.

Some of the commonly used animal product based concoctions in organic pest management in India are panchagavya and dasagavya. Panchagavya, an organic product has the potential to play the role of promoting growth and providing immunity in plant system. Panchagavya consists of nine products viz. cow dung, cow urine, milk, curd, jaggery, ghee, banana, Tender coconut and water. When suitably mixed and used, these have miraculous effects. This product is known to have a deleterious effect on the many insect pests attacking various crops when used at the dosage 3% solution.

Dasagavya is a variant of panchagaya prepared by adding certain plant extracts to panchagavya. Foliar extracts of weeds such as *Leucas aspera*, *Datura metal*, *Phytolacca octandra*, and *Artemisia nilgirica*, are then soaked in cow urine in the ratio 1:1 (1 kg chopped leaves in 1 litre cow urine) for ten days were then added to panchagavya. Dasagavya may be sprayed once every week for all vegetable and plantation crops. Spraying dasagavya is effective in controlling diseases such as leaf spot, blight, and powdery mildew, rust of vegetables and cut flower crops and tea blister blight. Dasagavya also controls pests such as aphids, thrips, white flies, mites and also foliar caterpillars. Three times spraying dasagavya on vegetable crops @ 3% solution recorded higher yields. These animal based products have to be scientifically validated for their use in the organic pest management.

12.3 INTEGRATED PEST MANAGEMENT IN ORGANIC FARMING

- Encouraging predatory beneficial insects to control pests by serving them nursery plants and/or an alternative habitat, usually in a form of a shelterbelt, hedgerow, or beetle bank.

- Encouraging beneficial microorganisms.
- Rotating crops to different locations from year to year to interrupt pest reproduction cycles.
- Planting companion crops and pest regulating plants that discourage or divert pests.

  Using row covers to protect crops during pest migration periods.
- Using biological pesticides and herbicides.
- Using no-till farming, and no-till farming techniques as false seedbeds.
- Using sanitation to remove pest habitat.
- Using insect traps to monitor and control insect populations.
- Using physical barriers, such as row covers.

Pest management in organic farming is a challenging task without the use of insecticides. It Involves careful planning in advance through a slight modification in the cultural practices as primary methods of pest control. The use of environment friendly tactics such as use of biological control agents and other plant based products as second line of defence against insect pests. When these products used alone or in combination with other tactics as integrated pest management have potential role to control insect pests and increase the economic yield in organic farming.

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Chapter **13**

APPROACHES FOR ORGANIC PRODUCTION OF HORTICULTURAL CROPS IN INDIA

R.A. Ram

13.1 INTRODUCTION

Significant increase in production, productivity and area expansion under horticulture crops has occurred during the past two decades under the influence of chemical intensive farming systems. Some portion of production is also being exported and the demand for safe produce is ever increasing. Imbalanced use of chemical fertilizers, especially nitrogenous has resulted in some regions manifesting adverse effects on the environment, polluting soil and ground water resources. Soil quality, especially that of organic matter and micro-nutrients deficiencies are becoming ubiquitous threatening sustainability and quality of produce impacting nutritional security. Further, indiscriminate use of agro-inputs specially pesticides, has led to development of resistance to pests to pesticides, while destroying irretrievably the beneficial ones viz., honey bees, pollinators, parasitoids, predators, besides causing harmful pesticide residues in the end product adversely impacting productivity and food safety. According to a WHO report globally, at least three million people are affected by pesticides residues annually, out of whom 20,000 die. A majority of the pesticide induced deaths are reportedly occurring in the developing countries, which use only 25 per cent of the global pesticides production.

India is the second largest producer of fruits and vegetables after China and Brazil. As per new estimate area and production of horticultural crop is 23417 (000 ha) and 283468 (000MT) for 2015 (NHB estimate, 2015) out of which fruit contributes 88819 (000T) from 6358 (000ha), 168300(000T) from 9541 (000ha) vegetables, 3233 (000T) from 816 (000ha) flowers and aromatic, 17131 (000T) from 3538 (000ha) plantation and 5908 (000T) from 3163 (000ha) spices. Although total horticultural production is quite high, but productivity of fruit (13.97T/ha) and vegetables

(17.64 t/ha) is very low compared to USA (23.47 t/ha), Israel (19.50 t/ha). With this much of total production, per capita fruit consumption is 88 g compared with minimum requirement of 126 g/capita/day. With increasing stress in day-to-day life, nutritional security becomes imperative for improving national health and improving work efficiency of the common masses. India has thus to make concerted efforts to meet the minimum fruit requirement in coming decade. This in envisaged by increasing production by extending area under different fruit crops and increasing productivity of existing plantations. Under Mission for Integrated Development of Horticulture this issues is being addressed by different strategies.

Productivity of various fruits continues to be low; post harvest losses are high; and there is ample scope to improve the quality further. Pests and diseases have to be managed by keeping in mind the permissible limit of the use of chemicals. Good Agricultural Practices (GAP), even without use of agro-chemicals i.e. (organic cultivation) have made impact in quality production and managing the insect pests. This needs to be given further impetus on large scale. Scattered plantation, poor quality planting material, old and senile orchards, incidence of large number of pests and diseases, lack of infrastructure for production, harvesting, post harvest management, slow pace in adoption of advanced technologies are some of the constrains which need to be addressed for harnessing the real potentials.

13.2 CURRENT STATUS OF ORGANIC FARMING

Many countries of the world are now looking at ways and means to minimize the use of harmful agro-chemicals in the production system focusing on safe and quality foods production. Increasing awareness about conservation of environment as well as health concerns caused by harmful agro-chemicals has resulted in paradigm shifts in consumers' preference towards safe foods globally with niche markets promoting organic out puts emerging. As per Organic Agriculture Worldwide (2016), 2.3 million farmers across 172 countries are now growing organically produced commodities on more than 47.3 million ha of agricultural lands. Total trade of organic produce was 80 million US dollar during 2014. The largest growth of organic agricultural land was in Oceana region with 40 % of total world organic land and Europe (11.6 mha, 27 %), Latin America has 6.8 mha (15%) followed by Asia (3.6 mha (15%) followed by Asia (3.6 mha, 8%), North America (3.1mha, 7%) and Africa (1.3 mha, 3%). The countries with most agricultural land are Australia (17.2mha), Argentina (3.1mha) and United States (2.3mha). Currently one per cent of the agricultural land in the countries is covered by organic. A part from agricultural land, there are further organic areas most of these being areas for wild collection. Other areas include aquaculture, forests and grazing areas on non agricultural land. The area of non agricultural land constitutes more than 37.6 mha. In total 81.2 mha (agricultural and non agricultural areas) are organic. In India total area under organic cultivation is 7.2 mha which is 0.4 % of the total area under organic cultivation. 39.90 mha is under wild collection. Total area under cultivation and non agricultural land is 47.1 mha. Total 6.5 million producers, 669 processors and exporters are engaged in organic industry of the India. Sporadic attempts for organic production are now being attempted by some enthusiasts in horticultural and plantation crops like tea, coffee and cardamom in certain pockets in India. By default, many regions in the north eastern states of the country are found pursuing organic horticulture which needs to be consolidated and promoted.

13.3 CONCEPT OF ORGANIC FARMING AND PREVALENT PRACTICES IN INDIA

Organic farming is a technique of enhancing the ultimate source of energy *i.e. Pancha mahabhutas* (land, water, air, ether & fire) in such a way that their energies are available for sustainable agriculture. It is based on the recycling of natural organic matter and crop rotation. These methods sustain the balance of the living organism (bacteria and earthworms) in the soil. Organic produce are not only free from harmful chemicals but are also safer, healthier and tastier. It is a holistic production management system, which promotes and enhances agro-ecosystem health including biodiversity, biological cycles and soil biological activities. In fact Indian farmers had been adopting the practice of green good production over ages. It is in last 4-5 decades; they have lost the track and agro-chemicals dependant practices created number of problems such as:

- Compaction of soil structure,
- low organic matter content in the soil,
- poor water holding capacity of the soil,
- increase in salinity, sodicity and land submergence,
- adverse effect on flora and fauna,
- deterioration in quality of produce,
- problem associated with residual toxicity,
- increase in hazards and outbreak of pest and disease including weeds,

- Deterioration in factor productivity and
- Varying degree of displacement of human settlement.

This has let GOI to consider seriously regarding future of Indian agriculture and a Task Force to suggest alternative of Modern Agriculture was constituted under chairmanship of Dr. Kunwarji Bhai Jadav, of Rajkot and Commissioner Agriculture GOI as member secretary. The Task Force came with following observations.

- The 'Organic farming' is being practiced by thousands of farmers and institutions in the country though mostly in unorganised way.
- The success stories indicate the benefits of organic farming.
- There is no awareness among people, in general, about the benefits of organic farming, as there is no state or Central Govt. support.
- No markets have been developed in the country for the sale/ promotion of organic produce.
- The system of export of organic produce is also presently at a limited level and exact data are not available.
- Huge subsidy is given per ton of production of chemical fertilizers; no subsidy or incentive is given for use of organic manures.
- The Ministry of Commerce in the Government of India have set up standards for organic farming and defined the system of Certification and Accreditation only in April, 2002, which may facilitate further growth of organic farming in the country.

Most of the fruits and vegetables are eaten fresh; hence any contamination (chemical residue) may lead to various kinds of health hazards. Hence organic production offers a better possibility in horticultural crops rather than in field crops.

In conventional production system, in general micronutrients are not taken care, there is every doubt that over long duration, their deficiencies may create production constraints and these; technologies might be a failure rather than a sustainable alternative. Biodynamic agriculture, under the present scenario appears to be a sound alternative. It is based on sound principles of soil biotechnology and microbiology. Indeed microscopic doses of few of the preparations have shown profound effects on growth, metabolism, crop yield and quality. It is interesting that these practices do not require sophisticated facilities and most of them can be created at farm itself by simple training. They are components of biological or soft agriculture, capable of affording long-term sustainability to agricultural and particularly to the ecosystem. The system is based on the principles of harnessing the synergy between Cosmos, Mother Earth, Cow and Plants. Now days, Biodynamic farming is becoming popular in several countries such as Germany, Australia, New Zealand, U.S.A. etc.

Biodynamic agriculture, Rishi Krishi, Panchagavya, Natural farming, Homa Farming, Ecological Farming etc were also being practiced by various organizations in the country. Brief account of few is given as under:

13.4 ORGANIC FARMING PRACTICES PREVALENT IN INDIA

13.4.1 Biodynamic farming

This system appears to be one of the sound alternatives to conventional agriculture. It is based on systematic and synergistic harnessing energies from Cosmos; mother Earth, Plants and Cow (Steiner, 1997). For harnessing cosmic energies, an Agriculture Calendar based on planetary configuration is used in agricultural operations and preparation of few biodynamic preparations. Few preparations are used in minute quantities but show remarkable effects on plant growth, metabolism, crop yield and quality. BD-500 i.e. cow dung duly incubated in cow horn is helpful in improving biological activity of soil and BD-501 Silica in horn mediates photosynthesis and provides defense to fungal infection. Efforts are made to restore soil fertility in form of humus, increase the living system of soil by skilful application of crop rotation. Nutrient requirement is managed by application of biodynamic compost, duly enriched with cow pat pit, BD-500; need base use of BD–liquid manures. Pests are managed by promoting locally adopted varieties, cultural, mechanical measures including use of trap crops, spraying of BD-501 and need based spray of biodynamic liquid pesticides prepared from cow dung, cow urine and locally available herbs such as neem, *calotropis,* lantana, custard apple etc. along with BD-sets for specific duration. With adaptation of biodynamic package of practice quality production of mango, guava and aonla has been demonstrated by ICAR-CISH, Lucknow. Similarly it has been demonstrated for management of *Phytophthora* infection in kagzi lime, Nagpur mandarin and management of decline in the state of Maharashtra.

13.4.1.1 Use of biodynamic calendar in organic production

In ancient days, most of the agricultural activities were performed as per calendar and it was very effective in crop management. Biodynamic Calendar for the year 2017 is annexed (Annexuture-1). With the experience over the decade and systematic research at CSK University of Agriculture, Palampur, Himachal Pradesh I advocate that if some care is taken and as for as possible the farm activities are performed accordingly, 12-18 per cent increase in yield and 12-15 per cent reduction in pest infection can be obtained. As thumb rule, during descending Moon cosmic energies below the ground are much pronounced it is said that Mother Earth breathes in. Hence these days are ideal for nutrient management i.e. application of compost and other bio inoculants. While during ascending period, activities above the ground are much pronounced (mother earth breathes up) hence ideal for above ground activities. Activities like pruning of tree should be done on fruit days during descending phase of the moon. If possible fruit should be harvested in ascending phase of the moon. Ram et al, 2010, have studied the influence of sowing date (as per biodynamic calendar) on yield of okra cv. Pusa-4. Results showed that highest yield (125.00 q ha^{-1}) was recorded when crop was sown during Moon opposite to Saturn phase and on fruit day (Table 13.1).

In another study, microbial analysis of biodynamic preparations was done and enumeration of different beneficial microbial populations viz. bacteria, fungi, actinomycetes, *Pseudomonas*, gram positive bacteria, gram negative bacteria, p-solubilzing bacteria, Rhizobium, *Azotobacter and Azospirillum* were carried out by using dilution plate count method using selective media viz. Nutrient agar, Rose Bengal Chloramphenicol Agar (RBCA), actinomycetes isolation agar, King's B (King *et al.*, 1954), methyl red agar (Hagedorn and Holt, 1975), crystal violate agar (Goud *et al.*, 1985), Pikovskaya's agar (Pikovskaya, 1948), Yeast extract mannitol agar with congo red (CRYEMA, Fred *et al.*, 1932), modified Jenson's agar (Jensen, 1954; Norris and Chapman, 1968) and N-free malate medium (Okon *et*

Table 13.1: Study on response of biodynamic calendar based date of sowing on yield of okra

Sowing of seeds as per biodynamic calendar	Yield (q ha^{-1})
Fruit (descending)	125.00
Root (descending)	104.00
Flower (descending)	116.00
Leaf (descending)	88.00
Moon opposite to Saturn	125.00
Root days (descending)	120.00
Node (ascending)	105.40

Table 13.2: Different microbial populations in cow pat pit and other biodynamic preparations

Sl.No.	Type of microbe	Multiplication factor	Microbial population (cfu/g)									
			Cow Pat Pit	Biodynamic preparations								
				500	501	502	503	504	505	506	507
1	Bacteria	10^8	16.7	3.80	1.80	2.40	85.50	8.50	110.3	12.20	2.60
2	Fungi	10^5	8.30	6.90	11.30	11.97	28.33	33.53	13.27	35.07	5.10
3	Actinomycetes	10^6	12.7	15.9	3.1	24.9	14.8	68.0	20.3	207.2	792.0
4	Gram positive bacteria	10^8	184.1	0.55	0.10	0.89	0	6.57	2.85	12.30	1.47
5	Gram negative bacteria	10^7	225.1	0.02	0.02	1.58	0.03	15.63	0.63	11.23	15.43
6	*Pseudomonas*	10^6	6.47	1.38	4.73	0.65	1.85	21.73	2.78	7.03	12.17
7	p- solubilizing microbes	10^5	8.30	3.93	25.43	39.63	24.17	0.69	95.13	21.70	10.00
8	*Azotobacter*	10^5	28.37	23.57	46.5	34.30	77.43	28.60	26.89	53.07	201.4
9	*Azospirillum*	10^5	224.3	9.80	0.67	54.40	96.10	76.47	0.53	528.8	830.3
10	Rhizobium	10^7	310.8	6.00	4.80	6.17	10.83	18.10	2.10	6.07	0.02

al., 1977), respectively. Details of isolated microbes are presented in table 14.2.

13.4.2 *Rishi Krishi*

The practice of organic farming has been adopted by large number of farmers in Maharashtra and Madhya Pradesh. In this technique, rhizosphere soil beneath *Banyan* tree (*Ficus benghalensis*) is spread over the area followed by regular use of *Amritpani* (a special bio-enhancer) through irrigation or drenching of organic mulches filled with organic wastes in trenches around the tree periphery (Despandey, 2003). *Amritpani* is prepared from cow dung, cow ghee, honey and is utilized for enrichment of soil by overhead sprinkling, drip or through irrigation water. It invigorates the living soil and converts a dead soil into living one. The practice has been demonstrated successfully on a wide range of crop production including kagzi lime, mango, guava etc. Microbial analysis of Amritpani is presented in table 13.4.

In an study, microbial analysis of Amritpani is presented in table 13.4. rhizospheric soil of some selected trees showed that *Ficus benghalensis* contained maximum number of *Azotobacter* (1.50 x 10^6 cfu g^{-1}) and *Azospirillum* (1.40 x 10^6 cfu g^{-1}) followed by *Ficus religiosa* which contained *Azotobacter* (1.0 x 10^5 cfu g^{-1}) and *Azospirillum* (8.5 x 10^5 cfu g^{-1}). Other rhizospheric soils of *Mangifera indica*, *Syzigium cuminii* and *Azadirachta Indica* contained comparatively less number of *Azotobacter* and *Azospirillum* population (Table 13.3). Rhizospheric soils of *Ficus benghalensis* and *Ficus religiosa* also contained highest soil organic carbon which attributed presence of maximum aerobic bacteria (Ram et al 2014).

Table 13.3. Percentage soil organic carbon, total bacteria, *Azotobacter* and *Azospirillum* population in different rhizospheric soils

Soil samples	Soil organic carbon (%)	Bacterial populations (cfu/g)		
		Total bacteria (x 10^8)	*Azotobacter* sp. (x 10^4)	*Azospirillum* sp.(x 10^4)
Banyan (*Ficus benghalensis*)	0.72	13	15	140
Peepal (*Ficus religiosa*)	0.32	17	10	85
Jamun (*Syzigium cuminii* Skeel)	0.17	11	4	5
Neem (*Azadirachta indica*)	0.31	10	6	3
Mango (*Mangifera indica* L.)	0.16	8	2	1.2

Table 13.4. Isolation of different microbial population in *Amritpani*

S. No.	Type of microbe	Multiplication factor	Microbial population (cfu/ml) of preparation (Mean)
1	Bacteria	10^8	3.29
2	Fungi	10^6	0.001
3	Actinomycetes	10^7	0.10
4	Gram positive bacteria	10^8	0.30
5	Gram negative bacteria	10^8	0.58
6	*Pseudomonas*	10^7	1.29
7	Rhizobium	10^6	1.20
8	p-solubilizing microbes	10^6	3.20
9	*Azotobacter*	10^7	0.01
10	*Azospirillum*	10^6	0.02

1.3.4.3 *Panchagavya Krishi*

Panchagavya is a special bio-enhancer prepared from five products of cow, i.e. dung, urine, milk, curd and ghee. When suitably mixed, incubated and used, has shown miraculous effects on soil fertility and crop productivity.

This preparation is rich in nutrients, auxins, gibberellins, and microbial fauna and acts as tonic to enrich the soil, induce plant vigour with quality production. Physico-chemical studies revealed that *Panchagavya* possess almost all macro, micronutrients and growth hormones (IAA, GA) required for plant growth. In general 3-4 (3-4 kg/100 liters) per cent solution of *Panchagavya* has been found effective in crop production. This solution can be mixed with irrigation water @ 50 liters per hectare either through drip or flow irrigation. Its remarkable effects have been demonstrated in fruits like mango, guava, acid lime, and it can also be attempted in other fruits. Microbial analysis of panchagavya (Ram et al, 2017) is presented in table 13.5.

13.4.4 Natural farming

It is a zero budget farming method and was promoted by Subhash Palekar and Masanobu Fukuoka (Natural Farming). In this practice farmers use mulching, soil protection techniques, natural pesticides and manures.

Table 13.5. Isolation of different microbial population in *Panchagavya*

S. No.	Type of microbe	Multiplication factor	Microbial population (cfu/ml)
1	Bacteria	10^7	62.50
2	Fungi	10^5	0.20
3	Actinomycetes	10^6	2.20
4	Gram positive bacteria	10^7	0.11
5	Gram negative bacteria	10^6	17.40
6	*Pseudomonas*	10^6	47.00
7	Rhizobium	10^6	2.43
8	p-solubilizing microbes	10^6	3.20
9	*Azotobacter*	10^6	0.14
10	*Azospirillum*	10^5	1.03

The principal methods of this include crop rotation, green manures and compost, biological pest control, and mechanical cultivation. These measures use the natural environment to enhance agricultural productivity: legumes are planted to fix nitrogen into the soil, natural insect predators are encouraged, crops are rotated to manage insect pest and improve soil health. In this system two bio-enhancers Jeevamrita and Beejamrita are used for improving soil fertility and seed treatment, Agniastra and Brahamstra are prepared with cow dung, urine and neem leaves for the management of insect pests. It consists of regular use of *Jeevamrita* prepared by incubating (cow dung, urine, jaggery, pulse flour, virgin soil) at 15 - 30 days interval through irrigation water, coupled with mulching (green/ dry, monocot + di-cot) and proper soil aeration. *Jeevamrita* and *Beejamrita* are rich consortia of beneficial microbes (Ram et al, 2017). Microbial analysis of Jeevamrita and Beejamrita is presented in Table 13.6 and 13.7.

Two hundred liters of Jeevamrita is enough for use in one acre area. It can be applied through irrigation water by flow, drip or sprinkler or even by drenching on mulches spread over the field or the tree basin. Natural farming is practiced by a large number of farmers in organic production of fruits like mango, guava, lime, and mandarin, Kinnow etc.

Table 13.6. Different microbial population in Jeevamrita

S. No.	Type of microbe	Multiplication factor	Microbial mean population (cfu/ml)
1	Bacteria	10^7	324.20
2	Fungi	10^7	1.20
3	Actinomycetes	10^6	3.10
4	Gram positive bacteria	10^8	1.60
5	Gram negative bacteria	10^7	20.19
6	*Pseudomonas*	10^7	5.09
7	Rhizobium	10^6	75.10
8	p- Solubilizing microbes	10^6	5.04
9	*Azotobacter*	10^5	1.12
10	*Azospirillum*	10^5	0.01

Table 13.7. Different microbial population in Beejamrita

S.No.	Microbial population	Dilution factor	7th day of preparation
1	Bacteria	10(8)	41.06
2	Fungi	10(4)	Nil
3	Actinomycetes	10(6)	15.25
4	Pseudomonas	10(6)	28.32
5	Azotobacter	10(6)	78.98
6	Azospirillum	10(5)	44.93
7	Phosphate solubilizing bacteria	10(6)	1.36
8	Rhizobium	10(6)	17.72

13.4.4.1 Natueco farming

This practice of organic farming follows the principles of eco-system networking in farming system approach. Knowing nature more closely, through critical scientific inquiries and experiments farming is done. It has a new vision of infinite resource potentials in Nature and sunlight promises *plenty for all* through harvesting all these resources. The three relevant aspects of Natueco farming are:

Soil: Enrichment of soil by recycling the biomass and establishing a proper energy chain. The basic component of this technology is "*Amritmati*" a special bio-formulation rich in microbial consortia prepared from "Amritpani" fermented solution of cow dung, urine duly enriched with locally available organic waste, upper crust of soil, and decomposition of foliage from different crops at various stages of its maturity for ensuring availability of macro and micro-nutrients. It takes almost 90-100 days for its preparation.

Roots: Development and maintenance of white fibrous root zones for efficient absorption of nutrients

Canopy: Harnessing solar energy through proper canopy management for efficient photosynthesis and encouraging multistoried farming system.

The benefit of this technology in grape has revolutionized its organic production in Maharashtra. But it needs to be promoted in production of other horticultural crops.

13.5 SOIL HEALTH MANAGEMENT IN ORGANIC PRODUCTION

Healthy soil contains massive population of bacteria, fungi, actinomycetes and algae. The micro fauna are protozoa and nematodes. The small organisms (fauna) also include mammals (mice) spring tails, arthropods (mites, millipedes and centipedes), eel and worms. The total population in fertile soil life is numbered in billions per gram of soil and their live weight per hectare may be as much as more than 10 -12 tons. This predator prey relationship between protozoa and bacteria can account for 40 to 80 % of nitrogen in plants. The vast majority of soil organisms function as consumers and decomposers. Each of these micro organisms has a specific role or function within the soil. It is the number and diversity of these soil organisms which determines the soil fertility. Just as the plants we see above ground differ from place to place, the ratios and diversity of soil organisms change with the region, climate, vegetative succession, and intensity of soil disturbance. Soil microorganisms play a big part in supporting healthy plant life through nutrient retention, cycling, disease suppression, and improved soil structure, water infiltration, absorption, and holding capacity.

13.6 NUTRIENT RECYCLING

Fungi and bacteria have considerably more nitrogen in their bodies than other organisms. Nutrient recycling happens when other sets of soil organisms are present to consume the nutrient rich bacteria and fungi and release nutrients to plants in available forms. These rapid interactions and countless exchanges of nutrients between soil organisms occur in root zones of plants where the highest concentrations of organisms exist, because root exudates provide food for bacteria and fungi which in turn attract their predators, protozoa, nematodes, micro arthropods and earthworms. Nutrient cycling by these predators also occurs with other valuable plant nutrients such as potassium, phosphorus, calcium, sulphur and magnesium, resulting in a less leachable form than is usually applied through synthetic fertilizers (E-eco@echonet.org).

Earthworms accelerate the decomposition of biomass by removing dead plant material from the soil surface. During digestion of organic material, they mix organic and mineral soil particles and build stable crumbs, which help to improve soil structure. Their excrements contain 5 times more nitrogen, 7 times more phosphate, 11 times more potash and 2 times more magnesium and calcium than normal earth. Their tunnels promote infiltration and drainage of rainwater and thus prevent soil erosion and water logging. Earthworms need sufficient supply of biomass, moderate temperature and sufficient humidity. It is because of this they are fond of organic mulching.

13.7 IMPORTANCE OF SOIL ORGANISMS

- They help to decompose organic material and built up soil humus;
- Mix organic matter with soil particles and thus help to build stable crumbs;
- Dig tunnels, which encourages deep rooting of plants and good aeration of the soil;
- Help to release nutrients from mineral particles;
- Helps in management of pest and diseases.
- As the plant roots and the soil organisms consume air, good air circulation within the soil is crucial for their development.
- Soil organism is generally low when soils are very dry, very wet or too hot. Activity of soil organisms is highest in warm, moist soils when enough food (i.e. biomass) is available.
- Earthworms accelerate the decomposition of biomass by removing dead plant material from the soil surface. During digestion of organic material, they mix organic and mineral soil particles and build stable crumbs, which help to improve soil structure. Their excrements contain 5 times more nitrogen, 7 times more phosphate, 11 times more potash and 2 times more magnesium and calcium than normal earth.

- Their tunnels promote infiltration and drainage of rainwater and thus prevent soil erosion and water logging.
- Earthworms need sufficient supply of biomass, moderate temperature and sufficient humidity. It is because of this they are fond of organic mulching.

Some facts

- One gram of soil can contain 10 million to one billion organisms;
- There is strong link between macro-fauna flora and microbes;
- Better the presence of macro-fauna better will be micro organisms.
- They form an intricate community, each one helping or depending on other.
- It is the chain reaction, no one should break it.

13.8 IMPORTANCE OF ORGANIC MATTER

The term "organic matter" is used to describe the dead and decomposing remains of living things, such as plant debris, animal remains, and manures. These are crucial part of the soil, providing food for soil living creatures; for plants in particular, it is a major source of nitrogen. Without it, soil would be just sterile rock dust. Organic matter is continually being broken down by soil creatures and by natural oxidation. In nature, it is replenished in the natural cycles of life and death. Humus is the final product in the breakdown of organic matter. It acts as a valuable reservoir of water and plant nutrients, and helps soil structure. In short, organic matter contributes to soil fertility in the following way.

- Feed of soil fauna and flora,
- Encourages diversity of flora and fauna in soil;
- Improves physical structure of the soil;
- Absorbs water and retain for plants and soil biota.
- Supplies plant foods and help the soil to retain it.
- Soil organic matter helps to build up a loose and soft soil structure with a lot of cavities (pores). This leads to better aeration, better infiltration of rain or irrigation water and an easier penetration of roots.
- The visible parts of organic matter act like tiny sponges which can hold water up to five times of their own weight. Therefore, in dry

periods more water is available for the plants for a longer time. This is especially important in sandy soils and rain fed conditions.

- The non-visible parts of organic matter act like a glue, sticking soil particles together thus forming stable crumbs. Such aggregates improve the soil structure, especially in clay and sandy soils.
- Beneficial micro organisms and other soil organisms such as earthworms feed on orga-nic wastes during decomposition. As these organisms require sufficient humidity and aeration, soil organic matter provides a suitable environment for them.
- Organic matter has a great capacity to retain nutrients and releases it slowly. Therefore, it increases the plant nutrients supply for a longtime and reduces loss by leaching.
- During the process of decomposition, organic matter provides balanced mixture of all nutrients which are required by the crop and released at slow rate for maximum recovery.
- Organic matter acts as an absorption agent for nutrients added to the soil. In acidic soils, decomposed organic matter is responsible for entire nutrient exchange capacity (CEC) of the soil. Nutrients are bound reversibly to the humus and can be constantly released by the activity of plant roots and microorganisms.
- Beneficial micro organisms and other soil organisms such as earthworms, bacteria, and fungus feed on orga-nic wastes during decomposition. As these organisms require sufficient humidity and aeration, soil organic matter provides a suitable environment for them.
- Besides mineral particles and soil organic matter, soils also consist of minute pores filled with air and water. The spatial arrangement of particles and pores is known as "soil structure". Small pores are good in preserving moisture while the larger ones allow a fast infiltration of rain water, but also help to drain the soil and ensure aeration.
- Mineral particles and soil organic matter form stable aggregates in good structured and fertile soil.

13.9 IMPROVEMENT IN SOIL ORGANIC MATTER

- Provision for continuous recycling of organic wastes;
- Application of composts and farm yard manure;
- Application of pond sediments;

- If possible leave single tree growing in field (e.g. nitrogen fixing trees);
- Mulching with on farm produced organic wastes/locally available;
- Growing of green manures/cover crops and their incorporation;
- Appropriate crop rotation;
- Minimum tillage;
- Management of soil erosion through appropriate measures;
- Restriction on burning of biomass.

13.10 DISADVANTAGE OF BURNING ORGANIC SUBSTANCES

Burning of organic waste is one of the common practices in today's farming system and in shifting cultivation in NEH region of the country. It is process of destroying agricultural wastes, as it saves manpower. The ash contains some nutrients, which are directly available to plants. Demerits of burning of organic wastes are given as under:

- Large amount of carbon, nitrogen and sulphur are released as gas and are therefore lost.
- The nutrients in the ash are easily washed out with first rain.
- Plant materials are too valuable source of soil organic matter which is burnt?
- Burning harms the beneficial insects and soil organisms.
- It also creates environmental pollution which needs to be restricted.

These organic wastes can easily be converted in to rich composts like biodynamic, vermi, NADEP and vermi composts etc. to improve the soil fertility. Brief account of this compost is given as under:

13.10.1 Biodynamic compost

Biodynamic compost is an effective soil conditioner and is an immediate source of nutrient for crops. It can be prepared by using green (nitrogenous material) and dry leaves (carbonaceous material) in 40-60 ratio. Integration of cow dung slurry and BD-502-507 in the compost enhances the decomposition process. The

Fig. 1. Biodynamic compost

composition of air, moisture and warmth is very important in the breakdown and decomposition of the organic materials. The enrich compost gets ready in 3-4 months depending upon the prevailing temperature and moisture (Fig.1).

13.10.2 Vermicompost

Earthworms are versatile natural bioreactors for effective recycling of non-toxic organic wastes to the soil. They effectively harness the beneficial soil micro flora, reduce soil pathogens, and convert organic wastes into valuable products such as bio fertilizers, bio pesticides, vitamins, enzymes, antibiotics, growth hormones and proteinous biomass. Vermi compost can easily be produced with use of cattle dung and locally available organic wastes (Fig.2).

Fig. 2. Vermicompost bed and ready vermi compost for use

13.10.3 NADEP compost

A farmer from Maharashtra (Sri Narain Deorao Pandari Pande) has developed this method of aerobic composting. Aerobic composting process is fast and nutritional status of end product is better than the ordinary compost. Farm wastes (cow dung, green/dry grasses, wheat/paddy straw and weeds) along with good quality farm soils are used (Fig.3).

Fig. 3. NADEP compost

13.10.4 Microbe mediated (MM) compost

An effective micro-organism consortium was developed by Prof. Teruo Higa during early 1980 in Japan. Effective microorganism is a group of beneficial microbes acts as microbial inoculants in the soil and as well as develops congenial environment for the plants. It contains lactic acid and photosynthetic bacteria, yeast, filamentous fungi and actinomycetes etc. These are aerobic and anaerobic in nature and can exist in acidic and saline soil both. Theses effective microbes are used for production of good quality compost with dung and farm wastes.

Numbers of composting methods have been standardized in various parts of the country. Any of this can be attempted as per facilities available at the farm. These composts are more nutritious than common farmyard manure (Table 13.8).

Table 13.8. Nutrient analysis (% on dry weight basis) of different organic preparations (liquid/50ml)

S.No.	Preparations	N (%)	P (%)	K (%)	Ca (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
1	Vermi compost	2.15	1.29	0.53	1.72	168	61	3545	252
2	BD compost	1.68	0.17	1.23	1.20	96	45	357	3352
3	NADEP compost	0.98	0.35	1.00	1.25	162	56	430	230
4	MM compost	1.54	0.51	1.06	1.35	140	45	433	275
5	Farm yard manure	0.70	0.19	0.37	0.24	75	34	222	3134

13.10.5 Soil biological process

Plant needs over thirty different elements for its growth formation of leaves, stems, fruits etc. They receive oxygen and carbon form air and hydrogen from water. Nitrogen is obtained through air and also from the soil (Table 13.9).

Table 13.9. Essential plant nutrient elements and their sources

Essential elements used in relatively large amounts			Essential elements used in relatively small amounts	
Mostly from air and water	From soil		From soil solids	
Carbon	Nitrogen	Calcium	Iron	Copper
Hydrogen	Phosphorus	Magnesium	Manganese	Zinc
Oxygen	Potassium	Sulphur	Boron, I	Cl, Mo,Co

All these nutrients occur in available as well as unavailable from in the soil. Available from of nutrients can be readily taken up by plants through their roots. When readily available soluble mineral fertilizers are applied to soil, rapid response of plants in terms of increased green colour of foliage, growth and yield is noticed. The non available form of nutrients has to be processed by micro organisms which are in maximum numbers on the surface of the roots. These micro organisms convert unavailable form into available form through enzyme activity or by production of organic acids. The process of conversion from unavailable to available form is generally a slow process and depends on the type and numbers of different micro organisms. Much of the soil analysis at present is done only for available form and not for the total amount of available and unavailable.

13.10.6 Nitrogen fixing plants (BNF)

Atmosphere offers immense amount of nitrogen. Plants belonging to legume and mimosa family are capable of fixing nitrogen from the air with their roots to use as nutrients. Legumes do this by living in association (symbiosis) with bacteria called *Rhizobium* that are hosted in nodules growing on the roots. These bacteria take nitrogen from the air, transform it and make it available for the host plant. Bacteria take necessary energy from the plant roots (sugars, the product of photosynthesis). Blue green algae, e.g. Azolla growing in rice fields produce the energy through their own photosynthesis.

Among the nitrogen fixing plants, the annual and perennial species can be distinguished. In alley cropping, perennial shrubs are grown in rows between the main crops. The benefits of nitrogen fixing trees are:

- There is more than 78.6 % N in atmosphere which accounts for 75-80,000 T N /ha of area;
- This nitrogen is available freely to everyone, hence our all efforts need to be given for harnessing atmospheric nitrogen;
- Plants belonging to leguminous family have capability to harness it;
- It includes annuals, perennials, creepers, climbers and play their role through-
  - help to capture gaseous N in roots (nodules) and other vegetative parts,
  - Good source of pulses, grains, medicines, dyes,
  - Produce fuel wood & timber,

- Provide shade and support for crops,
- Used as living fence,
- Produce biomass for green manuring, mulching and composting,
- Foliage of few plants are used as fodder,
- Serve as shelterbelts, wind break, hosts for birds & beneficial insects.
- Hosts for birds and beneficial insects.

(Frank et al; 2002 training manual for organic agriculture in tropics)

Efforts should be made to grow few of these potential trees, shrubs as per climatic suitability on bunds, vacant lands to collect foliage and utilize them in the composting or even through as mulching material.

13.10.6.1 Measures to improve soil organic carbon

- Integration of legumes in system as main crop, green manures, cover crops or inter crop in crop rotation ;
- Application of compost and animal manures as per availability;
- Year round growing of soil cover in vacant area by establishing alley cropping, agro forestry, farm forestry;
- Leaving single tree standing in the field (e.g. nitrogen fixing trees), growth can be managed with intense pruning.
- Trees such as tamarind, neem, madhuca, Khejri (*Prosopis cineraria*) etc.
- Growing fodder at bunds and vacant area (grass, fodder hedges);
- Establishment of suitable agro-forestry systems
- Plantation of leguminous perennial trees for lopping as a potent source for bio mass;
- Leave single trees standing in field (nitrogen fixing or with pest management capacity) and manage them with pruning.
- Cultivation of pump crops (fast growing crops which can add large amount of organic material in short time and their incorporation viz; *Panicum* and *Brachiaria*. Crops like maize and sorghum can also be grown as pump plant.
- Encourage stay of ship and goats for few night in field or few days during summer months;

- Incorporate pond silt and manure from cattle shed;
- Encouraging Farming System Approach by integrating various farm activities such as agriculture, horticulture, farm forestry, cattle, ruminants, fisheries, and poultry as per soil, climate and farmers preference which can be viewed in the following fig.4.

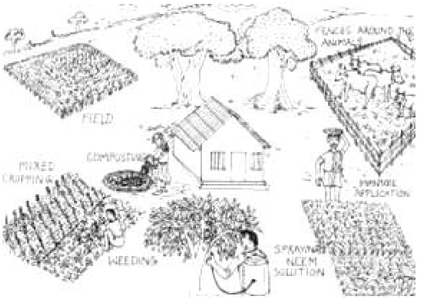

Fig. 4. Integrated farming system approach

13.11 ASSOCIATING CROPS AND CROP ROTATION

In many traditional systems, a diversity of crops in time or space can be accommodated for mutual benefits. There are different reasons why farmers do rotate or associate crops. Different plant species respond to the characteristics of the soil, have different root systems and have different needs for nutrients, water, light, temperature and air.

Associating crops is defined as the growing of two or more crops in the same field at the same time. If suitable crops are combined, mixed cultivation can lead to higher total yield per unit area. This is basically due to more efficient use of space (over and underground) and because of beneficial interactions between the mixed crops. A greater diversity of crops can be grown in the fields (Fig.5). This helps the farmer to avoid dependence of only one crop, ideally achieving a continuous supply of products from the field. Associating crops have agro-ecological benefits, too.

Fig. 5. Mix cropping of pine apple, coconut, banana and lime

13.12 GREEN MANURING, COVER CROP AND INTERCROP

Green manuring, cover crops/inter crops and mulching are interlinked activities and all are associated to improve soil fertility through improving organic carbon and enhancing soil biological activities.

Green manuring is a practice of ploughing or turning into soil undecomposed green plant materials for the purpose of improving soil health

(Fig.6). It increases the availability of plants nutrients that contribute to crop yield. Since there is never sufficient manure from the farm itself to cover the requirement of the farm, garden and orchards for organic manure, one can resort to growing certain catch crops for the purpose of turning the plant into the soil as green manure. In this way the soil organisms, such as bacteria, worms etc are provided with sufficient nourishment to ensure their multiplication and fungal activity is also stimulated. These organisms also bring aeration and organic transformation in the soil.

Fig. 6. Green manuring with Sesbania

Green manuring is incorporation of organic matter to the soil. These green manures crop supply organic matter as well as additional nitrogen particularly if it is a legume crop. A leguminous crop producing 8 to 25 tons of green matter per hectare will add about 60 to 90 kg of nitrogen other than nutrients when ploughed back. A brief of green manure crops, seed rate, sowing times, biomass productions and addition of nutrients in the soil is given in the following table 13.9.

Table 13.9. Green manure crops, biomass and nitrogen added in soil

Green manure crops	Sowing time	Seed rate (Kg/ha)	Biomass Production (t/ha)	N (Kg/ha)
Berseem *Trifolium alexandrium*	Oct - Dec	80-100	20-22	67-70
Black gram *Vigna mungo*	June-July	20-22	08-10	34-48
Cluster bean *Cyamopsis tetragonaloba*	April-July	20-22	10-12	40-49
Cowpea, *Vigna anguiculata*	April-July	45-55	15-18	74-88
Dhaincha *S. aculeata*	April-July	80-100	20-25	84-105
Green gram *Vigna radiata*	June-July	30-40	20-25	68-85
Horse gram *Dolichos biforus*	June-July	25-30	26-30	120-135
Pea, Pisum sativum	Oct-Dec	10-12	8-10	26-33
Sunhemp *C. juncea*	April-July	80-100	15-25	60-100

(Source FAO-report, 2006)

This amount would equal to application of 3 to 10 tones of farmyard manure on the basis of organic matter and its nitrogen contribution. The green manure crops also exercise a protective action against erosion and nutrients leaching and weed control. There are quick growing legumes and grasses (e.g. sun hemp, *Sesbania*) that are ploughed into the field, mulched on to the top of soil and used as compost making material. Out of these, sun hemp and *Sesbania* are the most outstanding green manure crops for Indian farmers in tropical and subtropical regions.

For proper rotting of the green manure, it is essential that the green material should be succulent and there should be adequate moisture in the soil. Plants at flowering stage contain highest amount of bulk with narrow carbon/nitrogen ratio, hence ideal time for turning in field.

13.12.1 Green leaf manuring

Green leaf manuring refers to incorporation of green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas. The most common shrubs and trees are *Glyricidia*, *Pongamia/subabul* and *Calotropis* etc.

13.12.2 Cover crops

Cover crops are grown particularly in areas, where the orchard soils are eroded during summer and rainy season and drainage is poor. These are grown between the tree rows in the orchard and turned into it, prior to the time of crop maturity. Legumes are preferred as cover crops because they add extra nitrogen through their nodules, which is fixed from the atmosphere (Fig.7). Cover crops protect the soil by reducing annual weeds through their smothering impact. Sometimes these are used to cover the soil over winter alive or dead, dense mat.

Few important cover crops are

- Cow pea (*Vigna unquiculata*)
- Green gram (*Vigna radiata*)
- Black gram (*Vigna mungo*)
- Peas (*Pisum sativum*)
- Moth (*Phaseolus aconitifolius*)
- Menthi (*Trionella foenungraecum*)

13.12.2.1 Role of cover crops

- They penetrate the soil with their roots, make it more friable and to bind nutrients that would otherwise be washed away;

- Helpful in minimizing soil erosion and in effective weed management;
- Helpful in moisture conservation and in improvement of soil biological complex;
- Helpful in maintenance and improvement of soil fertility and productivity;

Fig. 7. Growing of cover crop (Green gram, *Vigna radiata*) in mango orchard

- By decomposing green manure and cover crops these help in release of all kinds of nutrients for the main crops to utilize, thus improving their yield.

13.12.3 Intercrops

Fruit trees invariably have long juvenile phase. It is always advantageous to grow some crops in between tree rows till space is available. Inter cropping needs to be promoted as an important cultural operation particularly in the non-bearing orchards (Fig. 8).

Fig. 8. Turmeric as inter crop in guava orchard

13.12.3.1 Role of inter crops

- It ensures additional income particularly during initial years of the orchard.
- It is helpful in better plant stand and vigour of the orchard.

13.12.4 Mulching

Mulching is a method of covering the soil with a thin layer of organic wastes (biomass) (Fig. 9). If the soil is open and exposed be sure that there will not be any fauna. Fauna can only survive under the leaves in fact, soil organisms can't withstand with scorching sun; hence they are active during night hours. Besides they prefer organic rich soil, humidity around 65-70% and temperature in between 25-35 ^{0}C. They are unable to live in soil exposed to sun. So if we can put organic matter on the soil surface, fauna will come back very quickly. In fact mulching is the best option for tropical and equatorial countries. The ease and cheap options under such situation is to encourage mulching with locally available organic wastes. The benefits of mulching are to prevent the loss of water by surface evaporation and transpiration, keep down weeds due to soil cut in solar radiation, increase soil moisture, and facilitate uniform distribution of moisture in the soil. It reduces the runoff and soil losses, prevents crusting, soil compaction, and reduces blowing and beating action of water and wind. Mulches modify the micro-climate, alter the environment of soil microbes, enhance soil flora and fauna activity, and modify soil moisture regimes and properties associated with it and soil temperate in root zone, improve rooting environment and soil productivity. Water use efficiency can be doubled

The most useful type of mulch is that which absorbs little moisture, does not pack or form water shedding type surface and allows the rainwater to move downwards rapidly in the soil. In organic farming, organic mulching is preferred over inorganic one.

Fig. 9. Mulching in mango and cabbage

13.12.4.1 Role of mulching

- Helpful in minimizing water requirement through reducing evapo-transpiration and thus better establishment and growth of plants;
- Helpful in effective weed management and minimizing the soil erosion.
- Helpful in maintaining optimal temperature in the rhizosphere particularly during adverse weather conditions and slow release of nutrients.
- Reduces overheating and cooling of soil and thus helpful in maintaining continued activity of soil biological activities;
- Helpful in reducing the fruit drop, better coluration and higher quality production.

- Continuous use of organic mulches over the years is helpful in improving organic matter content, earthworm and microbial population.

13.12.5 Tillage

Careful soil cultivation can improve the soil's capacity to retain water, its aeration, capacity of infiltration etc. Wrong soil cultivation can also harm the soil fertility as it accelerates erosion and the decomposition of humus. Ploughing, tilling, digging, hoeing, harrowing etc. are the activities which improves aeration, water holding capacity, infiltration etc. Excess tillage can badly affect the soil fertility by promoting erosion and decomposition of organic wastes. If soils are cultivated in wet conditions or burdened with heavy machineries, there is risk of soil compaction which results in suppressed root growth, reduced aeration and water logging. Where soil compaction is potential problem, farmers should be aware of the following aspects:

- The risk of soil compaction is highest when the soil structure is disturbed in wet conditions.
- Do not drive vehicles on land soon after rains
- Ploughing of wet lands can lead to a smearing of the plough sole
- Soils rich in sand are less prone to soil compaction than soils rich in clay
- High content of soil organic matter reduces the risk of soil compaction
- It is very difficult to restore good soil structure once soil compaction has taken place
- Deep tillage in dry conditions and the cultivation of deep rooted crops can help to repair soil compaction.

In tropical countries there are distinct dry and wet seasons. During the dry season, ground vegetation usually becomes scare and thin, leaving the soil exposed. As a result, when the rains arrive, large amount of topsoil can be washed away, leaving the land uneven with gullies and low soil fertility. It is not only steep slopes but plain fields are also prone to soil erosion, and can be severely affected. Besides rain, excessive irrigation can also cause soil erosion.

There is need to develop appropriate system for tillage based on soil type and crop. Depending on the cropping system and soil type, appropriate cultivation practices must be followed.

13.12.5.1 Reduced tillage/minimum tillage

In tropical soils, regular tillage accelerates the decomposition of organic matter which can lead to nutrient losses. The mixing of soil layers can severely harm certain soil organisms. Soil after tillage is very prone to erosion if left uncovered before the onset of heavy rains. Zero –tillage systems help to build up a natural soil structure with a crumbly top soil rich in organic matter and full of soil organisms. Reduced tillage or no tillage is a practice of minimising soil disturbance and facilitating crop residues to remain on the surface instead of being wasted or incorporated into the soil. Nutrient losses are reduced to a minimum. Soil erosion won't be a problem as long as there is permanent plant cover or sufficient input of organic material in soil. Reduced tillage practices may progress from reducing the number of tillage passes to stopping tillage completely (zero tillage).

13.13 USES OF BIO ENHANCERS FOR IMPROVING SOIL FERTILITY

13.13.1 Bio enhancers

Use of organic liquid preparations is age old practice in India. Preparation of *Kunapajala* which involves boiling of flesh, fat and marrow of animals such as deer, pig, fish, sheep, goat in water, placing it in earthen pot, and adding milk, powders of sesame oil cake, black gram boiled in honey, decoction of pulses, ghee and hot water used to be the common booster of plant vigour. This fermented liquid manure is called as *Kunapajala*. It is sprayed on plant to enhance its vigour and production. Preparation of kunapajala is bit complex, and hence the other preparations which are easy to prepare and are being used by a large number of farmers, have been discussed as under:

Concentrated manures, bio products in powder or in liquid form, henceforth termed as Bio-enhancers are organic preparations, obtained by active fermentation of animal & plant residues over specific duration. These are rich source of microbial consortia, macro, micronutrients and plant growth promoting substances including immunity enhancers. Utilized to treat seeds/ seedlings, enhance decomposition of organic materials thereby enrich soil and induce better plant vigour. These could be a potent tool to utilize these in fertigation in various crops.

These preparations can be applied with irrigation water, drenched on organic mulches, diluted and sprayed as foliar spray. On the basis of materials used in the preparation, impact on crops, these organic liquid manures have varying response. In general, these play important role in quick decomposition of organic wastes, improve humus content of the soil which is essential to maintain the activity of microorganisms and other life forms in the soil. These are prepared with locally available materials, can resolve number of apprehensions, helpful in boosting production and mitigating number of nutritional disorders in soils and crops. It is interesting to record that these can be produced at the farm with some infrastructure facilities and hands on trained persons. These products belong to the Ayurvedic medical tradition, where indigenous cow products (dung, urine, milk, ghee and curd) are central ingredients in addition to few select medicinal herbs. These are known to supplement major and minor nutrients, growth stimulants and other beneficial substances to the plants.

13.13.2 Cow horn manure (BD-500)

It is biodynamic field spray, basically fermented cow dung and is used to improve soil fertility and renewal of degraded soils. Specially prepared manure is sprayed to vitalize the soil, enhance seed germination, root formation and development. With regular application of preparation-500 soil fertility can be improved as under:

- Strong humus formation
- Improved crumb structure and soil tilth.
- Increase in bacterial population.
- Increase in rhizobacta activity (nodulation) in all legumes, e.g., gram, pea, mung bean, sun hemp etc.
- Increase in phosphate solubilizing bacteria.
- Increase in earthworm's activity.
- Water absorption and retention power of the soil increased.
- Plants develop deep root system.

13.13.3 Cow pat pit (CPP)

It is a special biodynamic field preparation also called as 'soil shampoo'. Fresh cow dung obtained from lactating and pasture going cows is used for preparation. CPP is a strong soil conditioner. It is a concentrated source of beneficial organisms. It enhances seed germination, promotes rooting in cutting and grafting, improves soil texture, provides resistance to the plants against pests and diseases, replenishes and rectifies the trace elements deficiency. CPP is increasingly used for the seed treatment and as well as foliar applications.

Cow Pat Pit contained three plant growth hormones such as Indole Acetic Acid IAA (28.6 mg/kg), Kinetin (7.6 mg/kg) and Gibbrerllic acid (23.6 mg/kg). CPP provides nutrient and stimulate plant growth by enhancing microbial population and protecting against fungal diseases.

13.13.4 Biodynamic liquid manure

Biodynamic liquid manures/pesticides are prepared by materials i.e. cow dung, urine and leaves of leguminous tree, neem leaves, fish waste, caster leaves and other medicinal plant parts. Besides cow dung, cow urine and one set of biodynamic preparations (502-507) are also incorporated. The liquid manures are used to promote the vigour and quality production. On an average, preparation of liquid manure takes 2-3 weeks. In a comparative study on nutritional status of different bio enhancers, cow pat pit contained higher level of macro and micro nutrients followed by bio dynamic preparation 500 (Table 13.10). Vermi wash and plant based different biodynamic liquid manures contained sufficient level of nutrients and pesticidal properties for better growth and development of crop.

13.13.5 *Amrit mati*

The first step of Natueco Farming is to develop the Nursery Soil (***Amrit mati***) using neighborhood resources. Nursery Soil consists of 50% biomass and 50% activated mineral top soil by volume. The biomass forms the organic part and the top soil forms the inorganic part of the Amrit mati. The nursery soil provides support and delivers water and nutrients to the plant in the most efficient manner.

To obtain high quality nursery soil, it is most important to build its organic part through biomass addition. The well composted organic part of the nursery soil is called HUMUS which contains ligno proteins. It is black in colour, light, and easily friable material that can be broken into small fragments or crumbs. It has good water holding capacity twice its own weight. Generally, the weight of such material per liter of its volume in fine crumb from is about 400 grams. It has a peculiar black luster and layers of dead colonies of the micro flora especially in well composted (humidified) animal dung can be seen.

13.13.6 Panchagavya

It is a special bio-enhancer prepared from five products obtained from cow, i.e. dung, urine, milk, curd and ghee. When these are properly mixed, incubated for recommended period and ready fermented solution has miraculous effect on crops. Preparation is rich in nutrients, auxins, gibberellins, and microbial fauna and acts as tonic to enrich soil, induce

Table 13.10: Nutrient analysis (% on dry weight basis) of different bio-enhancers (liquid/50ml)

S.No	Preparations	N (%)	P (%)	K(%)	Ca(%)	Zn(ppm)	Cu(ppm)	Fe(ppm)	Mn(ppm)	Na (%)
1.	Cow pat pit	2.10	3.85	0.42	1.25	160	62	26.5	309	0.30
2.	BD-500	1.26	1.32	0.57	0.45	100	55	14.5	173	0.20
3.	Vermi wash	0.27	0.64	1.73	0.69	60	31	8.2	28	0.75
4.	Neem based biodynamic pesticide	0.0037	0.006	0.0785	0.25	40	34	9.6	24	1.07
5.	Castor based biodynamic pesticide	0.0054	0.005	5.87	0.36	50	37	12.3	57	1.00
6.	Karanj based biodynamic pesticide	0.0075	0.004	5.95	0.57	70	44	14.3	58	1.12
7.	Calotropis based biodynamic pesticide	0.0065	0.004	6.30	0.76	65	50	15.3	83	1.02
8.	Lantana based biodynamic pesticide	0.005	0.007	5.87	0.97	35	36	11.5	51	5.87
9.	Amritpani	0.004	0.0085	0.0183	0.35	65	33	11.2	109	6.45
10.	Panchagavya	0.007	0.01	0.06	0.45	2.9	2.4	1.7	25.8	trace

plant vigour with quality production. Due to presence of macro (N,P,K and Ca) and micro (Zn, Fe, Cu, Mn) nutrients and bio agents such as *Azospirillum, Azotobacter,* Phosphobacteria and *Pseudomonas*, growth promoting enzymes along with essential plant nutrients. Panchagavya is now gaining attention as an efficient organic growth promoter.

13.13.7 Dasagavya

As name indicates Dasagavya is a mixture of ten products, consisting of Panchagavya and certain plant extracts. The leaf extracts of five commonly available weed plants, viz., *Artemisia nilagirica, Leucas aspera, Lantana camera, Datura metal* and *Phytolacca dulcamera* are obtained by soaking the plant materials separately in cow urine in 1:1 ratio for ten days. The extracts are collected, mixed well with Panchagavya and left for 25 days.

For tropical region the recommended plants are neem (*Azadirachata indica*), akara (*Calotropis gingatia), adhatoda (Adathoda vasica)*, karanj (Pongamia *pinnata*), Vitex (*Vitex negundo*), Ratan jot (*Jatropha curcas*) etc.

Dasagavya has potential to promote growth and boost immunity in the plant system against pests and diseases. The fermentative bacteria, *Lactobacillus,* that develop in the solution, produce various beneficial metabolites such as organic acids, hydrogen peroxide and antibiotics, which are effective against other pathogenic microorganisms. The short chain baldheads are involved in hypersensitive response of plants against pathogens. The fatty acids constitute embryo development and seed formation.

13.13.8 Jeevamrita

Jeevamrita is a rich bio-formulation contains consortia of beneficial microbes. Two hundred liters of Jeevamrita is enough for one acre of cropped area. In general 2-3 times application during crop period is recommended. It can be drenched on mulch either by drip irrigation or through spraying. It is also effective in quick decomposition of crop residues if applied with irrigation water given for field preparation. With micro irrigation, 3 to 4 times more area can be covered with 200 liter of Jeevamrita.

13.13.8 Amritpani

It is a special bio formulation, rich in nutrients and beneficial microbes. Ingredients for preparation of amritpani and its intensive use to improve seed germination, soil fertility and plant vigour.

13.13.9 Bio digester extract

The extract is prepared by fermenting crushed leaves of plant along with cow dung and urine in a plastic container of suitable size known as Bio digester. In general green leaves of neem, *Calotropis*, *Vitex, Adhatoda, Ipomea,* custard apple, and agave (5 kg each) are mixed with little soil and 200 liters of water. The mixture is stirred thrice a day and gets ready for use in three weeks. The microbial load and nutrient status of *Panchagavya, Beejamrita,* Jeevamrita and bio digester extract. Presence of naturally occurring beneficial microorganisms predominantly bacteria, actinomycetes, yeasts, photosynthetic bacteria and certain fungi are the major strength of these bio enhancers.

The results of the study revealed that the nutrient status and microbial load present in the bio enhancers, which may differ with the type and quantity of material used, period of fermentation, environmental conditions etc. However the nutrients and micro flora present in bio-enhancers support the improvement in soil fertility and in turn better yield when these are used irrespective of any crop. It is because of microbial richness, formulations show dramatic impact on various attributes associated with soil fertility and crop productivity.

The proposed package of practices that can be adopted in organic production of fruits has been summarized in fig.10.

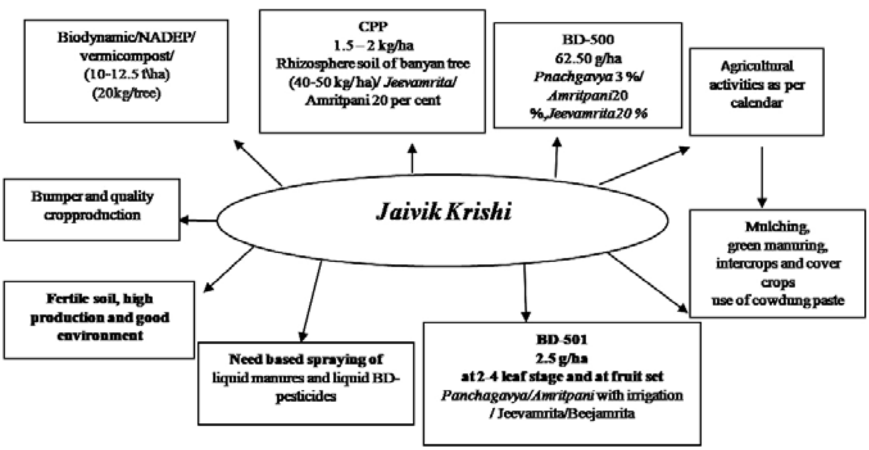

Fig. 10. Schematic presentation for package of practice of *Jaivik Krishi*

13.14 NUTRIENT MANAGEMENT IN FRUIT CROPS

- Growing of legumes for green manuring or as inter/cover crops as per requirement and as per calendar
- Growing of leguminous shrubs such as Glyricidia, Luecanea etc at the farm boundary and its recycling in compost, liquid manure or through mulching
- Recycling of litchi leaves along with some legumes as mulch material
- Application of organic manures, 10-20kg/tree (NADEP/ Vermi/ Biodynamic Compost, Microbe Mediated Compost) in descending moon period
- Mulching after application of 100g CPP, spraying of cow horn manure (BD-500)/ *Amritpani/ Panchagavya/ Jivamrita* /Vermi wash
- Need based foliar spraying of biodynamic liquid manures/vermi wash/ cow pat pit (CPP)

13.15 INSECT PEST MANAGEMENT

- Spraying of Biodynamic/Organic pesticides/ prepared from cow urine, neem, karanj (*Pongamia pinnata*), Lantana, *Calotropis procera*, castor, *Thevetia nerifolia, Vitex* sp. leaves as per experience.
- Regular performance of *Agnihotra* at sun set and sun rise and use of *Aghnihotra* ash enriched water/ Biosol (if possible)
- Nettle leaf/ kalmegh leaf extract sprays to control hard pests like midge, leaf minor, mites etc.

13.16 DISEASE MANAGEMENT

- Biodynamic tree paste/cow dung paste for the control of gummosis and dieback.
- Two sprays of cow horn silica (BD-501) *Biosol* at flowering and fruit development stage particularly on Moon opposite to Saturn phase
- Spraying of horsetail (*Equisetum arvensis*)/*Casuarina* leaf extract for the control of fungal diseases in ascending Moon period.

13.17 TREE PASTE

- Tree paste can be prepared by thoroughly mixing cow dung + cow urine + bentonite powder/ BD-500
- It is thoroughly pasted on tree trunk and main limbs

- It is advantageous to paste twice, once immediately after rains (August/ September) and again during February/March
- It protects stem from borer and fungal infection
- It also accelerates nutrient movements through trunk

In pollution free atmosphere and fertile soil, incidentally pest and disease infection are minimum. Crop rotation, solarization, organic seed treatment, trap crops, predators, parasites, use of bio-pesticides and peppering are the number of option available which can be utilized for pest control. Phelan, *et al. a*nd Phelan (1997) investigated mechanism that could explain why insect pests can be lower on organic farms. Soils from organic and conventional farms were brought in the laboratory and treated with various conventional and organic amendments. Maize plants were grown in pots of these soils in the greenhouse and exposed to female Europeans corn borers (ECB). These insect preferred to lay eggs on plant grown in soil with history of conventional management. With respect to plant disease lower incidence of some disease on organic farm was observed. Such as *Fusarium* head blight (Oerk *et al*., 2001)

The top ten plants which posses pesticidal properties are neem (*Azadirachta indica*), custard apple (*Anona squamosa*), papaya (*Carica papaya*), giant milkweed (*Calotropis procera*), pongamia (*Pongamia pinnata*), oleander (*Nerium indicum*), chaste tree (*Vitex nugundo*), snake root (*Aristolichia bracteata*), Indian tinospora (*Tinospora cordifolia*) and caste (*Ricinus communis*). Decoction prepared from these alone, or in combination with cow urine effective for control of large number of pests. Garlic–onion-chili acts, as repellent and buttermilk spray is also effective for the control of caterpillar and spider mites. Spray of BD-501 brings immunity against fungal infection. Biodynamic liquid pesticides prepared from casuarina/horse tail leaves also provide tolerance to disease.

Mango hopper management in organic mango orchard was effectively done using bio-pesticides (Ram et al, 2017). Spray was carried out twice (11th and 14th SMW) with biodynamic liquid pesticides after panicle emergence stage. The observation on hopper population was recorded during the flowering and fruiting period at

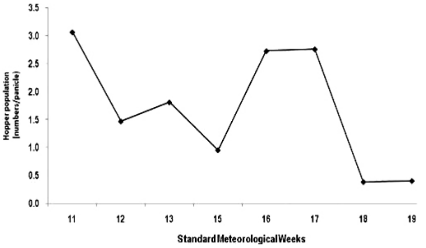

Fig. 11. Mean hopper population in experimental mango orchard before and after spray

weekly intervals. Before spray, the hopper population was 3.07 hoppers panicle^{-1} and after the spray the reduction in the hopper population was found up to 15th SMW with 0.95 hoppers panicle^{-1}. Second spray was taken up at 14th SMW, as result hopper population reduced to 0.4 hoppers panicle^{-1} up to 19th SMW. Powdery mildew was managed with spraying of BD - 501 and 02 % wettable sulphur/lime sulphur (Fig.11).

Gummosis is one of the major diseases of mango. Results revealed that the pasting with cow dung is very effective in controlling gummosis in mango plants inoculated artificially with *Lasiodiplodia theobromae* and in rejuvenated mango orchards. Attempts were also made to determine the mode of action of cow dung. An actinomycete was isolated from fresh cow dung, which showed antipathogenic potential against *Colletotrichum gloeosporioides* (anthracnose pathogen) and *Lasiodiplodia theobromae* (gummosis, stem end rot & die back pathogen) of mango. Mode of antipathogenic activity was studied under the microscope and it was found that actinomycete (filamentous bacteria), identified as *Streptosporangium pseudovulgare* attacks the mycelial (pathogen) cell wall, and enters the host. In side the host it utilizes the host cytoplasm for its multiplication and finally the host cell degrade completely. *In vitro* experiment on mango and guava (artificially inoculated) also, actinomycete was found effective against *C. gloeosporioides* and *L. theobromae* under *in vitro* conditions (Garg *et al.* 2003).

13.18 PRODUCTION OF HORTICULTURAL CROPS IN ORGANIC FARMING

In organic production organic manures, bio-enhancers, bio-agents, bio-pesticides and biofertilizers are used for crop management which is very slow in action. Emphasis should be given for on farm production of quality inputs production and their use at proper time.

Issues in organic production are as under:

- on-farm input generation to make it cost effective,
- quantum production equal to or higher than what is expected from optimum combination of agro-chemicals,
- continuous improvement in physico-chemical and biological properties of soil,
- par excellence produce quality with respect to nutrition, essential constituents, therapeutic value and storability and
- eco-friendly and cost effective technology.

In a study comparison among conventional and organic production of mango was made. The average yield of mango cv. Dashehari was recorded 56.54 kg/tree with application of recommended dose fertilizers whereas it was 90, 35, 80 and 95 kg/ tree in Mallika, Amrapali, Langra and Dashehari, respectively (Pathak et al, 2010) in organic production. Improvement in fruit TSS was also recorded (19.20-21.50^{0}B, respectively) in all the cultivars in comparison to conventional (17.25^{0}B) Table 13.11).

Table 13.11: Difference between yield and fruit quality of organically grown mango cultivars.

Cultivar	Yield (Kg tree^{-1})	Acidity (%)	TSS (^{0}Brix)
Conventional production			
Dashehari	56.54	0.20	17.25
Biodynamic production			
Mallika	90.00	0.16	19.20
Amrapali	35.00	0.11	21.60
Langra	80.00	0.18	19.20
Dashehari	95.00	0.16	21.50

In guava cv Allahabad Safeda, maximum yield (89.58 kg/tree) was recorded with 30 kg vermicompost + 250 g *Azospirillum* + PSB culture / tree + vermiwash spray and minimum (73.03 kg/tree) with 30 kg FYM/ tree. Improvement in fruit quality with application of different treatments was also observed and maximum TSS (14.86^0 Brix) recorded with application of 30 kg FYM /tree. Maximum ascorbic acid (209.41 mg/100g) was recorded with application of 30 kg vermicompost + 250 g *Azospirillum* + PSB culture/tree and minimum (185.98^{0}Brix) with 30 kg vermicompost + 250 g *Azospirillum* + PSB culture /tree$^+$ vermiwash spray (Table 13.12).

Study on organic production of papaya cv Pusa Delicious revealed that the fruit yield was recorded highest (56.00 kg tree^{-1}) with application of 10 kg FYM + BD-500/tree (Pathak et al, 2010). Maximum mean fruit weight was recorded (1.03 kg) with FYM 20 kg + 250 g *Azospirillum.* Fruit TSS was recorded highest (9.8^{0}B) with CPP 500 g + 50 kg FYM (Table 13.13).

Comparison in fruit weight and ascorbic acid was made between conventional, organic and forest aonla fruits. Maximum fruit weight and TSS were recorded (55.0g & 9.40 ^{0}B) in cv. Krishna, while ascorbic acid

Table 13.12. Response of different organic inputs on yield and its attributes of guava

Treatment	Av. fruit wt. (g)	Fruit number (/tree)	Fruit yield (Kg /tree)	Av. Fruit diameter (cm)	Av. fruit length (cm)
30kg FYM /tree	141.66	391.66	73.03	6.30	6.26
30kg FYM + 250 g *Azospirillum* + PSB culture /tree	175.33	453.33	87.48	6.10	6.44
30kg FYM + 250 g *Azotobacter* + PSB culture /tree	192.0	443.33	79.56	6.18	6.32
30 kg vermicompost /tree	193.33	457.66	88.51	6.56	6.90
30 kg vermicompost + 250 g *Azospirillum* + PSB culture /tree	178.33	418.33	73.22	6.59	6.61
30 kg vermicompost + 250 g *Azotobacter* + PSB culture /tree	184.33	473.33	85.26	6.35	6.56
30 kg vermicompost + 250 g *Azospirillum* + PSB culture /tree + vermiwash spray	199.00	480.33	89.58	6.38	6.70
CD 5%	25.28	54.48	12.10	NS	NS

Table 13.13. Response of various organic inputs on yield attributes of papaya cv. Pusa Delicious

Treatment	Yield and other associated parameters				
	Yield (kg plant^{-1})	Weight (kg fruit^{-1})	Fruit length (cm)	Fruit cavity (cm)	TSS (^{0}B)
Vermicompost 5kg	47	0.86	11.70	9.00	9.20
Vermi-wash (1:7)+10kg FYM	44	0.75	12.00	8.50	8.00
BD 500 spray +10kg FYM	56	0.88	12.00	10.00	9.00
CPP 500g + 5 kg FYM	49	0.83	14.00	17.50	9.80
FYM 20kg+250g *Azospirillum*	44	1.03	21.50	17.00	9.50
FYM 20kg+250g *Azotobacter*	29	0.75	13.00	8.50	9.00
FYM 10 kg+5kg Celrich	33	1.20	13.50	10.00	7.80
Control (350g N+200g P+350g K)	28	0.75	11.20	8.50	7.50

was more (438.77 mg 100 g^{-1} fruit) in cv. Chakkiya. Fruit weight (35g), TSS (7.4^{0}B), acidity (2.21%) and ascorbic acid (377.54/100 g^{-1} fruit) were lower in conventional grown aonla cv. NA 7 (Table 13.14).

Table 13.14. Comparison between yield and fruit quality of aonla grown under different conditions

Variety/ cultivation system	Fruit weight (g)	TSS (^{0}B)	Acidity (%)	Ascorbic acid (mg 100 g^{-1} fruit)
a. Conventional				
NA-7	35	7.40	2.21	377.54
b. Forest aonla	10	9.30	2.40	455.04
c. Biodynamic production				
NA-10	45	9.20	2.14	408.16
NA-7	45	7.60	1.94	306.12
Chakkiya	40	8.00	1.88	438.77
Krishna	55	9.40	2.21	418.36

13.18.1 Production of vegetables in different organic farming systems

Cauliflower, cabbage, okra and cowpea were grown with different organic package of practice. Maximum yield (95.95q ha^1-cauliflower, 178.73 q $ha.^1$-cabbage and 89.27 q $ha.^1$-okra) was recorded with biodynamic package of practice, while maximum yield of cowpea (69.71 q $ha.^1$) was with *Panchagavya* package (Pathak et al, 2010). Cost benefit ratio was worked out maximum (4.06) in cauliflower with biodynamic, 5.36 and 4.38 in cabbage and okra respectively with Rishi Krishi. (Table 13.15 and figure-12).

Table 13.15. Yield of vegetables in different organic farming systems

Farming systems	Cauliflower (q $ha.^1$)	Cabbage (q $ha.^1$)	Okra (q $ha.^1$)	Cowpea (q $ha.^1$)
Rishi Krishi	71.38	114.95	88.39	64.81
Panchgavya POP	64.24	131.6	54.06	69.71
Biodynamic POP	95.95	178.73	89.27	60.86
Farm yard manure	68.13	125.42	86.62	61.52
RDF	90.00	122.80	27.25	50.00
CD at 5%	NS	22.05	NS	NS

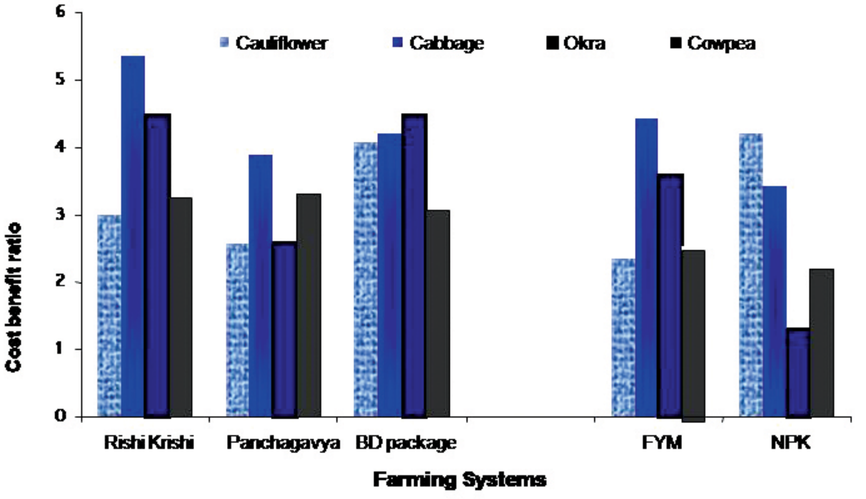

Fig.12. Cost benefit ratio of vegetables in different farming system

13.18.2 Energy analysis in organic production

In a field experiment, various organic inputs were applied in 15 years old trees of guava cv Allahabad Safeda. Energy input and out put in organic and conventional production of guava was worked out by converting input and out put values into energy (Ram and Verma 2017). Machinery consumed less energy (577.8 MJ) and chemical fertilizers ranked first (10088 MJ) in energy consumption (Table 13.16). Maximum input energy was consumed (47120.76 MJ) in application of recommended dose of chemical fertilizers compared to 6973.36 MJ with application of 30 kg FYM tree^{-1} + 5 per cent *Panchagavya*. Output input and energy ratio (9.91) was highest in 250 g rhizospheric soil of *Ficus benghalensis* tree^{-1} + 5 per cent *Amritpani* + organic mulching compared to 3.48 with application of recommended dose of chemical fertilizers. Net return (Rs. 127746 ha^{-1}) and benefit cost ratio (4.4) was worked out maximum with application of 250 g rhizospheric soil of *Ficus benghalensis* tree^{-1} + 5 per cent *Amritpani* + organic mulching compared to Rs.120820 and 3.7 with application of 350 g N, 150 g P_2O_5 and 350 g K_2O tree^{-1} (Table 13.17).

13.18.3 Management of weeds in organic production

Effective weed management in organic farming includes creation of conditions which suppress weeds from growing. The most sensitive phase of a crop to weed competition is in its early growth stage in annual crops. Weed competition later in crop stage is less harmful. However, some weeds may cause harvesting problems and reduce the crop yield in that way.

Table 13.16. Energy consumption and output in guava production in different treatments

	T1	T2	T3	T4	T5	T6	T7
Total energy input (MJ)	9653.1	12104.3	5216.9	7427.03	10905.6	7135.37	13523.41
Total output energy (MJ)	37673.9	38287.0	46973.2	36402.2	42340.6	33154.848	47120.76
Energy output-input ratio	3.90	3.16	9.00	4.90	3.88	4.65	3.48
Specific energy ($MJkg^{-1}$)	0.73	0.897	0.315	0.579	0.731	0.611	0.815
Energy productivity (kg MJ^{-1})	1.375	1.114	3.172	1.727	1.368	1.637	1.228
Energy intensiveness (MJ Rs^{-1})	0.254	0.297	0.133	0.201	0.274	0.209	0.318
Net energy yield ($MJha^{-1}$)	28020.8	26182.7	41756.2	28975.2	31434.9	26019.5	33597.3

Table 13.17. Economic analysis of guava production

Cost items	T1	T2	T3	T4	T5	T6	T7
Total production costs (Rs ha^{-1})	37940.68	40667.61	39196.75	36907.85	39771.02	34127.92	42500.8
Yield (kg ha^{-1})	12256	12704	16580	7376	10456	11872	16600
Total production value (Rs ha^{-1})	122560	127040	165800	73760	104560	118720	166000
Productivity (kg Rs^{-1})	0.33	0.32	0.43	0.28	0.31	0.37	0.33
Net return (Rs ha^{-1})	85731	87164	126895	47570	70573	86334	115794
Benefit cost ratio	3.33	3.19	4.26	2.82	3.08	3.67	3.31

Therefore, weeds should not be completely ignored after the most critical growth period of the crop is over, but in general, they beco-me less important.

These considerations should influence the selection and timing of weed management measu-res. In general, such measures aim at keeping the weed population at a level which doesn't result in economic loss of the crop production.

13.18.4 Management of weed population

- Mulching
- Altering planting time
- Balanced nutrition
- Summer ploughing and hoeing
- Use of cleaned tools

13.18.5 Preventive measures to suppress the weeds

Several preventive measures may be applied at the same time for weed management. The importance and effective-ness of the different methods depend to a large extent on the weed species and the environ-mental conditions. However, some methods are very effective for a wide range of weeds management.

1. Mulching with dry, hardy material, that decomposes slowly, keeps its effect on weed suppression longer than fresh mulch material.
2. Living green cover competes successfully against the weeds for light, nutrients, and water and therefore helps to prevent weed growth.
3. Crop rotation is the most efficient measure to regulate seed and root weeds.
4. Growing of green manure crop before sowing of kharif crops reduces weed problem.
5. Weed pressure during the critical period (initial stage of the crop) can be reduced by altering sowing time.
6. Increase in sowing density reduces weed pressure.
7. Balanced nutrition can support an ideal growth of the crop, which promotes the growth of the crop over the weeds.
8. Proper tillage can influence the total weed pressure as well as the composition of weeds.

9. Weed seeds germinate during sowing of the crop, ploughing before sowing is effective in reducing weed pressure.
10. Stubble treatment during dry weather conditions to allow the weed roots which have been brought to the surface to dry out.
11. Weeding at the time of flowering prevent dissemination of weeds seeds.
12. Sowing of weed free seeds reduces weed pressure.

13.18.16 Mechanical method for weed management

Weed population can be reduced by different mechanical methods. Therefore, mechanical methods remain an important tool for weed management.

- Manual weeding is the most important method for weed management.
- Use of right tools can increase work efficiency as well as reduces labour cost

Fig.11 Manual weed management in annual crop

13.18.7 Improvement in soil and plant health

Practice of biodynamic farming for management in mango orchard was initiated during 2002 at ICAR-CISH, Lucknow. It consisted of application of biodynamic compost, mulching with banana leaves, supplemented with drenching with CPP and BD-500. Analyses of biological and chemical properties of basin soil were followed for three initial years is presented table 13.18.

Table 13.18: Changes in chemical and biological properties of rhizospheric soil of mango tree basin with biodynamic package of practice

Particular	Initial year	II year	III year
Organic carbon (%)	0.535	0.80	1.003
P (ppm)	8.66	8.66	22.66
K (ppm)	140.00	142.50	202.50
Yeast and mould (cfu'/g)	1.3 x 104	5.8 x 104	8.5 x 104
Bacteria (cfu's/g)	3.7 x 106	4.8 x 106	8 x 106

Perusal of table indicates that even in absence of chemical fertilizer application, steady increase in organic carbon, phosphorus, potash and count of bacteria, yeast and mould were observed (Pathak et al, 2010). In another experiment, response of organic and conventional inputs on soil, plant nutrients and soil microbial property of soil was studied for two years in mango cv. Mallika (Ram et al, 2017). Treatments were applied in 30 years old trees as under:

1. FYM (40 kg /tree)+ *Azotobacter* + *Azospirillum* + PSB (10^8 cfu/g) + Mycorrhiza (Inoculum)
2. Biodynamic compost (30 kg/ tree) + bio-enhancers (CPP 100 g, BD – 500 and BD 501 as soil and foliar spray)
3. Neem cake + Farmyard manure (20 kg each/tree) + *Azotobacter* + *Azospirillum* + PSB (10^8 cfu/g)
4. Vermi compost (30 kg /tree) + *Azotobacter* + *Azospirillum* + PSB (10^8 cfu/g)
5. Farmyard manure (40 kg/ tree)+ bio-enhancer (Amritpani 5% soil application)
6. FYM (40kg/ tree) + Green manuring (sun hemp) *Azotobacter* + *Azospirillum* + PSB (10^8 cfu/g)
7. 1000g N P K /tree

13.18.8 Soil nutrient analysis

Composite soil samples were taken at 0-15 cm and 15-30 cm soil depths from experimental plots before treatments application. Soil contained 1.18 % organic carbon, 170 ppm available N, 180 ppm available P, 190 ppm available K, 2.79 ppm Zn, 9.11 ppm Cu, 9.09 ppm Mn and 7.38 ppm Fe. At 15-30 cm soil depth organic carbon was 1.11 %, available N (140 ppm), available P (67ppm), available K (180 ppm), Zn (2.59 ppm, Cu (7.89ppm), Mn (6.89ppm) and Fe (6.23ppm). After one year of treatments application improvement in soil nutrient level was recorded at 0-15 cm soil depth. Maximum organic carbon (1.20%), available N (168.933ppm), P (27.667ppm), Zn (3.78ppm), Cu (14.78ppm), Mn (2.547ppm) and Fe (4.9583ppm) was recorded with biodynamic compost (30 kg/ tree) + bio-enhancers (CPP 100 g, BD–500 and BD 501 as soil and foliar spray) (T2) while, minimum N (121.467ppm), Zn (2.047ppm) and Cu (7.493ppm) was recorded in 1000g N P K /tree (T7) and minimum P (23.267ppm) and Fe (4.133ppm) was analysed in rhizospheric soil applied with FYM (40 kg /tree)+ *Azotobacter* + *Azospirillum* + PSB (10^8 cfu/g) +

Mycorrhiza (inoculum). Observations on level of K and organic carbon varied non-significantly (Table 13.19) Improvement in soil nutrient level at 15-30 cm soil depth was also recorded, maximum available N (151.20ppm), K (200.85ppm), Zn (2.41ppm) and Cu (9.46 ppm) was recorded with T2 while maximum P (33.10ppm) with T5 and Mn (2.2.ppm) was recorded with T6 (Ram et al, 2017). Minimum level of available N (110.53ppm), K (181.72 ppm) and Cu (5.59ppm) was recorded in T7 while minimum P (27.53ppm) with Neem cake + Farmyard manure (20 kg each/tree) + *Azotobacter* + *Azospirillum* + PSB (10^8 cfu/g) (Table 13.20).

Table 13.19: Soil organic carbon and nutrients level in availability in experimental field (0-15 cm soil depth) after application of treatments

Treat-ments	OC (%)	Available N (ppm)	P (ppm)	K (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
T1	0.92	155.867	23.267	191.35	2.127	9.533	1.573	4.133
T2	1.20	168.933	27.667	201.517	3.78	14.78	2.547	4.953
T3	1.09	140.00	21.367	193.23	3.05	12.44	1.780	4.627
T4	1.02	135.86	26.967	182.85	2.687	12.447	2.073	5.587
T5	1.11	135.60	26.267	200.38	3.447	13.747	1.94	4.287
T6	1.16	137.467	24.60	190.15	2.68	8.053	2.16	5.313
T7	0.98	121.467	23.467	187.83	2.047	7.493	2.10	4.587
CD 5%	NS	22.85	2.081	NS	0.686	2.431	0.321	0.426

Table 13.20: Soil organic carbon and nutrients level in availability in experimental field (15-30 cm soil depth) after application of treatments

Treat-ments	OC (%)	Available N (ppm)	P (ppm)	K (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
T1	0.84	146.07	29.43	175.46	1.94	7.67	1.55	4.90
T2	1.19	151.20	29.46	200.85	2.41	9.46	2.13	4.94
T3	1.07	126.0	27.53	192.85	2.13	7.95	2.03	5.26
T4	1.02	130.933	32.26	200.28	2.19	5.93	1.920	5.33
T5	0.92	130.0	33.10	174.30	2.09	8.32	1.93	4.14
T6	1.09	126.867	32.86	183.43	2.18	7.31	2.23	4.86
T7	0.85	110.533	28.53	165.05	1.67	5.59	2.55	4.61
CD 5%	NS	15.725	3.129	24.13	NS	2.01	0.491	NS

13.18.9 Leaf nutrient analysis

Composite leaf analysis for major and minor nutrients shows that experimental trees contained 1.65 % N, 0.1% P, 1.61 % K, 23.75 ppm Zn, 13.50ppm Cu, 62.25 ppm Mn and 371.25 ppm Fe. Concentrations in leaf nutrients were recorded after one year of treatments application. Maximum N (2.347%), K (0.993%) Zn (39.00ppm), Cu (41.0ppm), Mn (72.67ppm) and Fe (256.0ppm) were recorded in T2 while minimum N (1.797%) in T6, K (0.894%) in T1 Cu (25.00ppm), Mn (51.33ppm) in vermi compost (30 kg /tree) + *Azotobacter* + *Azospirillum* + PSB (10^8 cfu/g) and Fe (182.66ppm) was recorded in T7 (Table 13.21).

Table 13.21 Leaf nutrients level after application of various treatments

Treat-ments	N (%)	P (%)	K (%)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
T1	2.20	0.099	0.894	28.33	29.667	63.00	232.33
T2	2.347	0.107	0.993	39.00	41.00	72.667	256.0
T3	1.993	0.105	1.056	37.33	35.667	56.33	252.66
T4	2.165	0.095	1.095	22.667	25.00	51.33	203.00
T5	2.123	0.10	0.978	29.00	38.667	61.33	241.00
T6	1.797	0.098	0.940	22.33	34.33	66.00	240.667
T7	2.15	0.100	1.10	18.33	29.33	66.00	182.66
CD 5%	0.202	NS	0.083	13.88	6.87	7.76	29.67

13.18.10 Improvement in microbial properties of soil

Composite soil samples were collected at 0-15 and 15-30 cm depth before treatment application. Total bacterial population was recorded 1.7 x 10^9 CFU/g at 0-15 cm soil depth and 0.08 x 10^9 CFU/g at 15-30 cm depth. Total fungal population in experimental soil was recorded 8.74 x 10^5 CFU/g at 0-15 cm depth and 4.10 x 10^5 CFU/g at 15-30 cm depth. Total actinomycetes population was recorded 1.1 x 10^7 CFU/g at 0-15 cm depth and 0.03 x 10^7 CFU/g at 15-30 cm depth. After one of experimentation, maximum increase in total bacterial population (69.14 x10^8) was recorded with T2 at 0-15cm soil depth and minimum (4.23 x 10^8) in T7. Maximum increase in total bacterial population (18.21 x 10^8) was also recorded with T2 and minimum (3.7 x 10^8) with T7 at 15-30cm soil depth. Fungal population in rhizospheric soil was varied significantly with application of different organic inputs. Maximum total fungal population (32.13 x10^4)

in soil was recorded with T4 and minimum (4.10 x 10^4) with T7 at 0-15cm soil depth while variation in fungal population at 15-30 cm depth varied non-significantly. Significant variation in increase in actinomycetes population was recorded due to application of different treatments. Maximum actinomycetes population (60.91 x 10^6) was recorded with T4 followed by (30.64 x 10^6) with T2 and minimum (2.4 x 10^6) with T7 at 0-15 soil depth while maximum actinomycetes population (38.94 x 10^6) was recorded with T2 and minimum (2.38 x 10^6) in T7 (Table 13.22).

Table 13.22 Improvement in microbial populations in plant rhizospheric soil after application of different organic inputs

Treatments	Bacterial population at different soil depth (x 10^8)		Fungal population at different soil depth (x 10^4)		Actinomycetes population at different soil depth (x 10^6)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T1	44.37	11.10	8.72	0.53	12.63	2.38
T2	69.14	18.21	13.44	5.42	30.64	38.94
T3	52.24	4.88	20.82	5.06	37.47	20.88
T4	47.67	23.57	32.13	5.50	60.91	6.18
T5	26.58	14.83	4.80	2.23	42.82	6.87
T6	34.33	9.50	4.73	3.77	6.86	4.55
T7	4.23	3.70	4.10	8.63	2.40	7.23
CD at 5%	9.34	10.79	11.49	NS	22.75	13.25

Initial microbial biomass carbon was recorded 179.36 mg C/kg soil at 0-15 cm soil depth while it was 121.99 mg C/kg soil at 15-30 cm depth. After one year of treatments application maximum microbial biomass (750.27 mg kg^{-1}) was recorded with T2 and minimum (148.67 mg kg^{-1}) with T1 at 0-15 cm soil depth. Microbial biomass phosphorus was recorded 2.82 mg P/kg soil at 0-15 cm depth and 0.78 mg P/kg soil at 15-30 cm depth before the treatments application. Significant improvement in microbial biomass phosphorus was recorded and maximum (4.58 mg kg^{-1}) was recorded with T2 and minimum (0.36 mg kg^{-1}) was with T7 at 0-15 cm soil depth whereas, maximum microbial phosphorus (2.18 mg kg^{-1}) was recorded at 0-15 cm soil depth with T2 and minimum (0.43 mg kg^{-1}) with T7 (Ram et al, 2017). Microbial biomass nitrogen was recorded 93.32 mg N/kg soil at 0-15 cm soil depth and 46.66 mg N/kg soil at 15-30 cm depth before the treatments application. Maximum increase (181.42 mg kg^{-1}) was recorded with T2 and minimum (112.57 mg kg-1) in T7 at 0-15 cm soil depth while it was maximum (136.67 mg kg^{-1}) in T2 and minimum (31 mg kg^{-1}) with T7 at 15-30 cm soil depth. Improvement in urease activity of recorded at 0-15cm and 15-30 cm soil depth but observations were varied non-significantly (Table 13.22). Significant improvement in alkaline phosphate activity was recorded with application of different treatments. Maximum alkaline phosphate activity (136.37 µ g pnp $g^{-1}h^{-1}$) was recorded with T2 and minimum (69.33 µ g pnp $g^{-1}h^{-1}$) with T5 at 0-15 cm soil depth whereas, maximum (86.56 µ g pnp $g^{-1}h^{-1}$) was recorded with T2 and minimum (47.58 µ g pnp $g^{-1}h^{-1}$) with T7 at 15-30 cm soil depth. Improvement in improvement of acid phosphate activity was also recorded but variations among the treatment varied non-significantly at 0-15cm soil depth while it was recorded maximum (80.26 µ g pnp $g^{-1}h^{-1}$) with T2 and minimum (43.05 µ g pnp $g^{-1}h^{-1}$) with T7 at 15-30 cm soil depth (Table 13.23).

Table 13.23 Microbial biomass carbon, phosphorus, alkaline phosphatase and acid phosphatase activity in rhizospheric soil of experimental trees after application of different organic inputs.

Treatments	Microbial biomass carbon (mg kg^{-1})		Microbial biomass phosphorus (mg kg^{-1})		Alkaline phosphate activity (µg pnp $g^{-1}h^{-1}$)		Acid phosphate activity (µg pnp $g^{-1}h^{-1}$)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	148.67	182.03	0.78	0.58	88.33	62.93	55.09	56.90
T_2	750.27	192.50	4.58	2.18	136.37	86.56	70.01	80.26
T_3	237.40	148.97	1.47	1.52	88.03	61.91	59.05	67.72
T_4	287.13	142.97	1.97	0.87	88.97	79.58	59.29	62.75
T_5	311.63	169.43	1.12	1.09	69.33	60.83	58.34	43.89
T_6	438.27	195.03	2.80	1.74	116.93	85.48	64.47	74.15
T_7	274.33	33.27	0.36	0.43	85.10	47.58	54.98	43.05
CD at 5%	186.01	NS	1.09	1.13	32.95	13.74	NS	15.23

Dehydrogenase activity in composite soil was recorded 2.04 µg TPF/ g soil/hr at 0-15 cm soil depth and 1.77 µg TPF/g soil/hr at 15-30 cm soil depth before application of treatment (Table 13.24). After one year, maximum Dehydrogenase activity (4.57 µg TPF/g soil/hr) was recorded

Table 13.24: Improvement in microbial biomass nitrogen (mg kg^{-1} soil) and urease activity (mg urea/g/hr) in rhizospheric soil experimental trees after application of different organic inputs

Treatments	Microbial biomass nitrogen (mg kg^{-1} soil)		Unease activity (mg kg^{-1} soil)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	133.23	47.67	1.45	1.24
T_2	181.43	136.67	1.55	1.52
T_3	154.77	80.33	1.43	1.43
T_4	140.70	71.37	1.23	1.12
T_5	133.60	106.20	1.20	1.25
T_6	188.87	119.60	1.12	1.30
T_7	112.57	31.67	0.99	1.12
CD at 5%	41.16	29.99	NS	NS

Table 13.25: Improvement in dehydrogenase activity (µg TPF g^{-1} hr^{-1}) and FDA (mg fluoroscein g^{-1} hr^{-1}) in rhizosphere of tree after application of different organic inputs

Treatments	Dehydrogenase activity (µg TPF g^{-1} hr^{-1})		FDA (mg fluoroscein g^{-1} hr^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T1	2.39	2.94	516.33	345.67
T2	4.57	4.09	944.33	798.33
T3	3.25	2.93	595.00	593.83
T4	3.16	3.41	539.67	481.83
T5	2.81	3.00	525.0	606.33
T6	4.08	3.66	832.0	762.83
T7	2.73	1.98	403.50	304.83
CD at 5%	1.31	1.15	236.74	236.48

with T2 and minimum (2.73 µg TPF/g soil/hr) in T7 at 0-15cm soil depth. Highest dehydrogenase activity (4.09 µg TPF/g soil/hr) was also recorded with T2 and minimum (1.98 µg TPF/g soil/hr) with T7 at 15-30 cm soil depth (Ram et al, 2017). Fluroscent diacetate activity was varied significantly with application of different treatments. Maximum FDA (944.33 mg fluorescin k/g/hr) was recorded with T2 and minimum (403.50 mg fluorescin k/g/hr) with T7 at 0-15 cm soil depth. Highest FDA (798.33 mg fluorescin k/g/hr) was recorded with T2 and minimum (304.83 mg fluorescin k/g/hr) with T7 at 15-30 cm soil depth (Table 13.25).

13.19 ECONOMICS IN ORGANIC PRODUCTION

In a long-term experiment on organic production, seven treatments viz; 50 kg FYM/tree (T1), 50 kg FYM + 250 g *Azospirillum* + PSB culture /tree (T2), 50 kg FYM + 250 g *Azotobacter* + PSB culture/tree (T3), 50 kg vermicompost/tree (T4); 50 kg vermicompost + 250 g *Azospirillum* + PSB culture /tree (T5), 50 kg vermicompost + 250 g *Azotobacter* + PSB culture/ tree (T6) and 50 kg vermicompost + 250 g *Azospirillum* + PSB culture /tree + vermiwash spray (T7) were applied in 35 years old trees of mango cv Dashehari. Economic analysis showed that the production cost (Rs.22800.43 /ha), production (9624 kg fruit/ha), production value (Rs.96240/ha), productivity (0.422 kg/Rs), net return (Rs.73439.65/ha) and benefit cost ratio (4.22) was recorded with application of 50 kg vermicompost + 250 g *Azospirillum* + PSB culture /tree+ vermiwash spray while minimum (Rs.19212.04 /ha), 5014 /ha, (Rs.30927.95 /ha), Rs.50140 /ha and 2.60 with 50 kg FYM /tree, simultaneously (Ram and Verma, 2015) (Table 13.26).

Table 13.26: Economic analysis of production

Particular	T1	T2	T3	T4	T5	T6	T7
Total production costs (Rs. /ha)	20315.47	21821.72	21959.48	22383.65	24353.43	25069.84	26565.31
Yield (kg /ha)	8365	9992.333	11125	11609	15358.33	17534	21057.67
Total production value (Rs. /ha)	83650	99923.33	111250	116090	153583.3	175340	210576.7
Productivity (kg /Rs)	0.41	0.45	0.50	0.51	0.60	0.67	0.75
Net return (Rs. /ha)	63334.53	78101.62	89290.52	93706.35	129229.9	150270.2	184011.4
Benefit cost ratio	4.06	4.54	5.00	5.07	6.01	6.68	7.46

In an experiment on organic production of mango cv Mallika economic analysis showed that the maximum cost of production (Rs.11.50/kg) was recorded with recommended dose of fertilizers and minimum (Rs.5.41/kg) with biodynamic package of practice. Maximum production (10898.67kg/ha), production value (Rs.163480/ha), benefit cost ratio (5.10) was also recorded with biodynamic package of practice (Table 13.27).

Table 13.27: Economic analysis of production

Treatments	Cost of production (Rs./kg)	Yield (kg /ha)	Total production value (Rs. /ha.)	Net profit (Rs. /ha.)	Benefit cost ratio
T_1	9.24	6068.33	91025	36436.50	1.67
T_2	5.41	10898.67	163480	112298.67	3.19
T_3	9.84	8175.33	122630	46056.30	1.60
T_4	9.27	6955.67	104335	49606.67	1.90
T_5	9.16	5795.33	86930	36956.30	1.74
T_6	7.43	8218.33	123275	68938.07	2.26
T_7	11.50	5353.00	80295	24623.11	1.44
CD at 5%	2.04	2565.26	38478.85	38479.04	0.78

13.20 LIMITATIONS IN ORGANIC PRODUCTION

Nutrient, insect and pest management in organic production is laborious and slow process, which response slowly and makes the process less favorite to the growers. The fact cannot be denied that, organic farming can prove quite beneficial for the producers as well as the consumers if practiced in a continuous and proper way but the other fact is there are certain linked limitations from the producers as well as consumers point of view that hinders the adaptability of organic farming on a large scale.

- The organic farming is a labour intensive as in case of organic farming extensive observation is required on a regular basis in comparison to the conventional agriculture.
- It is known that, organic farming is a time taking process and hence, an organic farmer need to be very skilful and attentive.
- Since, the uses of agro chemicals are strictly prohibited in organic farming so the farmers have to manage insect pest and weeds in natural means.

- It is necessary for the farmers to learn organic farming practices practically so that he can produce inputs at his farm with locally available materials.

13.21 IMPACT OF ORGANIC AGRICULTURE

- If complete package of practice is not adopted, yield may decline in intensive farming systems,
- In the so-called green revolution areas (irrigated lands), conversion to organic agriculture requires over use of organic manures and bio-pesticides.
- In traditional rain fed agriculture (with low external inputs), organic agriculture has shown the potentials in increase yields.

A number of studies have shown that under drought conditions, crops in organic agriculture systems produce significantly higher yields than comparable conventional agricultural crops, often out-yielding conventional crops by 7 – 90 per cent. Others have shown that organic systems have less long-term yield variability.

During conversion period in intensive farming system, yield may decline in the first 1- 2 years of transition, followed with yield increase when soils health is improved. Studies conducted in Punjab clearly indicated that organic farming produced higher or equal yields of different cropping system compared to chemical farming after an initial period of three years. At ICAR-CISH, Lucknow, equal and higher yield were obtained after adoption of biodynamic package of practice in mango, guava, aonla, cabbage, cauliflower, okra, etc.).

13.22 POTENTIAL OF ORGANIC AGRICULTURE IN INDIA

- As per data from the Govt. of India, 74% of farmers in India own less than 2 hectares of agricultural land. Compared to developed countries, this was considered a strength because organic farming practices would require low cost inputs and could be produced on-farm which could be managed by the family Rabo Bank Survey, 2005, reported that 65% of the total cultivable area in India is organic by default. Therefore system would facilitate the conversion of this area, to start with, into organic and work within natural systems and cycles throughout all levels from the soil to plants and animals.
- India is rich in 'Traditional Knowledge' in farming which is well recognized and documented. ICAR has published 3 volumes on this topic by Das and C L Arya. In addition, websites of some NGO's-

SRISTI, Ahmadabad, CIKS, Chennai, Green Foundation, Bangalore, have thousands of items of Indigenous Traditional Knowledge (ITK) relevant to organic farming.

- India has abundant resources in trained manpower for on farm activities. Several examples were brought out during the two days deliberations - for instance, Amrit Pani, prepared involving cow dung, cow urine and jaggery was reported to be rich in agriculturally beneficial bacteria such as P solubilizers and N fixers.
- India has good institutional infrastructure for research, extension and development.
- The group strongly felt that hill areas, tribal habitats and rain fed agriculture zones that form 66% of the cropped area are more suited for organic farming in order to maintain the long term fertility and biological activity of these soils and to treat livestock ethically, meeting their physiological and behavioural needs.
- Diverse climatic zones in India naturally encourage crop and biological diversity to respect regional, environmental, climatic and geographic differences and practices (appropriate) that have evolved in response to them. The role of native species is also important in this context and conservation is enhanced through organic farming by default.
- The rich cultural heritage of India binds the farming community through various festivals and local cultures are addressed to the annual agricultural calendar. Farmers in general are supportive of each other in agricultural practices such as seed sharing and in producing food of high quality and in sufficient quantity.

13.23 ENVIRONMENTAL BENEFITS OF ORGANIC AGRICULTURE

The impact of organic agriculture on natural resources favours interactions within the agro-ecosystem those are vital for both agricultural production and nature conservation. Ecological services derived include soil forming and conditioning, soil stabilization, waste recycling, carbon sequestration, nutrient cycling, predation, pollination and habitats.

The environmental costs of conventional agriculture are substantial, and the evidence for significant environmental amelioration via conversion to organic agriculture is over-whelming. There are also high pre-consumer human health costs to conventional agriculture, particularly, in the use of pesticides. According to a WHO report globally, at least three million people are affected by pesticides residues annually, out of whom 20,000 die. A majority of the pesticide induced deaths are reportedly occurring in the developing countries, which use 25 per cent of the global pesticides production.

Experience showed that systematic adoption and application of organic farming practices will resolve aforesaid apprehensions. Since the three sources of energy have been polluted beyond their recovery, it is advocated that integration of organic farming practices in the name of *Jaivik Krishi* will be cheap, effective and sustainable option for organic production of horticultural crops. One of the viable options particularly for small and marginal farmers would be to adopt livestock in Farming System mode to obtain best possible synergy between the components, greatly surpassing the additive values, individual beneficial effect of the different components of the properly managed system. It is apparent from the above that *Jaivik Krishi* which is the integration of few techniques from different organic farming systems is capable of enriching rhizosphere. After close observation, it is confirmed that as on today there is immense possibility of assuring sustainable horticulture/agriculture production with continuous improvement in natural resource base. Since number of approaches have not given expected dividends, I urge let us try this with full dedication. Hence, there is urgent need to initiate systematic research and promotion of modern tools of transfer of technology (TOT) so that it is promoted on wide range of crops in different agro climatic situations in assertive way in the country.

13.24 FUTURE STRATEGIES, THRUST AREAS AND CROPS

1. Numbers of traditional organic farming methods are being practiced by a large number of farmers. There is need to inventorize these methods, study the possibility of their integration, validation and development of package of practice, specific to crop and agro-climatic situations.

2. Identification/ selection of appropriate varieties adapted to organic production methods and agro-climatic situations.

3. Research/ extension activities on production of organic seed and planting materials need to be taken up vigorously in order to ensure quality seeds and planting materials.

4. Appropriate crop rotation and role of legumes as cover, intercrop as green manure, need to be investigated and included in the package.

5. Development of techniques to enhance the nutritive value of composts through incorporation of various organic waste, rock phosphate, dolomite, lime, cakes, bio-fertilizers, ash, bone, blood, fish meal acceptable in organic production system.

6. In order to minimize the impact of insect, pest, disease and weeds, various methods such as cultural, mechanical, use of predators, parasites, bio-pesticides, bio-agents etc. need to be integrated and package developed.

7. Besides the quantum of production, the nutritive value of produce (protein, amino acids, vitamins, micronutrients, antioxidants etc.), taste, keeping and therapeutic value etc, should be considered in organic production.

8. There is need of continuous monitoring of soil health with respect to physico-chemical and biological soil properties and monitoring of ground water, environment and flora and fauna on conventional and organic farm.

9. Integrated model involving various stakeholders such as farmer's organization (FIGs, FA's), NGOs, corporate bodies, State/Central Government/ICAR/SAUs and International organizations in organic farming need to be developed and promoted.

13.24.1 Thrust areas

- Rainfed and mostly one crop and default organic areas should be focused to conversion in to organic farming. These areas exist in N.E. H. region, Jharkhand, Uttarakhand and Rajasthan.
- Areas primarily under rainfed farming having little irrigation support. These are suitable for organic production of various crops. These areas are in Orissa, HP, J&K, MP, Chhattisgarh and Gujarat and also parts of Maharashtra and Karnataka.
- The area which is intensive farming and applied with heavy doses of agro-chemicals requires adoption of proper package of practice in organic production otherwise there will be loss of production.

13.24.2 Thrust crops

In India certain crops are grown organically since longtime such as tea, coffee, spices, fruits, vegetables, cotton, cereals, oilseeds, pulses, etc. Based on this thrust may be given to the following crops organically.

- Horticultural crops viz; grapes, mango, banana, apple, orange, sweet orange, lime, cashew nut, walnut and vegetables etc.
- Cereals viz; basmati rice, millets
- All pulses, soybean, groundnut and cotton
- All spices viz; cardmom, chillies, garlic, turmeric, coriander, ginger etc.
- Medicinal and aromatic crops

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Chapter 14

ADVANCES IN INTEGRATED PEST AND DISEASE MANAGEMENT IN ORGANIC FARMING

Chandra Bhanu and Veena Yadav

14.1 INTRODUCTION

Organic farming is a holistic food production management systems which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity (FAO). It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, wherever possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system. According to International Federation of Organic Agriculture Movement (IFOAM), 'organic agriculture' is a production system that sustains the health of soils, eco systems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

Nitrogen and pest management are key factors deciding the success of crop under organic farming. In general, pests include weeds, insect-pests, diseases, nematodes, rodents and other organisms causing harm (quantitative or qualitative losses) to our crops. In case of conventional farming systems, farmers or farm managers, in their integrated pest management programme, use the assistance of synthetic chemical pesticides for a quick fix. In contrast, due to ban on the synthetic chemical pesticides, organic farming mostly relies on other non-chemical management practices for controlling or managing these pests.

14.2 INTEGRATED PEST MANAGEMENT IN ORGANIC FARMING

The ecological approach which encourage and enhance biological cycles within the farming system; increase biodiversity of flora harbouring natural enemies (predators, parasitesand parasitoides); enhance internal resistance of crop plants to pests; making soil suppressive to soil borne pests and diseases, is base for pest management in organic situation. Many a times, due to unavailability of a control measure, farmer has to tolerate the losses in yield due to pests in organic farming conditions. In organic farming in India, farmers can only use the pesticides listed in National Standards for Organic Production (NPOP) updated time to time. In absence of synthetic chemical pesticides, cultural, host resistance, physical, biological, botanical, bio-rational methods etc. are mainly employed for pest control in organic farming with uncertainty in the level of pest control.

14.3 MAINTENANCE OF AGRO-BIODIVERSITY AT FARM

Maintenance of an appropriate habitat for sustaining different life forms is an essential part of Organic Farming. This agro-biodiversity can be created by ensuring crop diversity, plantation of wide varieties of trees and shrubs fit to the local climatic conditions. These plants/trees apart from increasing the soil health, also attracts birds, pollinators and many natural enemies of the insect-pests of crops by providing them shelter and food (nectar etc.) source. These birds and natural enemies (predators, parasites or parasitoides) in turn, regulate the pest population in agro-ecosystems. Pollinators attracted, also helps in increasing the crop yield by facilitating pollination particularly in cross pollinated crops. The boundary plantation of these shrub/tree species may be adopted in a multistoried fashion. For example, for a 10 acre organic farm, five-six neem trees (*Azadirachta indica*), one to two tamarind (*Tamarindus indica*), two gular (*Ficusglomerata*), eight to ten ber (*Ziziphus mauritiana*), one to two aonla (*Emblica officinalis*), one to two drum stick (*Moringaoleifera*) and 10-15 bushes of other wild species fit to the locality should be planted in plain region of the country (Yadav, 2011). The subabool (*Leucaena leucocephala*) can be a good source for forage and green leguminous nitrogen rich leaves for good quality compost or as soil mulch. Lemon can also be included for attracting pollinators and natural enemies. This also provides additional yield of fruits. Many of the above tree species provide fruits and thus additional income to the farmer. Neem which has a wide-spectrum pest control activity, provides leaves and seed kernels for preparation of neem leaf of neem seed kernel extracts which are used for managing a wide variety of insect-pests and vectors of virus diseases.

In between *Glyricidia/Sesbania* rows, few plants of pesticidal value such as *Adhathoda vasica*, *Vitex negundo, Calotropis procera* or *C. gigantia, Datura* spp., *Ipomoea carnea* (Besharam) etc. should be planted for making preparations for pest/disease control. Some of these plants also serves as medicinal plants for farm livestocks for organic cure of diseases. Surrounding the farm of garden, there should be hedgerows or a live fence of coppiced or pollarded, multipurpose, deep-rooted trees and shrubs and medicinal herbs such as *Adathoda vasica, Vitex negundo, Jatropha curcas* etc, for maintaining ecological diversity which is an essential component of any successful organic farming system. The *Calotropis* spp. attract early infestation of aphids in north plains and hence, facilitate the early establishment of predatory insects like lacewing and ladybird beetle which further moves to and controls the aphids on main crop.

14.4 TILLAGE, LAND CONFIGURATION AND CROP SPACING

Tillage is an old age practice of pest management in agriculture. Deep summer ploughing exposes the roots of many weeds and facilitate their drying. It also helps in exposing hibernating stages of insects for predation or killing by desiccation. The sclerotia and other resting structures of many pathogenic fungi and stages of nematodes get destroyed by summer ploughing. Intercultural operations besides proving proper aerations and growing conditions to soil, also helps in weed management. Hence summer ploughing and proper interculture should be among main strategies for weed, pest and disease management in organic farming.

Planting of crops especially turmeric, ginger, pulses, vegetables, maize etc. on raised beds or bunds particularly during rainy season provides protection against some soil borne diseases caused by *Pythium* and *Phytophthora* spp.

Crop spacing should be kept at larger side to avoid the build-up of congenial environment for pests and diseases attack. Widely spaced crops have proper aeration and lower humidity and lesser attraction for insect shelter and thus avoid the heavy attack of pests and diseases. Keeping 2' space vacant at every 3-4 meter in case of basmati or non-basmati rice helps in managing brown plant hopper, sheath blight disease and other pests. Larger plant to plant distance in case of okra helps in minimizing yellow vein mosaic disease due to lesser white fly vectors.

14.5 SOIL SOLARIZATION AND PEST MANAGEMENT

Soil solarization is a technique of raising soil temperature by clear plastic sheets which allows shorter wavelength solar radiation to enter into soil and heat it up and at the same time it restricts the longer wavelength radiation into soil during night time. Thus, the soil solarization keeps soil temperature continuously above lethal range (up to 60^{0}C) to many soil borne plant pathogens of mesophilic nature (*Fusarium* spp. *Verticillium* spp. etc.), nematodes (root knot nematode), weeds (annual grassy weeds and some broad leaved weeds also), and hibernation stages of insect-pests. Solarization of soil also creates a microbial vacuum which is later covered at faster rates by competitive microflora and thus helps in reducing soil pathogen population. It also promotes crop growth by modifying soil environment through nutrient solubilizing and cycling. This practice is done during summer months (May-June) to exploit maximum benefit of solar heating. Two months solarization is sufficient to provide its benefit for about three consecutive crop seasons. The thickness of clear polyethylene sheets should be in the range of 25-30 µm. The soil before solarization should be well prepared and has proper moisture for maximum conductivity of heat into the soil. This is a best practice for controlling weeds; root knot nematode and root rot and wilt diseases in nursery as well as high value crops. The sowing of seeds or transplanting of nursery after soil solarization should be done without much disturbance to the soil. Soil application of biological agents just after opening of polyethylene sheets at completion of solarization gives maximum benefit of bioagents in controlling diseases and promoting plant growth.

14.5 CONVERSION OF SOIL TO ORGANIC AND SUPPRESSIVE TO PESTS AND DISEASES

The soil of an organic farm should be converted into a pure organic by the application of low input alternatives like mixture of compost and vermicompost in 2:1 ratio @ 2.5 tons/acre and it should also be enriched with biofertilizer cultures i.e. *Azotobacter* (4 kg) and phosphate solubilising bacteria (PSB) @4 kg or consortia of microbes at final land preparation. Mandatory planting of legumes with crops helps in maintaining the soil fertility. **Jivamrut** is a low input alternative applied @ 200 lit per acre. Soils poor in phosphorus are added with low grade mineral rock phosphate @300 kg/acre. Repeated application of Jivamrut can be done at irrigation after the germination. After harvesting of legumes (picking of pods or separation of grains), recycle the total remaining biomass into the field. Also recycle entire residue of other crops either as such or after composting.

Apply preparations of*Trichoderma*and *Pseudomonas fluorescens/ Bacillus subtilis*@ 5 kg/ha along with organic manure during final stage of soil preparation which could suppress many soil or seed borne diseases of many crops including nematodes. Soil application of *Beauveria bassiana* or *Metarhizium anisopliae*@ 2.5 kg/ha has been found effective for controlling many important insect-pests including foliar insects, termites and white grubs.Application of crushed oil cakes @ 500 kg, 100 kg of neem cake along with organic manures and biodynamic preparations, has been reported to enhance the population of competitive microorganisms in the soil and also increase the its suppressiveness to soil borne plant pathogens.

14.6 MULTIPLE CROPPING AND MIXED CROPPING

Mixed cropping is the outstanding feature of organic farming in which variety of crops are grown simultaneously or at different time on the same land. In every season, care should be taken to maintain legume crops by at least 40%. Mix cropping promotes photosynthesis and avoids the competition for nutrients, because different plants draw their nutrients from different depth of soil. The Legume fixes atmospheric nitrogen and make available for companion or succeeding crops. Deep rooted plants draw nutrients from deeper layer of soil and bring them to the surface of soil through their leaf fall. So the nutrients leached down to lower strata are further brought back to upper layer by these deep rooted plants. Also help in protecting soil from soil erosion. Farmers should select the crops combination according to their needs and season. In addition to the above,mixed cropping is also a strategy to compensate the losses caused by pests and diseases. If main crop is damaged by the disease or pests, the mixed crop can compensate for the losses in main crop. Some of the mixed crops i.e. cow pea or *Dhaincha* smother weeds in between the rows of wide spaced crops and also add nitrogen to the soil. Any other interested crop which is having weed smothering property and if, compatible with main crop, can be planted in rows of main crop. Intercropping of Marigold in between wide spaced crops can smoother the weeds and also controls many nematode species of the crops.

Entire organic farm should have at least 8-10 types of crops at every time. Each field/ plot should have at least 2-4 types of crops out of which one should be legume. In case if only one crop is taken in one plot then adjacent plot then adjacent plots should have different crops. For maintenance of diversity and pest control, randomly plant 50-150/ acre vegetable seedlings for home consumption and 100 plants/ acre of marigold inside all the crops. Even exhaustive crops such as sugarcane can also be grown with suitable combination of various legume and vegetable crops with optimum productivity. Crop combinations with synergistic effects should be taken for inter/mixed croppinge.g. maize with beans and cucumber, tomatoes with beans and cucumber, tomatoes and sugarcane with onions and marigold.

14.7 CROP ROTATION

Crop rotation is back bone of organic farming. It is practice of growing a series of dissimilar or different types of crops on a piece of land in a definite time schedule. To keep the soil healthy and to allow the natural microbial systems working, crop rotation is must. Generally 3-4 years of crop rotation is followed. All high nutrient demanding crops should precede and follow low nutrient requiring crops like legume dominated crop combinations. Rotation of a host crop with non-host crops for a particular pest helps in controlling soil borne diseases and pest. It also helps in improving soil structure through different types of root system (deep rooted vs. shallow rooted crops). Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find place in planning rotations to maintain soil fertility and productivity. Breaking the life cycle and population build-up of pests, pathogens and weeds in agro-ecosystems, crop rotation is one of the main strategies. During adoption of crop rotation, care should be taken to include non-host crops of a particular pest or pathogen, to manage that particular pest. The important benefits of crop rotations are:

a. It exploits the differential in nutrient requirement of different crops categories and thus improves the soil fertility

b. It improves soil structure through different types of root systems, and

c. It helps in breaking the life cycle and population build-up of pests, pathogens and weeds in agro-ecosystems

14.8 USE OF RESISTANT VARIETIES

Since, the synthetic chemical pesticides are strictly prohibited in organic crop production and there are not many options under biological, botanical or other strategies of pest management allowed, the use of pest/disease resistant or tolerant and weed smothering varieties must be in our package of practices to manage the pests. The varieties of crops resistant or tolerant to pests vary from region to region; hence they should be selected according to locality. If no resistant or tolerant varieties are available, intensive use of biological or botanical pesticides along with cultural management should be done to manage the pests or disease.

Induced resistance is another area which can be exploited in organic farming. Seed treatment with bioagents like *Trichoderma* and *Pseudomonas* *fluorescens/Bacillus subtilis*has been reported to induce broad range resistance in many crops against various pathogens.

14.9 TREATMENT OF SEED/ PLANTING MATERIAL

Prevention of pest or pathogen is best strategy particularly in organic cultivation of crops where we do not have much effective options of control beyond threshold level of disease or pest attack. As for as possible, the seed or planting materials should be free from the disease causing pathogens, pests and weed seeds. Some of the formulations and seed treatment methodologies which have been reported effective under organic farming are listed as below:

14.9.1 Hot water treatment

Hot water treatment is often used to eradicate the inoculum of plant pathogens and hibernating stages of insect-pests from seed, bulbs, setts and nursery stocks. Treatment of seeds at 52-54^{0}C temperature for 25-30 minutes eliminates most of the pathogens (including fungal, bacterial, phytoplasmal and viral pathogens) and pests from the seed. At this temperature, the viability of seed is not affected much. In case of organic farming where we do not have options of broad spectrum fungicides, antibiotics or systemic insecticides, hot water treatment can play a great role for eliminating seed borne inoculum. In case of paddy hot water treatment of seeds at 54 ^{0}C for about 25-30 minutes can eliminate many of the seed borne pathogens including *Bipolarisoryzae*, *Xanthomonas campestris* pv. *oryzae*. Extreme care should be taken during hot water treatment of the seeds, because a slight rise in temperature than the recommended can negatively affect the seed germination and the lower temperature could not effectively eliminate the inoculum from the seed.

14.9.2 Seed treatment with biocontrol agents

Treatment of seed or planting materials with fungal or bacterial bioagents like *Trichoderma viride* or *T. harzianum* (@ 4g/ kg seed) or *Pseudomonas fluorescens* (10 g/kg seed) or consortia of different bioagents can suppress many of the seed and soil borne plant pathogens and nematodes. Seed treatment is also a good delivery system of bioagents into the rhizosphere. Besides suppressing plant diseases, these bioagents have also been reported to promote the plant growth and thus early establishment of the seedlings. Treatment of seed with these bioagents and keeping them for overnight at suitable temperature and humidity to activate the bioagents, before sowing, is known as **seedbio-priming**. It is the best method of seed treatment and helps in early establishment of bioagent into the applied niche. For seed bio-priming, seed treatment should be done in evening and incubate the treated seeds in shade for overnightand perform sowing in next morning.

14.9.3 Seed treatment with Beejamrut

Beejamrut is a biodynamic preparation commercially exploited foe seed treatment in organic farming and reported to suppress many seed borne diseases. For preparation of Beejamrut, put 5 kg fresh cow dung in a cloth bag and suspend in a container filled with water to extract the soluble ingredients of dung. Suspend 50 g lime in one litre of water separately. After 12-16 hours, squeeze the bag to extract all the ingredients of cow dung and add 5 litre of cow urine, 50 g of virgin forest soil, prepared lime water and 20 litre water. Again incubate the preparation for 8-12 hours. Filter the content and this filtrate is ready for seed treatment. Apply he amount of Beejamrut on seed which can make a layer over it and dry it in shade before sowing.

14.9.4 Other seed treatment formulas

Seed treatment can also be done with *Panchgavya* extract, Turmeric rhizome powder+cow urine, *Dashparni* extract etc. Treatment of seeds with symbiotic nitrogen fixing bacteria e.g. *Rhizobium* spp. (in legume crops) or non-symbiotic nitrogen fixing bacteria e.g. *Azotobacter*, *Azospirillum* etc. in case of other crops must be done to fix the atmospheric nitrogen in the soil. Many of the *Pseudomonas fluorescens*strains have been reported to solubilise the fixed phosphorus of the soil and make them available to crops. Seed treatment with these phosphate solubilising microorganism should be a mandatory practice in organic farming.

14.9.5 Mechanical methods

Removal of affected plants and plant parts, collection and destruction of egg masses and larvae, installation of bird perches, light traps, sticky coloured traps and pheromone traps are most effective mechanical methods of pest control. In bigger plots of crop, put 'T' type of bird perches with 5-6 feet height which attracts the birds to sit over and predate the insect larvae and adults infesting the crop. The boundary trees and shrubs planted in farm also serve the purpose of bird perches.

Light traps are very effective for collecting and destroying adults of white grub, many of the moths and borers and termites.

Pheromonetraps of methyl-eugenolare very effective for collecting and destroying the adult stages of fruit fly in orchards (guava, mango etc.) and cucurbitaceous vegetables.

14.10 WEED MANAGEMENT AND REMOVAL OF ALTERNATE HOSTS

Weed management is one of the biggest problems in organic farming. Besides direct reduction in crop yield and quality, weeds harbour a variety of plant pathogens and insect-pests particularly during off season, which are transferred to crops by vectors and other means during crop season and thus causing indirect direct losses also. Due to ban on chemical herbicides, weed management mainly relies on cultural, manual, mechanical and other means in case of organic farming. Use of seeds and planting materials free from weed seeds is a preventive measure. Certain weeds like *Trianthemaportulacastrum, Amaranthusviridis* etc. mainly spread through organic manure and care should be taken to decompose weeds only before fruiting stage during compost preparation. The farm animals should also be fed weeds grasses before fruiting stage only. **Stale seed bed** (pre-sowing irrigation of field and allowing weed seeds to germinate and then destroy them during preparatory tillage) technique can be used to reduce weed seed bank in soil. Manual weeding and mechanical interculture through various hoes and instruments remain main options for weed management in organic farming. As for as possible keep organic field free from weeds which hosts insects and pathogens of crop plants (removal of alternate hosts).

14.11 BALANCE CROP NUTRITION FOR PEST AND DISEASE MANAGEMENT

Properly balanced nutrition is a critical factor in allowing crops to realize their full yield potential. The application of manuresand fertilizers to accomplish this balance is a universal practice in commercial crop production. Macro-and microelements have long been recognized as being associated with size, quality, and yield of crops, and also affect the attack of weeds, pests and diseases. Pathogens, as well as crops, have nutritional requirements of their own. Two major objectives of nutrient applications to crops for protection from pathogens can be summarized as follows;

1. Avoid plant stress, which may allow crops to better withstand pathogen attack,
2. Manipulate nutrients to the advantage of plants and disadvantage of the pathogen

Since organic crop production exclusively depends on organic manures which provide sufficient quantities of major and micronutrients to crop plant and thus plant health is maintained and it can better withstand the attack of pests and diseases. Generally organically grown crops are less affected by pest and diseases.

14.15 PEST AND DISEASE MANAGEMENT IN STANDING CROP

As in organic farming management use of synthetic chemicals are strictly prohibited, the pest management is achieved by(i) cultural or agronomic measures, (ii) mechanical methods, (iii) biological or by (iv) organically acceptable botanical extract or some chemicals such as copper sulphate and soft soap etc. The list of permitted, restricted and prohibited inputs for pest control is given in Table 14.1. Mechanical and cultural alternatives described in details in previous sections. The use of bioagents and herbal preparations as bio-pesticides are described as below:

14.16 BIOLOGICAL ALTERNATIVE

14.16.1 Mass release of predators, parasites and/or parasitoides

Use of pest predators, parasites or parasitoides has also proved to be effective method of keeping pest problem below ETL. Inundative release of egg parasitoides *Trichogramma*spp. @50,000 to 1,00,000 parasitized eggs per hectare, *Chelonusblackburni* @15,000 to 20,000 per hectare, pupal parasitoides *Apentalis* sp.@ 15,000 to 20,000 per ha and predator*Chrysoperlacarnea*@ 5,000 per ha., after 15 days and others parasites and predators after 30 days of sowing, can also effectively control pest problem in organic farming. Four to five releases of egg parasitoides *Trichogramma* spp. in rice and sugarcane gives almost total control of borers which are major pests of these crops.

14.16.2 Use of Bio-pesticides

For the management of fungal diseases and nematodes the *Trichodermaviride* or *T. harazianum*are found to be best. Four to five kg of formulation with desired number of viable spores is sufficient for one hectare. They can be applied as spray at regular intervals fro desired level of disease control. *Pseudomonas fluorescence* formulations @ 4g/ kg seed either alone or in combination with *Trichoderma* spp. mange most of the seed and soil borne diseases. It can also be used as spray for managing the crop diseases.

For controlling the insect-pests, formulations *viz. Beauveriabassiana*, *Metarhiziumanisopliae*, *Nomuraearileyi*, *Verticillium*sp., are available in the market and can manage their specific insect-pest. Massive application of *Beauveriabassiana* can be done to manage many insect-pests including beetles, caterpillars, termites etc.inorganically grown field or orchard crops.

Formulations of bacterial bioagents*Bacillus thuringiensis* @ 0.5-1.0 kg/ ha are effective against Lepidoptera and Coleopterans as well as some other insect species. Viral biopesticides of *Baculovirus* group vi. Granulosis viruses (GV) and nuclear polyhedrosis viruses (NPV) provided a great scope in plant protection field. Spray of nuclear polyhedrosisviruses(NPV) of *Helicoverpaarmigera* (Ha-NPV) or *Spodopteralitura* (Sl-NPV) @ 250 larval equivalents are very effective tools to manage the *Helicoverpa* sp. or *Spodoptera* sp. respectively which are wide host range insect-pest in many crops (particularly pulses and vegetables).

14.16.3 Use of botanical pesticides

Many plants are known to have pesticidal properties and the extract of such plants or its refined forms can be used in the management of pests. Among various plants identified for the purpose, neem has been found to be most effective.

14.17 NEEM (*AZADIRACHTAINDICA*) PREPARATIONS

Neem has been reported to be effective in the management of approximately 200 insects, pests and nematodes. Neem is very effective against grasshoppers, leaf hoppers, plant hoppers, aphids, jassids, and moth caterpillars. It has strong repellent and anti-feedant activities. Neem extracts, are also very effective against beetle larvae, butterfly, moth and caterpillars such as Mexican bean beetle, Colorado potato beetle and diamond black moth. Neem is very effective against grasshoppers, leaf minor and leaf hoppers such as variegated grasshoppers, green rice leaf hopper and cotton jassids. Neem is fairly good in managing beetles, aphids and white flies, mealy bug, scale insects, adult bugs, fruit maggots and spider mites.

14.18 NEEM SEED KERNEL EXTRACT (NSKE)

For preparation of neem seed kernel extract 5 kg of neem seed is grinded gently to make a fine powder of it. Soak the ground kernels in 10 litre of water for overnight. In morning stir the suspension till it becomes milky white. Filter the suspension through double layer muslin cloth and make up the volume to 100 litre by adding fresh water. Add 1% soft soap and mix the spray suspension thoroughly. Care should be taken to use good quality neem seed kernels (not more than eight months old). Always use freshly prepared NSKE for pest control. Spray NSKE in late afternoon to get best results. NSKE prepared from 8-12 kg neem seed is sufficient for one hectare crop.

Table 14.1: List of permitted, prohibited and restricted products for pest management in organic farming

Name of input		Conditions for use of input *
A. **Substances from plant and animal origin**		
1.	*Azadiracta indica* (neem preparations)	Permitted
2.	Neem oil	Restricted
3.	Preparation of rotenone from *Derris elliptica, Lonchocarpus, Thephrosia* spp.	Restricted
4.	Gelatine	Permitted
5.	Propolis	Restricted
6.	Plant based extracts– garlic, pongamia etc.	Permitted
7.	Preparation on basis of pyrethrins extracted from *Chrysanthemum cinerariaefolium*, containing possibly a synergist P*yrethrum cinerafolium*	Restricted
8.	Preparation from *Quassiaamara*	Restricted
9.	Release of parasite predators of insect pests	Restricted
10.	Preparation from *Ryania* species	Restricted
11.	Tobacco tea	Prohibited
12.	Lecithin	Restricted
13.	Casein	Permitted
14.	Sea weeds, sea weed meal, sea weed extracts, sea salt and salty water	Restricted
15.	Extract from mushroom (Shitake fungus)	Permitted
16.	Extract from Chlorella	Permitted
17.	Fermented product from Aspergillus	Restricted
18.	Natural acids (vinegar)	Restricted
19.	Chloride of lime/soda	Restricted
20.	Clay (e.g. bentonite, perlite, vermiculite, zeolite)	Permitted
21.	Copper salts / inorganic salts (Bordeaux mix, copper hydroxide, copper oxychloride) used as a fungicide depending upon the crop and under the supervision of accredited Certification Body	Restricted

22.	Mineral powders eg : stone meal	Prohibited
23.	Diatomaceous earth	Restricted
24.	Light mineral oils	Restricted
25.	Permanganate of potash	Restricted
26.	Lime sulphur (calcium polysulphide)	Restricted
27.	Silicates, clay (Bentonite)	Restricted
28.	Sodium bicarbonate	Restricted
29.	Sulphur (as a fungicide, acaricide, repellent)	Restricted
1.	**Microorganisms used for biological pest control**	
30.	Viral preparation (eg. Granulosis virus, Nuclear Polyhedrosis Virus etc.	Permitted
31.	Fungal preparations (*Trichoderma* spp.)	Permitted
32.	Bacterial preparations (*Bacillus* spp.)	Permitted
33.	Parasites, Predators and sterilized insects	Permitted
C. Others		
34.	Carbon dioxide and nitrogen gas	Restricted
35.	Soft soap (potassium soap)	Permitted
36.	Ethyl alcohol	Prohibited
37.	Homeopathic and Ayurvedic preparations	Permitted
38.	Herbal and biodynamic preparations	Permitted
39.	Synthetic chemical pesticides	Strictly prohibited
D. Traps		
40.	Physical methods (Chromatic traps, Mechanical traps, sticky traps and Pheromones	Permitted
41.	Insect nets/ molluscs nets etc.	Permitted

Source: NPOP (2014)

*Permitted=Those items that can be used in organic farming,

Restricted=Those items that are allowed in organic farming, in a restricted manner, after a careful assessment of contamination risk, natural imbalance and other factors arising out of their use. Farmers should consult the certifying agency.

Prohibited= Not allowed or banned in organic farming

14.19 SOME OTHER PEST CONTROL FORMULATIONS

Many of the organic farmers and NGOs have developed large number of innovative formulations which are effective in managing various pest and diseases of crop. Although none of these formulations have been subjected to scientific validation but their wide acceptance by farmers is witness of their usefulness. Farmers can try these formulations, as they can be prepared on their own farm without the need of any purchases. Some of the popular formulations are detailed as below:

14.19.1 Chilli-Garlic extract

Crush 1 kg *Ipomoea carnea* (*besharam*) leaves, 500 g hot chilli, 500 g garlic and 5 kg neem leaves in 10 lit cow urine. Boil the suspension 5 times till it becomes half. Filter and squeeze the extract. Store the preparation in glass or plastic bottles. Two to three litres of this extract diluted to 100 lit of water and used for one acre area. This is widely used preparation and useful against leaf roller, stem/ fruit/pod borer.

14.19.2 Cow urine

Cow urine diluted with water in ratio of 1:20 and used as foliar spray is not only effective in the management of crop disease and insects, butalso acts as effective growth promoter for the crop.

14.19.3 Fermented Curd water

In some parts of central India, fermented curd water (butter milk or *Chhaachh* or *mattha*) is also being used for the management of white fly, jassids, aphids etc.

14.19.4 Dashparni Extract

Crushed neem leaves 5 kg + *Tinospora cordifolia* (*giloya*) leaves 2 kg, *Annona squamosa* (custard apple) leaves 2 kg, *Nerium indicum* leaves 2 kg, *Pongamia pinnata* (Karanja) leaves 2 kg. Green chilli paste 2 kg, garlic paste 250 gm, cow dung 3kg, *Calotropis procera* leaves 2 kg and cow urine 5 lit. in 200 lit waterand fermented for one month. The suspension is shaken regularly three times a day. Extract is finally obtained after crushing and filtering. The extract can be stored up to 6 months and used to control insect-pests and diseases of crops @500 litre/ha.

14.19.5 Neem-Cow urine Extract

Crush 5 kg of neem leaves in water. Add 5 lit cow urine and 2 kg cow dung, ferment for 24 hrs with intermittent stirring. Filter, squeeze the extract and dilute to 100 lit. Use this extract as foliar spray over one acre. This is useful against sucking pests and mealy bugs.

14.19.6 Mixed leaves extract

Crush 3 kg neem leaves in 10 litres of cow urine. Crush 2 kg custard apple leaf, 2 kg papaya leaf, 2 kg pomegranate leaves, 2 kg guava leaves in water. Mix both the formulas and boil 5 times at some interval till it becomes half. Incubate for 24 hrs, then filter and squeeze the extract. This formula can be stored in bottles for 6 months. Dilute 2-2.5 lit of this extract in 100 lit of water for 1 acre of crop area. This is useful against sucking pest, pod/ fruit borers.

14.20 BROAD SPECTRUM FORMULATION

Mix 3 kg fresh crushed neem leaves and 1 kg neem seed kernel powder with 10 lit of cow urinein a copper container. Seal the container and allow the suspension to ferment for 10 days. After 10 days, boil the suspension, till the volume is reduced to half. Grind 500 g green chillies in one lit of water and keep for overnight. In another container crush 250 g of garlic in water and keep for overnight. Next day mix all the ingredients to make broad spectrum pesticide. This preparation can be used on all crops against wide variety of insects. Dilute 250 ml of this preparation in 15 lit of water and use it for spray. About 400-500 litre diluted suspension is required for one hectare of crops.

14.21 USE OF COMPOST TEA

Compost Tea is a liquid preparation for general disease management in crops. Compost Tea, in fact, is all the rave for gardeners who repeatedly attest to higher quality vegetables, flowers, and foliage. Very simply, it is a liquid, nutritionally rich, well-balanced, organic supplement made by fermenting aged compost in water. But its value is amazing, for it acts as a very mild, organic liquid fertilizer when added at any time of the year.

14.21.1 Preparation of compost tea

I. Fill a bucket 1/3 full with a quality finished compost

II. Add unchlorinated water to the top of the bucket

III. Allow the mixture to ferment for 3-4 days. Shake the mixture 2-3 times a daily for up to five days

IV. Filter the mixture through fine porous cloth into another bucket

V. Add the remaining solids to your garden or compost bin

VI. Dilute the remaining liquid with water in 10:1 ratio (water to tea)

14.21.2 Applications of compost tea

Use tea immediately for optimal absorption into the soil around plants. For young delicate or potted plants dilute the tea. For hardy shrubs, trees, or established plants in the vegetable garden, simply pour the tea from the bucket around the root system at the base of the plant. It can be used as foliar spray on plants for this, also add 3/8 tspof vegetable oilor mild dish-washing liquid per 10 litre of suspension.

Pest and diseases still remains major constraints in organic crop production and their proper management decides the success of crop under organic situation. The ecological based approaches which encourage and enhance biological cycles within the farming system; increase biodiversity of flora harbouring natural enemies (predators, parasites and parasitoides); enhance internal resistance of crop plants to pests; making soil suppressive to soil borne pests and diseases, is base for pest management in organic situation. In organic crop production in India, farmers can only use the pesticides listed in National Standards for Organic Production (NPOP) updated time to time by the concerned ministry. In absence of synthetic chemical pesticides, cultural management, host resistance, physical, biological, botanical, bio-rational methods and some indigenous preparations are mainly employed for pest control in organic crop production.

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Chapter **15**

ROUND THE YEAR FODDER PRODUCTION MODULE FOR INTEGRATED ORGANIC FARMING SYSTEMS IN DIFFERENT AGRO-CLIMATIC REGIONS OF INDIA

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15.1 INTRODUCTION

Organic farming is an alternative agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices. Organic agriculture continues to be developed by various organic agriculture organizations today. It continues to grow and practiced in over 100 countries on more than 26 million hectares (Rahmann and Bohm, 2005).The highest percentage of acreage of organic farming is in Europe (6.3 million hectares). The area under organic farming in India is only 1.5 million hectares across the 15 states. The major development needs were animal welfare, animal health, animal breeding and animal feeding. On the other hand if we see the data regarding area under organic fodder production is negligible and livestock farmers have been applied low quantity of chemical fertilizers in fodder crops than other crops. Generally fodder growers in the country are using farm yard manure mainly in fodder crops at the time of sowing or at post sowing. The organic farming systems are more beneficial than inorganic farming systems, because they do not increases the soil fertility but also increase nitrogen availability in soil and uptake by plants. Organic farming also improves the yield and quality of fodder crops. Forage production is necessary for livestock production since they form an essential diet (Ismaeil *et al*., 2012). It relies on fertilizers of organic origin such as compost, manure, green manure, bone meal and places emphasis on techniques such as crop rotation and companion planting. Biological pest control, mixed cropping and the fostering of insect predators are

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encouraged. In general, organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances. For instance, naturally occurring pesticides such as pyrethrin and rotenone are permitted, while synthetic fertilizers and pesticides are generally prohibited. Synthetic substances that are allowed include, for example, copper sulfate, elemental sulfur and Ivermectin. The interest in organic crop and livestock farming remerges in recent time due to growing concerns about the conventional farming paradigm that relies on synthetic inputs to maximize yields which poses threats to the environment and health. On the other hand organic production focuses on building soil organic matter and biology to create a sustainable and dynamic environment for producing healthy food and feed and proved to be beneficial for flora and fauna (Fuller *et al.,* 2005; Gabriel *et al.,* 2006; Gabriel *et al*., 2010). The organic crop and livestock farming is gaining ground among Indian farmers. It is also considered as only feasible alternative and interesting option for sustainable agriculture in developing countries because it offers a unique combination of low external inputs and technology, environmental conservation and input/output efficiency (Augustine *et al*., 2013). Organic dairy farming means rearing animals on organic feed (i.e. pastures cultivated without the use of fertilizers or pesticides), have access to pasture or outside, along with the restricted usage of antibiotics and hormones. It deliberately avoids the use of synthetic inputs such as drugs, feed additives and genetically engineered breeding inputs. Organic dairy farming is a system of production, a set of goal-based regulations that allow farmers to manage their own organic integrity. Giving the predominance of close to traditional and integrated farming system in rural India and rising consumer awareness and demand in domestic as well as foreign market for healthy food products organic farming could be a blessing for Indian farmers. Some of the agro-climatic regions in India are best suited for organic fodder production. These areas include the rainfed areas of Rajasthan, Gujarat, Madhya Pradesh, Hilly areas of Himachal Pradesh, Uttaranchal, Jammu and Kashmir, Tamil Nadu and whole of North-Eastern region. There are some areas in the country (especially mountain areas) and communities (certain tribes) where the green revolution technologies have so far not reached and did not adopt the use of agro-chemicals. These areas have been classified as “organic zones” (Singh, 2007). The North Eastern region of India also has high potential for organic fodder production due to least utilization of chemical inputs. It is estimated that 18 million hectares of such land is available which can be exploited for systematic organic production (Ghosh, 2006). The Trans-Gangetic plains region of Punjab, Haryana, Western U.P. and parts of Rajasthan have witnessed the most intensification of crop husbandry by way of intensive crop rotations and the heavy use of inorganic fertilizers and agro-chemicals. However, even in this region and also in other region, dairy farming has not received much intensification as has been the case with advanced countries and, therefore, is amenable to conversion to organic with little effort. The organic dairy farming has a good scope in the country as it is the small holder's low input, crop residue fodder based production system contributing 70% of total milk production of the country (Kumar *et al*., 2005). Thus these systems are expected to offer a more profitable and sustainable production system based on low input (Hermansen, 2003). But the predominance of small holder and landless dairy farmer in this sector is also a source of potential challenge for organic dairy farming especially due to certification difficulties, traceability problem. Also these small farmers are producing a few litres of milk daily are not in a position to market it as organic milk due to ignorance and unavailability of local market for organic produce (Maji *et a*l.2017). However, the cooperative organization can play an important role for promoting organic dairy farming in the interior rural areas by certifying, procurement, processing and marketing of organic milk. On the other hand given the less demand of organic products in domestic market for getting premium price for their products farmers definitely need to depends on export market. The animal products are still a small share of the organic market, compared to fruits, cereals and herbs in terms of exports, are almost negligible in developing countries (Willer and Kilcher, 2011).

15.2 CROPPING SYSTEMS FOR FORAGE PRODUCTION

Survey was conducted in Western Uttar Pradesh and results revealed that improved package of practices with new cropping systems developed for fodder production were not adapted properly by the farmers. Most of the land in Uttar Pradesh is arable and thus, there is opportunity to produce fodder under intensive forage production systems. Presently, most of the farmers are adopting either sorghum- berseem-sorghum or/and sorghum-oat-sorghum, cropping systems for fodder production during all three seasons. Owing to increase fodder production, multiple cropping systems in which at least three to four high yielding fodder crops to be grown on a piece of land in a calendar year. Thus, such cropping sequences can be adopted with an objective to achieve the high yields of green fodder. These systems may also assure regular supply of green fodder when staggered sowing and harvesting schedules are followed. Apart from the mentioned systems under assured irrigation facilities following multiple cropping sequences *viz*. bajra-oat-cowpea, sorghum-dolichos-teosinte, cowpea-stylosorghum and teosinte-sorghum-clitoria may be adopted. These systems are better suited to well manage small holdings. A viable option will be available to the farmers by combining the annual and biennial forage species as above mentioned to enhance the supply of green fodder throughout the year in the area.

15.3 USE OF BIOFERTILIZERS FOR SUSTAINABLE ORGANIC FODDER PRODUCTION

Certain microbial activities in soil, which have a bearing on the mobilization of nutrients for absorption by plants are also knows. It has been observed that the Rhizobium inoculation to the forage legumes has increased crop yields from 14 to 50% especially for legumes like cowpea, guar, pea, lucerne and berseem. Similarly, the inoculation with non- symbiotic nitrogen fixers like Azospirilium and Azotobacter helps in the increase of crop yield from 15 to 30% in crops like maize, sorghum, bajra, teosinte, Napier hybrid bajra and some range grasses. The benefit from such non-symbiotic nutrient fixers has been found to be of the order of 10 to 18 kg/ha.

15.4 SOIL FERTILITY BUILDS UP THROUGH FODDER CROPS

1. Sunhemp, lucerne, cowpea and clitoria incorporation increased the soil fertility.
2. 25% of N can be reduced through using of leguminous fodder crops as green manure.
3. N balances of 92 kg/ha for 1:1 and 48kg/ha for 2:1 when fodder legumes intercropped with cereal fodders.
4. Fodder crops used as cover cropping such as *Melilotus indica* promising at Sirsa(Haryana).
5. In–situ GM of green gram (Praharaj *et al*. 2004) and cowpea substitute 25 % of N.
6. Chilli-Desi cotton and *Stylosanthes hamata* used as cover crop at 1:2 with a cutting interval of 45 days and saved the 25-50% of NPK. Organic N addition to the extent of 144 kg/ha and increased soil organic carbon content from 0.58 to 0.73%.
7. Lucerne cutting frequency at 30 days reduced the weed intensity and reduced fertilizer demand by 25-50%.
8. Lucerne green manuring with 50% N recorded higher yield (Somasundaram and Nandhini, 2016).

15.5 CULTIVATION OF FODDER IN EXISTING CROPPING SYSTEMS

A wide range of crops graminaceous, leguminous and others can be grown in India for forage purpose. Except in high hills and in the coastal regions, maize, sorghum, hybrid Napier X bajra, guinea grass, pearl millet (in light and shallow soils), teosinte, oat, cowpea, berseem, lucerne, *Desmanthus*, Dolichos, cluster bean, fodder rape and Dinnanath grass can be grown at all other places. There is wide scope of breeding varieties of different crops to suit different environments, land situations, and for fitting them in different cropping sequences. At high altitudes Dactylis and red clover are doing well. *Setaria anceps* is doing well at lower altitude in Himachal Pradesh. For coastal soil and drainage congested areas *Coix lacryma jobii* will do well. Guinea grass is more cold and shade tolerance than Napier. Hedge lucerne grows better in areas where winter is rather mild and has got a better crop to be utilised as a hedge alley cropping. Some of the Amaranthus species show a high rate of grown as a vegetable crop in the eastern region being a C_4 crop. The crop has potential to be used as forage crop.

15.6 REGIONAL IMBALANCES IN FODDER AVAILABILITY

The pattern of deficit varies in different parts of the country. The regional deficits are more important than the national deficit, especially for forage, which is not economical to transport over long distances. An estimate from National Wasteland Development Board (1991) found that 43 of the 55 micro- regions exhibited deficits, only 12 micro-regions exhibited surpluses. In the surplus regions, improved livestock are mostly stall-fed and under better nutrition. In most deficit regions, the deficiency is due to the large livestock population, little or no area under fodder cultivation, and very low biomass yield from degraded/marginal lands (0.0-1.0 mt DM/ha). For instance, the green fodder availability in Western Himalaya, Upper Gangetic Plains and Eastern Plateau and Hills Zones is more that 60% of the actual requirement. In Trans Gangetic Plain, the feed availability is between 40-60% of the requirement and in the remaining zones the figure is below 40%. In case of dry fodder, availability is over 60% in the Eastern Himalaya, Middle Gangetic Plains, Upper Gangetic Plains and East Coast Plains and Hills Zones the availability is highest (>60%) as compared to Trans Gangetic Plain, Eastern Plateau and Hills and Central Plateau and Hills (40-60%) and in the remaining zones of the country the availability is below 40 per cent.

15.7 YEAR-ROUND FORAGE PRODUCTION THROUGH COMBINATION OF PERENNIAL AND ANNUAL FORAGES

Overlapping cropping systems developed at the Indian Grassland and Fodder Research Institute (IGFRI), Jhansi, to fulfill the needs of dairy farmers for green fodder throughout the year and for small farmers requiring maximum forage from a piece of land. It consists of raising berseem, inter-planted with hybrid Napier in spring and intercropping the inter-row spaces of the grass with cowpea during summer after the final harvest of berseem. This system was found superior to multiple crop sequences both in terms of production and economic returns. The hybrid Napier could be successfully replaced with relatively soft and palatable perennial grasses like Setaria and guinea grass and berseem with lucerne wherever is required.

15.8 ASSOCIATION OF PERENNIAL GRASS AND LEGUME COMPONENTS

Attempts were made to select suitable ideotypes of perennial grass and forage-legume components in order to reduce the necessity of repeated sowing and tillage and to economise the use of irrigation water in the system. This resulted in the identification of an erect, leafy and compact hybrid Napier-IGFRI No.3 and K8 variety of subabool (*Leucaena leucocephala*). These crops when grown together in alternate paired rows (2:2) yielded around 200 tonnes of nutritious green forage/ha/year. Such types of system are less sensitive to fluctuations in soil moisture and are more suited to southern region where both the components grow throughout the year. The associated legumes improve the herbage quality in terms of protein and minerals and help to economise on the use of nitrogenous fertilizers. Moreover, such production systems are less expensive and offer continuous employment potential. The component crops of the system can be changed depending upon inputs availability and yield indices of the crops in a region. Similarly, cultural management practices like crop geometry, spacing, planting pattern, etc. could be adjusted to facilitate use of appropriate farm machinery and effective utilization of irrigation water.

15.9 ORGANIC WEED MANAGEMENT IN FODDER CROPS

India is deficit in green fodder and certified fodder seeds of improved high yielding varieties. Infestation of pests, diseases and weeds in fodder/ seed crops, further cause enormous losses and aggravates the availability of green fodder and quality seeds. Hence, there is need to control infestation of pests, diseases and weeds using environmental friendly technologies.

Few such technologies for insect, pest and weed control have been standardized for commercial application which when used in conjunction with other pest control measures prove to be more economic and effective. Such eco-friendly technologies are economically sustainable and known as integrated pest management (IPM). It is important component of a total IPM program. Weeds not only decrease fodder/seed yield by competing with crop for water, light and nutrients but also make fodder unpalatable. Weeds also provide shelter to many insects-pests and cause diseases leading to economic losses. Integrated weed management (IWM) combines a variety of approaches to suppress weeds and reduces dependence on herbicides for weed control.

a) Deep tillage during summer.

b) Proper field preparation.

c) Sowing of certified/ truthfully labelled fodder seed for fodder production.

d) Application of well decomposed farm yard manure.

e) Keeping irrigation channels and field boundaries free from weeds.

f) Using crop residues for mulching.

g) Changing crop sequences.

15.10 INTEGRATED PEST MANAGEMENT IN FORAGE CROPS

It is an ecologically based strategy that focuses on long-term solution of pest through a combination of technologies such as biological control, habitat manipulation, modification of agronomic practices and use of resistant varieties. Embracing a single tactic to control a specific organism does not constitute IPM, even if the tactic is an essential element of the IPM system. Pesticides may be used to remove/prevent the target organism only after assessing that they are needed to prevent economic damage. Pest control tactics, including pesticides, are carefully selected and applied to minimize risks to the human health, beneficial and non- target organisms and environment. Through IPM approach farmers need to be advised to use the following practices:

15.10.1 Cultural pest control

§ Use of treated seed of improved varieties, resistant to disease/pest.

§ Timely ploughing/ sowing of crops and follow proper crop rotation.

- § Fallowing of field and destruction /burning of old crop debris.
- § Removal of weeds from field boundaries and deep ploughing during summer.

15.10.2 Physical and mechanical control

- § Manual destroying of insect-pests eggs, larvae and pupa etc.
- § Pheromone trap is a type of insect trap that uses pheromones to lure insects. Sex pheromones and Aggregating pheromones are the most common types used.
- § Insect light trap is also one of the very effective tools of insect pest management in organic agriculture. The ordinary light trap consists of an electric bulb emitting yellow light as attractant and a funnel to direct insects into a container containing water.

15.10.3 Biological control

- § Rearing of biological control agents for their field use and conservation of naturally occurring bio-agents such as *Trichogramma* spp., Lady bird beetle and Chrysopa.
- § Installation of bird Perches@15 per hectare for attracting Predatory birds.

15.10.4 Organic pesticides

- § Promotion of bio-pesticides such as Neem seed kernel extract@5% as alternative to chemical pesticides.
- § Spray of Nuclear Polyhedrosis Virus (NPV) suspension@2.5 ml/10 litre of water are recommended for the control of foliage eating spodoptera and heliothis spp. larvae.
- § For the effective management of *Helicoverpa armigera* larvae spraying of *Bacillusthuringiensis*@1kg/ha at flowering stage is recommended.
- § Soil application@1.25 kg/ha or seed treatment with 5g/kg of seed of different fodder crops before sowing by bio-fungicide like *Trichoderma viride*, *Verticillium* spp., *Aspergillus* spp., etc. that attack and suppress the growth of harmful soil borne plant pathogen causing root decay.

15.11 REGION WISE FODDER BASED CROPPING SYSTEMS

The intensive cropping systems when managed properly using modern techniques of soil and crop management are able to yield 180 - 300 tonnes of green fodder per hectare per year with 30 - 55 tonnes dry fodder per ha/year. Some of the intensive cropping systems have been developed for different regions.

15.11.1 North Zone

1. Maize + Cowpea – Sorghum + Cowpea (two cuts) – Berseem + Mustard.
2. Sudan grass + Cowpea – Maize + Cowpea – Turnip – Oats (two cuts)
3. Hybrid Napier or Setaria inter-planted with cowpea in summer and Berseem in winter (9 -10 cuts/year).
4. Teosinte + Cowpea (two cuts) – Carrot – Oats + Mustard/Senji (two cuts).

15.11.2 Western and Central Zone

1. Bajra + Guar (Clusterbean) (two cuts) – Annual Lucerne (6 cuts).
2. MP Chari + Cowpea (2 cuts) – Maize + Cowpea - Teosinte + Cowpea (2 cuts).
3. Hybrid Napier or Guinea or Setaria grass inter-planted with Cowpea in summer + Berseem in winter (8-9 cuts/year).
4. Hybrid Napier or Guinea or Setaria grass interplanted with Lucerne (8-9 cuts/ year).

15.11.3 Southern Zone

1. Sorghum + Cowpea (3 cuts) – Maize + Cowpea – Maize + Cowpea.
2. Hybrid Napier or Guinea or Setaria grass inter-planted with Lucerne (8-9 cuts) or Hybrid Napier + Subabul / Sesbania (9-11 cuts/year).
3. Sudan grass + Cowpea (3 cuts) – M P Chari + Cowpea (3 cuts).
4. Para grass + Centro (Centrosema pubescens) (9-11 cuts/year).

15.11.4 Eastern Zone

1. Maze + Cowpea – Teosinte + Rice bean (2 cuts) – Berseem + Mustard (3 cuts).
2. M P Chari + Cowpea – Dinanath grass (2 cuts) – Berseem + Mustard (3 cuts).
3. Hybrid Napier or Setaria grass inter-planted with Subabool or Common Sesban (*Sesbania sesban*) (9-10 cuts/year).

15.12 DEVELOPMENT OF YEAR ROUND FODDER PRODUCTION SYSTEMS

In order to ensure adequate fodder supply to meet the current and expanding fodder availability. There are several ways and means as illustrated below.

15.12.1 Forages in mixed cropping and inter cropping systems

Intercropping /mixed cropping system of forage production comprising grass/cereal and legume components is promising in improving herbage quality, as well as increasing biomass production (Table15.1). Besides, the intercropping helps in improving nutritive value of herbage and higher total crude protein yield in rainfed areas, the intercropping/mixed cropping system has been found promising. Different crop combinations and production are given in Table 15.1.

Table 15.1: Forage and crude protein yields under pure and mixed cropping system

Crop/crops combinations	Forage yield(t/ha) Green	Forage yield(t/ha) Dry matter	Crude protein (kg/ha)
Oat(Kent) pure	43.3	9.04	564
Oat (Kent)+Senji(S-76)	41.2	8.78	1034
Oat(Kent)+Pea(T-163)	39.8	8.68	1067
Sorghum(Pioneer988) pure	49.0	10.18	680
Sorghum(Pioneer988) +Cowpea	49.3	10.10	1024
Sorghum (M P Chari)pure	38.4	8.10	490
Sorghum(M P Chari)+Cowpea	39.1	8.10	886
Maize (African tall)pure	44.8	9.33	722
Maize (African tall)+Cowpea	45.4	9.30	1049
Maize(Manjari)pure	32.4	6.50	553
Maize (Manjari)+Cowpea	36.2	7.18	872
Bajra (Rajkot)pure	37.2	8.27	632
Bajra (Rajkot)+Cowpea	43.0	8.92	971
Pennisetum pedicellatum(pure)	46.3	7.72	658
Pennisetum pedicellatum(pure)+ Cowpea	43.5	7.68	942
Pennisetum pedicellatum(pure)+Guar	43.1	7.54	836

15.12.2 Food and fodder production system

An integral approach to food-fodder production aims at obtaining food as well as fodder production concurrently from the same piece of land. The dry land areas offen fail to support two successive grain crops in rotation because of long duration. However, short duration forage crops may be included to precede or succeed the food crops to increase the intensity of cropping in time on black soils. Among different crop sequences, forage sorghum-lentil has been found consistently more productive and remunerative. Similarly growing of cover crops like cowpea instead of keeping the field fallow during the kharif season not only increases the land productivity but also protects the soil from water erosion. In normal rain fall years with late cessation of monsoon the grain crops could be harvested and rabi forages like senji, barley and safflower could be grown on residual soil moisture. Grain crops under irrigated conditions gave a scope of 52-60 days as gap period to grow forages. For example, in wheat-jowar/maize/bajra sequence a gap period for April to June may be utilized to grow fodder crops like maize + cowpea/sorghum +cowpea/bajra + cowpea to yield 32-40t/ha green forage. Intercropping of leguminous fodder like cowpea (HFC42-1) with grain sorghum yields 100 t/ha green forage in only 45 days. Under rainfed situation, introduction of short duration (52-60 days) jowar, bajra, maize, cowpea and minor millets for fodder permits another fodder /oil seed crop like mustard or safflower in the rotation as sequential system, in soils having higher moisture retention capacity. In western and southern region of the country, where sorghum is grown both during *kharif* and rabi, rationing of kharif crop for fodder in the event of prolonged drought yielded higher. Similarly, in a gap period after the harvest of kharif crops and before planting of rabi crops, planting short duration fodder crops like Japanese rape or turnip yields 25-30t/ha green forage. It is imperative that the fodder crop production should be thought of in the context of overall farm practices. The production of forages has little implication as a single commodity to a farmer. He has to get the forage need for his livestock fulfilled through appropriate inclusion of forage crops in his cropping system. There are many opportunities to integrate the cultivation of appropriate short duration forage crops in between two or three main crops under normal rainfall as well as in rainfed situations. Such integration depends more on the soil and climatic conditions and also cropping pattern of the region. In dry land areas, the most common practices is to grow a productive crop in a year either during kharif or rabi depending upon the soil moisture conditions and the rainfall pattern of the region. For example, in Budelkhand region having about 40 per cent cultivated area during rainy season and about 70 per cent area during winter season, it is possible to grow short season fodder crops, namely cowpea, guar, sorghum, etc. yielding about 25-30 t/ha of green fodder within 45-50 days followed by normal winter season oilseed crops like mustard, linseed and safflower and pulses like gram and lentil. Similarly, in mono-cropped area with Pigeonpea, it is possible to grow short season sorghum or bajra as an intercropping yielding about 15 to 25 t/ha of forage without jeopardizing the yield of the main crop of Pigeonpea. Such practices could be possible to be extended in other areas. In southern India, there is a common practice of growing short duration legumes like pillipesara (*Phaseolus trilobus*) and sun hemp (*Crotolaria juncea*) after the harvest of normal paddy crop under the residual moisture. Possibility of growing pure crop of berseem and shaftal after rice should also be explored in northern, central and eastern India. With the use of appropriate varieties and adoption of efficient practices, it is possible to have both fodder and grain from a single crop. In the northern, north-western and central India, barley could be grown for such purposes. The simple practices comprise harvesting the crop at 55 days and managing the ratoon crop for grain with proper FYM, compost and press mud. A grain yield of 1.6-4.0t/ha and green fodder yield of 9.0 to 15.0t/ha is possible from barley varieties like KL36, DL157, DL452, DL454 and Azad. In case of maize (cv. Ganga2,), it is possible to obtain both fodder and grain by planting at 30 cm row spacing with50 kg seed rate per hectare and harvesting the alternate rows at 50days for fodder and the remaining rows for grain. An yield of 40 t/ha of green forage and 8.0t/ha of dry forage together with 3.8t/ha of grain yield was obtained at Chhotanagpur in Bihar. This information could also be proving to be useful for other growing tracts of the country.

15.12.3 Intensive forage production systems

Year round supply of green fodder is very important in order to stabilise animal production, especially in the milk shed areas and also for small farmers who maintain dairy animals as a regular source of income (Gupta and Behera, 2015). Various systems and technologies such as multiple cropping, overlapping cropping, parallel cropping, and mixed/intercropping systems for quality herbage production are in practice and technologies have been generated and practiced for these. Intensive forage production system aims at achieving maximum sustainable harvest of nutritive herbage per unit area and time by efficient utilization of land and other farm inputs without jeopardizing the productive capacity of soil. However, for successful implementation of intensive forage production programs productive land, assured irrigation, easy availability of manures and fertilizers, crop protection measures and appropriate farm machinery to complete the agricultural operations in time are essential. The year round provision of high quality involves adoption of suitable crop rotations and staggered planting and harvesting at proper intervals and helps in adequately feeding and maintaining the high yielding milch animals with minimum concentrate feeding. Therefore, availability of quality fodder is an essential pre- requisite of 'White Revolution' generally, the perennial forage component *viz*. Napier-bajra hybrid and in certain situations, guinea grass give the higher assured production in most of the locations round the year (Paroda, 1992). The low or no productivity of Napier- bajra hybrid during winter season could be compensated with more productive intercrops like berseem and lucerne. Under sub –temperate hilly region and tarai region with high water table, the annual crops in rotations proved to be efficient producers. The important intensive forage crop rotations identified based on concerted research programmes are presented in Table 15.2.

Table 15.2: Yearly production potential of improved crop rotation in various locations/regions

S.No.	Region	Crop rotation	Green fodder yield(t/ha)
1.	Sub-temperate	White clover+ rye grass	131
2.	Tarai region	Dinnanath grass-berseem-maize+cowpea	210
3.	Semi-arid north-west	Napier-bajra hybrid+berseem	212
4.	Semi-arid central and west	Napier-bajra hybrid+cowpea-berseem	255
5.	Sub –humid north-west	Maize+cowpea-P.pedicellatum-oat	130
6.	Semi-arid south	Napier-bajra hybrid+hedge lucerne	225
7	Humid	Guinea grass(year round)	135

The intensive fodder production systems for milk shed areas have been evolved keeping in view the suitable crop geometry. To obtain higher fodder production per unit area and time under intensive cultivated conditions, systems of intensive fodder crop rotations of cereals and leguminous crops in a particular season for particular agro climatic zone have been evolved under optimum management levels (Table 15.3). These rotations gave year round supply of forage from the same piece of land. The north-western and central zones of India have been found by far the efficient zones for intensive fodder production (168.5 to 287.7t/ha/annum green forage). In these zones, growing hybrid Napier or perennial grasses like Nandi grass, Setaria grass and Guinea grass intercropped with suitable forage legume have proved highly productive. In north-eastern and southern zones, green forage yield ranges from 62 to 144 t/ha/annum which warrants for the need to identify efficient forage crops/ varieties for these regions. The zone – wise intensive crop rotation and their production potentials are given in Table 15.3.

15.12.4 Multiple cropping systems of fodder production

It consists of growing 3-4 appropriate annual forage crops as sole crops in mixed stands (graminaceous and leguminous) in a calendar year to improve herbage quality substantially and to enhance forage productivity

Table 15.3: Intensive forage crop rotations for diffident agro climatic zones

Agro climatic Region	Crop rotation	Green fodder yield(t/ha)
North and north-western region	Sweet sudan+cowpea-berseem+oat	200.0
	Hybrid napier+ berseem intercropped in winter	214.1
	Hybrid napier+guar-lucerne	252.9
Central region	Hybrid napier+ cowpea-berseem+ Japan rape	286.3
	Maize+cowpea-jowar- berseem+ Japan rape	197.2
	Jowar+cowpea-berseem+Japan rape-jowar+cowpea	168.6
Eastern region	Maize+cowpea-Dinanath grass-oat	130.8
	Maize+cowpea-rice bean-berseem+sarson	111.5
	Hy. napier+cowpea/rice bean (summer) and berseem(winter)	210.0
Southern region	Jowar+cowpea-maize+cowpea-maize +cowpea	110.7
	Hy.napier+cowpea-Hy.napier+cowpea-Hy.napier+berseem	133.4
	Maize+cowpea-bajra+cowpea-berseem	126.7

Source: Annual Reports, All India Coordinated Research Project on Forages Crops 2015-16 per unit area. It also helps maintain soil fertility over long period due to addition of root organic matter. The degree of its success depends upon agro-climatic conditions, crop and soil management practices followed and availability of inputs. Selection of appropriate crops/varieties and adoption of scattered sowing and harvesting schedules ensure the regular supply of the quality forage.

15.12.5 Alley cropping system and relay cropping

In most of the rainfed areas, woody perennials (shrubs/ trees) of multiple use nature have scope for incorporation in the crop production systems. Species like *Leucaena leucocephala* under this system of alley cropping (2 m spaced hedge rows) has produced annually 7-8t/ha of dry nutritious forage in every three years, 8 to 9t/ha of firewood without interfering with the crop yield. Several short rotation woody perennials have been identified, namely *L. leucocephala (Subabul), Calliandra calothyrus, Acacia mangium, A.albida, Sesbania grandiflora, S. sesban, woody Cajanus cajan*, to enrich the soil and the following cereal crop even after 6 month cultivation gave 54 per cent higher yield compared to the control (Singh,1992).

15.12.6 Three strata forage production system

Three tier intercropping for obtaining higher monetary returns and meeting the need of food, fodder and fuel from one piece of land, it is recommended to adopt three tier cotton based intercropping system in which cotton, sorghum, pigeonpea and sorghum can be grown in 6:2:1 row proportion under rainfed situation. This system has the highest capacity to bear risk of the season due to erratic behaviour of monsoon and also being adopted on reasonably sizeable area in southern part of the country.

15.12.7 Harvesting aquatic plants (Lichen use as food and fodder)

Hydroponic fodder cultivation provides an opportunity to grow green nutritious fodder with better palatability and digestibility. It can substitute demand of land and water scarcity. The green fodder available from hydroponics is rich in nutrients including protein, micronutrients and vitamins, having better palatability and digestibility. The real challenge in producing hydroponic fodder in India lies in devising a system which is viable and adaptable throughout the year in a cost effective and energy sustainable manner. It is visualized that hydroponic system will be more useful in arid and hilly regions, and in areas of high population density where cultivable land and water scarcity prevails.

Lichens have been used by human and livestock population living in high altitude areas. The foliose rock tripes (Umbilicaris) called 'lwatake' are eaten in salads or fried in deep fat they are considered delicacy. Soil lichens are eaten by yak in Arunachal Pradesh and Sikkim. The important ones found in Arunachal high altitude. The analyzed forage lichens and found low in protein, calcium and phosphorus. It was reported that under severe conditions lichen may constitute 90 per cent of the total diet of some arctic animals.

15.12.8 Azolla as a source of organic green fodder

Azolla is a free floating water loving fern. It is commonly used as bio-fertilizer in rice crop. The blue-green algae (*Anabaena azollae*) grow in symbiotic association with this fern and are responsible for nitrogen fixation. Among different species of genus Azolla, *Azolla pinnata* is more popular. The higher crude protein content (above 20%) and presence of essential amino acids (high lysine content) vitamins like A & B and minerals like calcium, phosphorous, potassium and magnesium made Azolla more useful feed supplement for livestock, poultry and fish. Azolla is naturally found in ponds, ditches and wetlands of warm temperate and tropical regions throughout the world. It requires light for photosynthesis and grows well in partial shade. Generally, Azolla needs 25 to 50 per cent of full sunlight for its normal growth. Water is the basic requirement for the growth and multiplication of Azolla and is extremely sensitive to lack of water. Maintenance of adequate water level (at least 4 inches in the pond) is essential. The species vary in their requirement of ideal temperature. In general, the optimum temperature is 20°C to 30°C. Temperatures above 37°C will seriously affect the multiplication of Azolla. The optimum relative humidity is 85 to 90 per cent. The optimum pH is 5 to 7. Too acidic or alkaline pH has an adverse effect on Azolla. Azolla absorbs the nutrients from water. Though all elements are essential, phosphorus is the most common limiting element for its growth. About 20 ppm of phosphorus in the water is optimum. Micronutrient application improves the multiplication and growth. Sieved fertile soil mixed with cow dung and water need to be spread uniformly in the pond. About one kilogram of fresh Azolla culture is needed for a pond of 6 x 4 feet size. It has to be applied uniformly in the pond. Biogas slurry can also be used instead of dung. The depth of water should be four to six inches. During the monsoon season, if rain water can be harvested from the roof tops and used for cultivation of Azolla, it will ensure excellent and faster growth of Azolla. If the total salt content of the water used for growing Azolla is high, it will adversely affect the growth of Azolla.

15.12.9 Top feed resources

Fodder trees and shrubs in the silvipastoral system contribute substantial amount of green leaf fodder through lopping popularly known as top feed. Importance of fodder trees/shrubs has been emphasized by number of workers. Fodder trees like Hedge lucerne (*Desmanthus virgatus*), *Sesbania grandiflora*, Subabool (*Leucaena leucocephala*) etc. can also be grown on farm boundaries, field bunds, around nursery beds and homestead. Top fodder can also supplement the green forage requirement during shortage, especially those of small, marginal farmers and landless agricultural laboureres rearing livestock. Edible leafy mass, the edible leafy plant material was represented by tree leaves, shrubs, herbaceous, weeds and epiphytic ferns. Examples of these plants are banana, tapioca, pineapple, potato, squash, cauliflower and common vegetable leaves. Grasses are more important in flush season, but tree leaves, shrubs and weeds have an important role to play in feeding of domestic livestock during lean season. The promising fodder cum fuel trees are *Sesbania*, *Aegyptica* and *S. grandiflora* are the better substitute of *Leucaena leucocephala*. Leucaena under normal cultural practices do not grow so well. Among local trees *Acacia auriculiformis*, *A. mearnssii, Alnus nepalensis, Pseudoacacia* are good among exotic species. *Dalbergia sisso*, also grows very well in deep soil areas of mid altitude. Most of these edible leafy fodder trees belong to Moraceae, Leguminoceae, Verbinaceae, Rubiaceae, Araliaceae, Aroideceae, Rosaceae, Liliaceae, Urticaceae and Zingiberaceae families. The plants of genera Artocarpus, Bauhinia, Careya, Ficus, Grewia and Vitex were the most important for providing edible dry matter to domestic livestock during lean season of the year. The majority of these leafy fodders were higher in crude protein, and desirable low to medium in crude fibre content. Evidently these can be very profitably utilized to make up the deficiency in the poor-quality coarse grasses available during the lean periods. However, there is need to study the incriminating substances such as tannins, which depress the digestibility of proteins in the tree fodders.

15.12.10 Forage production on sloppy lands

To increase the fodder production from risers in between two cultivated fields, different improved grasses should be planted on the top of risers and also on sloppy sides. Rhodes, Guinea, Panicum, Coloratum, Setaria and Kazungula are the erect type of grasses may be planted on top of the risers, while Pangola, Star grass and Kikuyu as spreading type grasses could be planted on sloppy sides of risers.

15.13 BRIEF DESCRIPTION OF FODDER PRODUCTION SYSTEMS UNDER DIFFERENT AGRO-CLIMATIC REGION OF INDIA

15.13.1 The Humid North Western Region

The cultivated lands in middle hills and lower down, during short summer (May to Sept.), are put to rice cultivation in low lands with irrigation facilities. In uplands, with limited irrigation facilities, maize and pulses are grown. To improve the quality of maize crop residues, after second earthing, at the time of tasseling seeding of relatively cold tolerance legumes like velvet bean, silver leaf Desmodium(*Desmodium uncinatum*)and rice bean(*Vigna umbellate*) can be sown in July/ August. Oat is the main stay for feeding the cows in milk –shed areas, where the farmers are keeping cross bred animals. There is good scope for growing Kale (*Brassica oleracea* var. acephata), fodder rape, swedes, fodder beet and turnip as fodder crops. The berseem crop can be sown in standing rice crop, 10 days before harvest of rice in the plain which may provide one cut before the winter sets in and two cuts before planting of rice in the next season. The other fodder crops like barley, triticale vicia, fodder peas and turnips can be sown in the region. Crops like maize+cowpea, pearmillet+cowpea and sorghum+cowpea are also for fodder in lower temperate wet regions during June to October. In humid high rainfall areas, in the Himalayan region (Zone III) forage crops like maize, cowpea and rice bean can be grown as cultivated forage crops in level strips or in strips running across the slopes in Meghalaya (Chatterjee and Maiti, 1992).

15.13.2 Himalayan Foot Hills (Tarai zone)

In this region a wide range of fodder crops like Napier grass, cowpea, cluster bean and winter crops like berseem, fodder rapes, annual lucerne and oat are grown as sole crops or in mixture. Mize-wheat or sorghum/ pearl millet/wheat/mustard or rice –wheat is the important cropping systems in the region under irrigated condition. The quality of the crop residues of maize, pearl millet, sorghum and paddy can be improved by relay sowing of black gram, rice bean, velvet bean , 10-30 days before the harvest of these crops. Other crops in the regions are also being adopted by the farmers like rice bean, teosinte and Dinanath grass (*Pennisetum pedicellatum*). In the milk shed areas, rice-berseem or maize+cowpea-oat are being extensively cultivated.

15.13.3 Humid High Rainfall- North East Region and Bay Islands Zone

The cultivated crops of the north-east region have been discussed with Zone I. Rai and Singh (1989), while working at Gangtok in Sikkim, have reported the yield potentiality of Coix lacrymajobii (la local fodder grass) as high as 40t/ha. This grass has been reported to do well in the coastal saline (Sen, 1987) soils of West Bengal. In Bay Islands, the winter being mild, all the summer growing crops can very effectively be grown. Rice straw and local grasses constitute the main source of roughage feeding in the bay Islands.

15.13.4 Humid Assam Bengal Basin Region

The region is very intensively cultivated for food crop production and there is wide choice of growing large number of forage crops. There is wide scope for growing maize, sorghum, berseem, particularly in the rabi season (winter being mild), rice bean (in autumn)and Dinanath grass(in summer), as sole or in mixture; these can easily be filled in the turnaround period between two arable crops. An important development that has taken place recently is the use of *Lathyrus sativa* (Khesari) or grass-pea, as a fodder crop. This is being extensively grown in this region as paira crop, to be utilised as a cattle feed instead of grain crop.

15.13.5 Sub-Humid and Humid Sutlej Ganga Alluvial Zone

Forage beets, Coix lacryma-jobii+sweet potato vines can be grown on fodder crop. Para grass (*Brachiaria mutica*) and Rhodes grass can do well here. Barley and berseem crops grow well. Double cut barley (for fodder and seed production) varieties may be a great use in this region.

15.13.6 North-western Semi-arid and Arid Zone

Maize, sorghum, pearl millet, cowpea, bajra **xyz** Napier hybrid and oat are important crops of the region and the farmers either keep a plot separately for fodder production or try to grow them as sole crop in between two arable crops, depending upon rainfall and available irrigation facility. There is scope to maintain a perennial stand of forage crop for 2-3 years. Lucerne is an important crop. The variety 'Anand2' is a selection from Gujarat. Sirsa 9 is a dominating variety of Punjab and Rajasthan. Lucerne for2-3 years followed by cereals boosts up milk as well as cereal production in many of the canal irrigated areas in this region.

15.13.7 Central Semi -arid Vindhayan Zone

The region receives low rainfall and the natural pasture passes through severe drought periods for a long period in this region. Herbage production in cultivated areas can well be improved with supplemental irrigation and a wide range of forage crops maize, sorghum, oat, berseem etc. can be grown. Hazra (1989) indicated that high density of maize, sorghum, or pearl millet and alternate row harvesting for fodder at 50 days, provide substantial amount of forage in addition to normal seed yield. Ratooning of sorghum, can be practise. Sequential cropping of short duration fodder crops like sorghum, cowpea, rice bean, guar followed by mustard or safflower or barley provides both food and fodder.

15.13.8 High rainfall, High Runoff Chhotanagpur Plateau and Adjoining States of West Bengal and Orissa.

Rice, maize and pearl millet are the main food crops of the region. There is limited facility for irrigation. Due to its favourable topography and altitudinal variations the region provides scope to grow a large number of forage crops in the summer and winter months with irrigation. Bajra – Napier hybrid grow well and its productivity, particularly in winter months, can be improved by intercropping the slow growing stand of grass with lucerne.

15.13.9 Assured Rainfall Deep Black Soil-Malwa Plateau and Narmada Basin Zone

Large number of forage crops can be grown and their productivity can be increased to an appreciable extent with supplemental irrigation. Maize, pearl millet, sorghum, hybrid Napier, Guinea, Berseem and lucerne can be grown extensively, as short and long duration crops, by fitting in the sequence of other arable crops.

15.13.10 Chhattisgarh Plateau Zone

In this area particularly in Andhra Pradesh, Sunhemp is grown as a fodder crop either grown as a relay (or paira) crop or as sole crop. This is mixed with rice straw for feeding animals. Horsegram and pillipesara (*Phaseolus acountifolius*) are the two other crops grown in this area.Lablab beans can be grown well here as a fodder crops.

15.13.11 Variable Rainfall- south Central Deccan Plateau Zone

The sustenance of the dairy animals on natural grassland is difficult although good species of local grasses (*Chrysopogon mentanus, Dichanthium annulatum* and *Caricosum, Sehima* etc) are available. With supplemental irrigation, it is possible to grow forage very intensively as follows:

Crops	Duration	Expected yield
Pearl millet/maize+cowpea	Feb.-May	20-30t/ha
Sorghum + cowpea	July-Oct.	20-30t/ha
Maize+cowpea	Sept.-Nov.	20-30t/ha
Hybrid Napier or Guinea grass + Velvet bean/hedge lucerne	Year round	50-80t/ha

The most important forage crop of the region is sorghum which is mostly taken as a dual purpose type of crop. Sugarcane crop provides a good amount of fodder to the cattle in this region. There has been a good collection of the ecotypes of lucerne and some of them appear to be very promising at the Mahatma Phule Agriculture University Rahuri. In this region, seed productivity of berseem and lucerne is also fairly good.

15.13.12 South eastern Brown Red Soil Zone

Rice straw is the most important source of fodder in this region. As stated earlier in this region Sunhemp is grown as relay crop or as sole crop to feed the animals along with rice straw. There is scope to grow a large number of forage crops in this region as sole or intercrop with arable crops as discussed earlier.

15.13.13 Southern Variable Rainfall-Mixed Soil Zone

A good amount of work on forage crops has been done in this region. The main thrust has been on the following forage crops (Report of AICRP on Forage crops for Quinquenial Review, 2015-16).

(a) For irrigated areas- Bajra-Napier hybrid,Guinea grass, lucerne, maize

(b) For rainfed areas- *Cenchrus, Dichanthium* both *annulatum* and *Caricosum* and *Stylosanthes*.

(c) For semi-arid region –Dinanath, Desmanthus, sorghum,, pearl millet, Leucaena spp.

(d) For sand dunes- *Cenchrus* spp. and Lasiurus sindicus with Acacia Spp.

Desmanthus (hedge lucerne) has turned out to be a good forage crop and can be used for alley cropping. in this area wherever sugarcane is grow with irrigation, the sugarcane tops provide a good amount of fodder.

15.13.14 Southern Bi modal Zone

The cultivated forage crops are very similar to those described earlier in zone1and 13. The fodder growing period in this area is further extended due to bi- modal rainfall. Desmanthus (hedge lucerne) is showing great promise and can very well be used as hedge rows for alley cropping. Lucerne and oat in most part are also doing well.

15.13.15 Eastern Coranandal Coastal Zone

This zone comprises (a) high and medium rainfall-upper region (consisting of parts of Tamil Nadu and southern A.P. and (b) low and high rainfall coastal areas- lower region (comprising southern T.N., Kanyakumari and adjoining area). There is wide scope of growing forage crops as briefly described in Zone12.

15.13.16 Western Malabar Coastal Zone

Most of the plantation crop areas in the zone are covered by homestead farming where the farmers will be keeping bullock and milch cows along with various plantation crops, fisheries ,etc. in addition to a number of fodder crops that have been tested to grow well(Hybrid bajra x Napier, guinea grass, maize, sorghum, (multi cut), velvet bean(*Strizolobium deeringianum*) a few other crops appeared grass best suited for soil conservation purpose as well . Centro(*Centrosema pubescens*), calopo(*Calopogonium mucunoides*), *Clitoria ternatea* and *Pueraria phaseoloides*.

Organic forage production for good quality animal products is necessity in present prospective this is because of food habit of the people is turning year after year. The demand of animals based organic products such as milk, meat and milk based other products is glooming at alarming rate particular in urban and semi urban areas of the country. The physical activities of the people are slashing in present years and number of diseases has been developed in human being due to change in food habits. The challenges before the agriculture and animal scientists has increased tremendous and they have to develop such technologies which are cost effective and uses less quantity of industrial based products in fodder development programmes and more emphasis is to be wondered to recycle the animal based organic manure, urine and other by-products in fodder production. Under this chapter most important aspects related to organic fodder production is covered for organic fodder production in future without hampering environment pollution, animal health and good life for people.

15.14 MAJOR FUTURE CONCERNS AND THRUSTS

Global organic food demand is accelerating day by day, so is the demand of organic milk, meat and poultry. Urbanization has brought a marked shift in the lifestyle of people and people tend to change their food habits towards organic food with resultant increase in demand for more organic livestock products. Peri-urban livestock production and commensurate increase in demand of fodder and changing scenario of small-unorganized fodder market into large organized fodder market need attention of research and development efforts in forage crops.

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Chapter 16

ORGANIC VEGETABLE PRODUCTION: PRINCIPLES AND PRACTICES

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16.1 INTRODUCTION

India is second largest populous country with an estimated population of 1.31 billion after China. It is estimated that with 1.2 per cent annual population growth by 2050, Indian population will be the highest (1.7 billion) in the world. According to International Food Policy Research Institute (IFPRI), Washington 2016, an estimated 15.2% of the citizens in India are malnourished and not getting enough quantity of food (quantity and quality). In India per capita land resources (0.12 hectare) are shrinking due to tremendous pressure of population growth, therefore, it is very imperative to ensure higher production and productivity per unit of area. Vegetable crops are more productive than other crops, which have potential of providing more food per unit time and land area. According to study of the Indian Medical Research Council (ICMR), New Delhi and the National Institute of Nutrition, Hyderabad (NIN), changing food habit i.e., limited availability of vegetables is considered responsible for malnutrition in our country. To ensure good health it is recommended that at least 300 g of vegetable should consumed as a part of balanced diet, comprising 125 g leafy vegetables, 75 g other vegetables and 100 g root per person every day. Vegetables provide all the nutrients ingredients viz., vitamins, minerals and protein that are essential for balanced diet. The presence of good amount of vitamins and minerals in vegetables makes them protective food. Many vegetables carries good amount of nutraceutical properties and having capabilities to ensure good health.

India is second largest producer of vegetables with annual production of 162.9 million tonnes (NHD, 2015). The per capita gross availability of vegetable is 365 g/day whereas per capita net availability of vegetable (25% loss + 5% exports and processing) is 256 g/day (Horticultural Statistics at a Glance, DAC&FW, 2015). Thus in order to feed rapid growing population with the limited resources there is a need to enhance vegetable productivity (17.3 MT/ha) which is less than average world vegetable productivity (19.6 MT/ha) (NHB, 2015). Moreover, never ending demand for higher vegetable production for huge population has further led to a pressing demand of excessive application of fertilizers and pesticides. The consumption of fertilizers in India over the last three decades has grown to half a million tonnes on an average per year. The higher application of chemical fertilizers and pesticides led to the adverse impact on the aquatic life, plants and animals. The areas making use of high levels of chemical fertilizers has shown a drastic contamination of ground as well as irrigation water with higher nitrate levels. Thus, continuous application of chemical fertilizer and pesticides results in degradation of soil, environment and resources. Therefore, a natural balance needs to be maintained with a sustainable strategy to produce more vegetables from limited resources with less application of chemicals in the form of fertilizer and pesticides leading to less detrimental effects to soil and environment. Organic vegetable cultivation not only offers one of the most sustainable farming systems with recurring benefits to long-term soil health but also provides a lasting stability in production by importing better resistance against various biotic and abiotic stresses.

According to USDA definition of organic farming as, "It is a system which avoids or largely excludes use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection". FAO suggested that "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs". In simple words organic agriculture is the farming system without the addition of artificial chemicals.

16.2 CHARACTERISTICS OF ORGANIC FARMING SYSTEMS

The key characteristics of organic farming include;

- Long-term fertility of soils should be protected by maintaining soil organic matter levels, soil biological activity and careful mechanical intervention. Excess mechanization leads to compactness of soil and damage to earth worms and microbial population.

- The requirement of nitrogen should be full-filled by the use of leguminous crops and biological nitrogen fixation as well as effective recycling of organic materials, including crop residues and livestock wastes.
- The control of weed, disease and pests should be mainly based on crop rotation, natural predators, crop diversity, organic manuring, use of resistant varieties and limited thermal, biological and chemical intervention.
- Supplementary crop nutrients should be applied when and where it is necessary by using nutrient sources which are made available to the plants indirectly but the action of soil micro organisms and chemical reactions of the soil.
- Careful attention should be made on environment and the conservation of wildlife and natural habitats.

16.3 WHY ORGANIC FARMING OF VEGETABLE CROPS?

- Vegetables are eaten fresh, hence, any contamination (chemical residue) may lead to various kinds of health hazards.
- Vegetable growers largely are poor, small and marginal farmers.
- Decrease in land productivity due to an increasing use of chemical fertilizers and pesticides.
- Increasing cost of production by use of fertilizers, pesticides etc.
- High environmental pollution.
- Supply of vegetables free from chemicals and heavy metals.
- Organic vegetable cultivation can generates income through marketing high earning society, International and reducing production costs.
- Excessive use of chemical fertilizers as well as pesticides poses threat to the environment quality, ecological stability and sustainability of production.
- Properly managed organic farming system can increase the crop productivity and restore the natural base.

16.4 PRINCIPLES OF ORGANIC FARMING

16.4.1 Principle of health

Health is the completeness and reliability of living systems. Health means not only the absence of illness, but it includes maintenance of physical, mental, social as well as ecological security. Organic vegetable production should maintain and improve the soil, plant, animal, human and planet as one and indivisible health. The healthy soils bring out healthy crops that promote the health of animals and people. The role of organic vegetable production, either in vegetable farming, processing, distribution, marketing or ultimately to consumer, is to maintain and improve the health of ecosystems and organisms. In particular, organic vegetable production is planned to produce high quality, nutritious food that contributes to preventive health care. Organic vegetable production should avoid the use of chemical fertilizers, pesticides, drugs and food additives that may cause adverse health effect.

16.4.2 Principle of ecology

Organic production of vegetables should be based on living ecological systems and cycles, work with them, emulate them and help sustain them. It means production cycles should be based on ecological processes, and recycling of the produce. Nourishment and well-being are achieved through the ecology of the specific production environment. Organic vegetable farming, pastoral and wild harvest systems should be based on the cycles and ecological balances in nature. The management of organic vegetable farming system must be adapted to local conditions, ecology and culture. The process of reuse and recycling of available resources and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources should follow. Organic vegetable farming should attain ecological balance following the design of farming systems and maintenance of genetic diversity. The agencies or those who produce, process, trade, or consume organic products should protect and benefit the common environment including climate, biodiversity, air and water.

16.4.3 Principle of fairness

Organic vegetable production fairness is regarded by equity, respect, justice and stewardship among peoples. This principle states that those involved in organic vegetable farming should perform human relationships in a way that ensures fairness at all levels like farmers, workers, processors, distributors, traders and consumers. Organic vegetable farming should provide good quality of life and reduction of poverty. The main aim of this should be sufficient supply of good quality vegetables and other related products. The resources that are utilized for production and consumption should be managed in a direction that is socially and ecologically trust for future generations.

16.4.4 Principle of care

The basic idea behind organic vegetable farming should be in a protective and responsible manner to care for the health and well-being of current and future generations and also environment too. The principle of care states that provision and responsibility are the key concern in management, development and technology in organic vegetable farming system. It is essential to make sure that organic vegetable production system is healthy, safe and ecologically sound. The scientific knowledge about organic vegetable production alone is not sufficient but practical experience, accumulated wisdom, traditional and indigenous knowledge offer sound solutions.

16.5 ORGANIC VEGETABLE PRODUCTION PRACTICES

16.5.1 Conversion period

Conversion of non-organic/conventional farm to organic farm takes minimum three years as transition period. The transition period starts with the date of signing the contract with certifying agency and after completion of first year produce can be sold as "in conversion to organic agriculture" and after two years annual crops can be sold as "organic".

16.5.2 Selection of farm

Site selection is one of the most important criteria for successful organic production of vegetables. Site selection includes suitable soil and climate, regular supply of good quality irrigation water, availability of plenty of labour, transportation and marketing facility. The site for organic vegetable production should be free from pests and diseases infestations of the crops. For example, in the areas where higher rainfall occurs and large monocultures of similar crops are grown there may be greater risks with growing organic vegetables and infestation of pests and disease may be more.

16.5.3 Soil and crop nutrition

Most of the vegetable crops prefer a well drained loam or clay–loam soil with a pH range of 6.0 to 7.5. Some adjustment is required and is necessary before planting the crop for balanced nutritional requirements. The soil should also be tested for fertilizers and pesticides residues and contamination with heavy metal. If there is the unacceptable levels in the soil the produce could be exclude from organic certification or could exclude the growing of particular crops, such as root vegetables.

16.5.4 Soil fertility management

Soil fertility should be high for successful organic vegetable production therefore the main objective in organic farming is to build up reserves of nutrients in the soil and to establish a system of nutrient cycling. The primary aim of organic farmers should be supply of crop and animal nutrition by implementing practices that take care of the soil, enhance soil life, and also conserve nutrients. These practices involve development of both long-term and short-term strategies to advance soil health and supply crop nutrition. The organic fertility system involves a combination of practices such as organic manure, green manure, lime, rock phosphate and other rock materials, and supplemental organic fertilizers.

16.5.4.1 Organic manures (composts, vermicomposts and FYM)

Compost is an essential nutritional requirement for organic vegetable production. In compost the C:N ratio should be about 20:1 and it improves the soil structure and stimulates the beneficial micro-organisms. Compost may include animal manures and crop residues, but these should be free from excessive pesticide and heavy metals. The particular area of the farm should be kept for compost production. The organic manures should be given as a basal dose @ 25-38 t/ha through FYM, poultry manures, fish manures, sheep composts etc. Use of organic cakes from neem, mustard, groundnut, pongamia, and castor becomes imperative for organic vegetable production.

16.5.4.2 Green manuring

Green manure crops are raised and then ploughed or turned at flowering stage (40-45 days after sowing) into the soil for decomposition to improve the soil physical structure and fertility, enhances organic matter or organic nutrients to the soil and also increases microbial activities. Various leguminous crops such as sunnhemp (*Crotalaria juncea*), dhaincha (*Sesbania aculeata*), pillipesara (*Phaseolus trilobus*), cowpea (*Vigna unguiculata*) and cluster bean (*Cyamopsis tetragonoloba*). A luxuriant, vigorously growing legume sward (Daincha, sunhemp, faba beans) contains large amount of 80–120 kg nitrogen. It should be incorporated 20-30 cm deep into the soil with a tractor or a mould board plough. Some farmers cultivating organic vegetables also apply foliar sprays of sugar, molasses or compost tea prior to turning of the green manure crop. It is believed that this practice provide added energy for soil micro-organisms, which favours rapid breakdown of green matter prior to planting the subsequently vegetable crop.

16.5.4.3 Use of biofertilizers

Biofertilizers are the carrier-based preparation containing beneficial micro-organisms in a viable state intended for seed, seedling or soil inoculation. The major role of biofertilizers in vegetable production is to enhance atmospheric nitrogen fixation, decompose organic wastes, increase soil health, reduces environmental pollution, and reduction in production cost. Inoculation by improved strains of non-symbiotic nitrogen fixing bacteria i.e., *Azotobacter* significantly enhanced the productivity of vegetables, viz., potato, onion, brinjal, tomato, chilli, cabbage, cauliflower and okra. *Azospirillum* increased nitrogen uptake and also helps in reduction of the nitrogenous fertilizers. Use of PSB helps in increased availability of phosphorous.

16.5.5 How to apply biofertilizers in vegetable crops

There are many methods through which biofertilisers are applied in vegetable crops at various stages:-

(a) Seed treatment: Seeds of leguminous vegetable crops are treated with rhizobium culture (250 g per acre) by mixing the culture well with 5% of the gur soultion. To obtain uniform coating on each and every seed, the above mixture is first poured on seeds which spread on the cement floor or poylthene sheet and then mixed with hands properly. These seeds are then spread in shade for drying for at least 10-15 minutes. After this they are sown immediately in the soil.

(b) Seedlings treatment: This method is mainly recommended for tomato, chilli, onion etc. The culture suspension is prepared in the approx. ratio of 1:10 by mixing 1 kg of culture in 10 litres of water for one acre. Seedlings are first arranged into bundles and dipped in suspension for 15-20 minutes and transplanted in the soil immediately.

(c) Direct application: For applying the biofertlizers directly in the soil, approximately 2-3 kg of bio-fertilizer is mixed in 40-60 kg of soil, compost or FYM. This mixture is then broadcasted in one acre of land either at time of sowing or 24 hr before sowing. The application of phosphate-solubilizers is very much common through this method.

16.5.5.1 Accomplishment of nutrient requirements

For successful production of organic vegetables, additional nutrients might need to be supplied during transition period and during a crop's growth period.

(a) Nitrogen- short duration vegetables may able to complete their entire requirement of nitrogen from green manure, compost or organic fertilizers that have been applied before planting. Crops with a growing season beyond 6 to 8 weeks may require additional nitrogen, applied as side dressing or foliar spray. Commonly used source with readily available nitrogen are fish emulsion, worm juice and compost teas (concentrated organic liquid fertilizer that is made from steeping biologically active compost in aerated water).

(b) Phosphorus- Organic sources of phosphorus are rock phosphate, guano (accumulated excrement of seabirds, seals, or cave-dwelling bats), fish meal and bone meal.

(c) Potassium-Compost, seawood, basic slag, wood ash, and sulphate of potash are the organic sources of potassium.

(d) Other- Lime is a source of calcium, dolomite a source of calcium and magnesium and gypsum is source of calcium and sulfur.

The details of some of the concentrated organic manure and availability of nutrients is given in table 16.1.

Table 16.1. Concentrated manures/fertilizers used in organic farming

S.No.	Manure/fertilizer	N %	P_2O_5 %	K_2O%
1.	Blood meal	12	0	0
2.	Bone meal	2	15	0
3.	Chilean nitrate	16	0	0
4.	Guano	9-12	3-8	1-2
5.	Rock phosphate (Soft)	0	15-30	0
6.	Potassium magnesium sulphate	0	0	22
7.	Pelleted chicken manure	2-4	1.5	1.5

16.5.5.2 Variety and crop selection

The essential criteria which need to be taken into consideration for variety and crop selection are seed and seedlings availability, resistance to pest and disease, suitable market for fresh produce supply, physiological characteristics and environmental suitability. The variety to be grown must be obtained from organically certified seed or seedlings. The variety should also be popular among the vegetable growers, high yielding, pest and disease resistance, and superior seedling vigour. There are some varieties in each vegetable crop, which perform very well under limited resource availability and show resistant to major biotic and abiotic stresses including pest and diseases. These varieties can be grown to reduce the cost of cultivation in organic vegetable production. These varieties can meet the standards of organic vegetable cultivation, as they do not need pesticides for pest control (Table 16.2). It has been observed that vegetable crop varieties, which are early in vigour commonly, hamper the growth of weed plants.

Table 16.2. Varieties/ F_1 hybrids of vegetable crops tolerance/resistance to disease & pests

S.No.	Crop	Disease	Varieties/F_1 hybrids
1.	Tomato	Bacterial wilt	Arka Abha, Arka Abhijit, Utkal Pallvai (BT1), Utkal Kumari (BT10), Arka Alok, Arka Vardhan F_1 hybrids-Arka Rakshak, Arka Ananya, Arka Samrat, Arka shreshta
		Late blight	TRB1 and TRB 2
		Leaf curl virus	Hisar Anmol(H-24), Hisar Arun (H-36), H-88, F_1 hybrids-Arka Rakshak, Arka Ananya, Arka Samrat
		Early blight	F_1 hybrids-Arka Samrat, Arka Rakshak
		Root knot nematode	Pusa-120, Pusa Hybrid-2, Pusa Hybrid-4, Hisar Lalit (NRT8), Punjab-NR-7 F_1 hybrids- Arka Vardan
2.	Brinjal	Phomopsis blight	Pusa Bhairav, Pusa Purple Cluster
		Bacterial wilt	Arka Keshav, Arka Neelkanth, Arka Nidhi, Pusa Purple Cluster, Utkal Tarini, Utkal Madhuri, Annamalai
		Little leaf	Pusa Purple Cluster, Hisar Shyamal, Pant Rituraj
		Shoot & fruit borer	SM 17-4, Punjab Barsati, ARV 2-C, Pusa Purple Round, Punjab Neelam
3.	Chilli	Bacterial wilt	Ujjwala, Anugraha, Pant C-1, Punab Lal
		CMV, TMV, TLCV	Pusa Jwala, Pusa Sadabahar, Pant C-1

		Thrips	Pusa Jwala, Pusa Sadabahar, Pant C-1
		Mites	Punjab Lal, Pant C-1
		Aphids	Punjab Lal, Pant C-1, Pusa Jwala
4.	Sweet Pepper	Bacterial wilt	Arka Gaurav
5.	Okra	Yellow vein mosaic virus	Pusa Bhindi-5, Varsha Uphar, Arka Anamika, Arka Abhay, Punajb Padmini, Punjab-7, Punjab-8, Hisar Unnat, Azad Kranti, Utkal Gourav
6.	Cabbage	Black rot	Pusa Mukta
		Black Leg	Pusa Drumhead
7.	Cauliflower	Black rot	Pusa Shubra
8.	Onion	Purple blotch	Arka Kalyan, Nasik Red
		Thrips	Arka Niketan, Pusa Ratnar
9.	Pea	Powdery mildew	JP-83, JP-4, Arka Ajit, JP179, Arka Karthik, Arka Sampoorna (snap pea), JP9
		Fusarium wilt	Kalanagini, JP179, Pusa Vipasa
		Rust	JP. Batri Brown 3, JP. Batri Brown 4, JP179, Arka Karthik, Arka Sampoorna (snap pea)
10.	Cowpea	Bacterial blight	Pusa Komal
11.	French bean	Powdery mildew	Contender, Pusa Parvati
		Wilt	Jampa
		Rust	Pant Anupama, Arka Bold, Pant Bean-2
		Angular leaf spot	Lakshmi, Pant Anupama
		Common Bean Mosaic	Pant Anupama, Pant Bean 2
12.	Musk melon	Downy mildew	Punjab Rasila
		Powdery mildew	Arka Rajhans
		Cucumber green mottle mosaic	DVRM-1, DVRM-2
13.	Water melon	Anthracnose, Downy mildew, Powdery mildew	Arka Manik

16.5.5.3 Crop rotation

The legume crops like cowpea, beans, peas etc should be included in crop rotation not only for improving soil fertility by fixing atmospheric nitrogen but also to increase the yield up to 30-35%. Inoculation of legume crop specific rhizobial strains can further improve their N- fixing ability. The quantity of N fixed by different crops is given in the Table 16.3.

Table 16.3. Nitrogen content, biomass productivity and estimated N fixation by leguminous crops

S.No.	Crop	Nitrogen %	Biomass productivity (t/ ha)	Estimated N (kg/ha)
1.	Sunhemp	0.43	12-13	52-56
2.	Dhaincha	0.43	20-22	86-95
3.	Cowpea	0.49	15-16	74-78
4.	Clusterbean	0.34	20-22	68-75
5.	Berseem	0.43	15-16	65-69
6.	Green Gram	0.53	08-09	42-48

16.5.5.4 Mulching

The covering of soil surface with a layer of organic or inorganic material is known as mulching. It modifies soil environment, prevents soil erosion, checks weed growth and enhances activity of soil microorganism. Organic mulches which include plant or animal residue or by-products like, sawdust, straw, animal manure, leaves, sugarcane bagasse etc increases the organic matter content of soil thus improving physical and chemical properties. Mulching with black plastic film decreases solar radiation to the soil which helps in reducing weed intensity by inhibiting their germination and growth. Reflective plastic mulches (yellow, white, silver, aluminium coated etc.) have been reported to reduce aphids and other pest population in vegetable field.

16.5.5.5 Weed management

In organic vegetable production effective weed management is the most challenging aspects due to incorporation of local available organic manure to restore fertility of the soil. For higher organic vegetable production weed competition must be suppressed during the crop's critical period. In addition to the various mechanical methods viz., deep ploughing in summer, hand weeding different cultural practices such as composting of manures, use of black plastic mulch and cover cropping with other crops are the most common method to reduce weed pressure in vegetables. Crop rotation also an effective means for suppressing weeds in organic vegetable production.

16.5.5.6 Insect pest management

The management of insect pests relies on various integrated management practices to maintain the pest population at economic threshold level. To avoid or reduce the risk of losses from pest's infestation, it is essential to follow mechanical practices, crop rotation and develop planting strategies which includes time of planting, quality of planting material and source of planting material. The crop which is susceptible for a particular pest and disease should be avoided into a site that has a known pest or disease history. The weedy plants acts as a reservoir for particular disease carrying pathogens and pests should be managed or avoided.

16.5.5.7 Trap crops

Trap crops is also known as sacrificial crops which are planted to attract and hold insect and pests where they can be managed more efficiently thus reduces pest damage of the main crops. These crops can be planted in the periphery or in the middle of the main crop. When collard or Chinese cabbage planted in cabbage field attracts diamond back moth, onion and garlic planted in carrot decreases the outbreak of carrot root fly and African marigold planted in tomato field attracts tomato fruit borer.

16.5.5.8 Pheromone traps

It is a type of insect trap that uses pheromones to lure insects. The most common types of pheromones used are sex pheromones and aggregating pheromones. These traps used to monitor, mass-trap, and/or disrupt the mating process of insect pests. Pheromone traps are effectively used for control of tomato fruit borer, brinjal shoot and fruit borer and fruit fly in cucurbits.

16.5.5.9 Biological control of pests

In this method pest population is managed by natural enemies like predators, parasitoids and pathogens. There are various biological control agents which can be used for effective pest management in organic vegetable production (Table 17.4).

16.5.5.10 Disease management

Disease management in organic vegetable production based on the combination of organic soil management practices, cultural practices, IPM practices, natural remedies and limited use of permitted chemicals.

Table 16.4. Biological control agents of various vegetable pests

S.No.	Crop	Pest	Biocontrol agents	Field application
1.	Cole crops	Diamond back moth	Larval parasitoids *a) Cotesia plutellae* *b) Diadegma semiclausum*	Release adult parasitoids @15 thousnad/ha at weekly interval during the initiation of larval damage
		Tobacco caterpillar	Entomopathogenic fungus *a) Nomurae rileyi*	The fungus is diluted in water and mixed in Tween 80 (0.04%) and sprayed on the crop during evening hours
			Nuclear Polyhedrosis virus of *S. Litura* (SI NPV)	Spraying of SI NPV @ 250-300 Larval Equivalent (LE) mixed in 250 liters of water, 1% jiggery and 0.1% teeepol during evening hours
		Aphids	Lady bird beetles (*Coccinella septempunctata*)	Adult beetle @ 30/sq. m
2.	Tomato	Tomato fruit borer	Egg parasitoid: *Trichogramma chilonis*	Parasitoids are released as adult or in parasitized egg form @ 50,000/ha in 6 releases starting from 45 days after transplanting
			Larval parasitoid: *Campoletis chlorideae*	@15,000 adults/ha
			Nuclear Polyhedrosis virus of *H.armigera* (HaNPV)	Spraying of HaNPV @ 250-300 Larval Equivalent (LE) mixed in 250 liters of water, 1% jiggery and 0.1% teeepol during evening hours
3.	Okra and bean	Mites	Predatory mites (*Amblyseius tetranychivorus*)	@10-60 mites/plant or 100 mites/sq. m

Fungicides that may be allowed organically includes many copper and sulphur compounds and biological fungicides containing species of *Trichoderma, Bacillus, Pseudomonas, Gliocladium, Streptomyces* and other beneficial microbes. Application of *Trichoderma viride* @10 g/kg seed or *Trichoderma harzianum*@ 10 g/lit for spray or 10-12 kg/ha for basal dressing is effective against wilt and rot diseases in vegetables. Copper and sulphur based products are the only labelled fungicides allowed in organic certification. Copper are labelled for anthracnose, bacterial speck, bacterial spot, early and late blight, grey leaf mold and septoria leaf spot where as sulphur labeled for control of powdery mildew.

16.5.5.11 Irrigation Water

The reliable and good quality water supply must be available. The water testing is must to decide its suitability for irrigation and also be tested for chemical contamination, particularly if the source comes from a creek, river or irrigation channel.

16.5.5.12 Labour

Vegetable production is generally a labour-intensive venture particularly organic vegetable production. It is generally estimated that one labour can efficiently operate one hectare mixed organic vegetable enterprise. The additional labour should be taken into consideration during peak harvesting periods and extensive weeding operations. If producer is doing on-farm value addition, extra labour will be needed.

16.5.5.13 Transport

For supply of fresh produce from farm to market reliable transport is essential. If highly perishable vegetable crops are grown the transportation facility must be refrigerated. Transport operators should be aware that organic produce must be isolated from conventional produce to reduce the risk of contamination.

16.5.5.14 Market suitability

The selection of crop and variety is generally depends on consumers, therefore market research is also an essential part for organic vegetable production. It is also important to find out which vegetable is required and when it is required because sometimes vegetables may be undersupplied at particular time and it will be possible to fill the seasonal gap like sometimes in restaurants or hotels speciality vegetables for example, red capsicum, yellow capsicum and cherry tomato is required. In some processing factories, there are preferred cultivars for processing and for the fresh-food market this should also be taken into consideration.

16.6 HOW TO GET CERTIFICATION OF YOUR PRODUCE?

16.6.1 Organic certification

This is a certification process for organic food producers and related organic agricultural products. Any person doing business and directly involved in food production can be certified, including seed suppliers, farmers, food processors, retailers and restaurants. It involve a set of production standards for growing of crops, their storage, convert into processed products, packaging and shipping that exclude use of synthetic chemical inputs (e.g. pesticides, fertilizer, antibiotics, food additives, etc), genetically modified organisms. It allows the use of farmland that has been free from chemicals for a number of years (generally three or more), keeping record in detail for production and sales, strictly maintaining organic products from non-certified products and periodic site inspections.

16.6.2 Purpose of certification

Organic certification is necessary for increasing worldwide demand of organic food. It requires to assure product quality and also for prevention from fraud products. For organic producers, certification identifies suppliers of products approved for use in certified operations. For consumers, "certified organic" serves as a product assurance, similar to "low fat", "100% whole wheat", or "no artificial preservatives". Most certification bodies operate organic standards that meet the National government's minimum requirements.

16.6.3 Certification Procedure

For certification of a farm, the farmer is required to hold in a number of new activities in addition to normal farming operations:

(Source: National Project on Organic farming Deptt of Agriculture and Cooperation, Govt of India)

- Application is made to the certification agency in the prescribed format with necessary farm and process details
- Screening of application by certification agency and if necessary further details/clarification sought
- Cost estimate comprising of certification charge, inspection charge, travel cost, reporting cost, laboratory charges etc is sent for acceptance
- Acceptance of cost by the grower/producer
- Signing of agreement between grower/producer and certification agency

- Certification agency seeks cropping/production/cultivation /processing plan and supply a copy of the standards to the grower/producer to follow
- Certification agency raises an invoice and asks the producer to release 50% of the certification cost in advance
- Grower/producer pays the fee
- Inspection schedule is worked out
- Inspection is carried out at one or more than one occasion
- If required unannounced inspection can also be done. In case of doubt the inspection team can also draw plant/soil/raw material/input/product sample for laboratory analysis.
- Inspection report/(s) submitted to the certification committee
- Certification agency asks for final payment
- Final payment is made
- Certification is granted
- Grower/producer releases the stock for sale with Certification Mark (India Organic Logo)

List of Accredited Inspection and Certification agencies in India

IMO Control Pvt. Ltd.
No. 1314, Double RoadIndiranagar
2nd Stage Bangalore-560 038.

Indian Organic Certification Agency
(INDOCERT) Thottumugham
P.O.Aluva-(Karnataka) 683 105
Cochin, (Kerala)

Lacon Quality Certification
Pvt. Ltd Mr. Bobby Issac Director
Chenathra, Theepany,
Thiruvalla - 689

Natural Organic Certification Agency
Chhatrapati House Ground Floor
Near P. N. Gadgil Showroom Pune-411 038
(Maharashtra)

OneCert Asia Agri Certification Pvt. Ltd. Agrasen Farm, Vatika Road,
Vatika P.O., Off Tonk,Jaipur-303 905,
(Rajasthan)

Bureau Veritas Certification India Pvt. Ltd. (Formerly known as BVQI (India) Pvt. Ltd.) Marwah Centre, 6th Floor Opp.
Ansa, Industrial Estate Krishanlal Marwah
Marg Off Saki-Vihar Road Andheri (East)
Mumbai-400 072 (Maharashtra)

ECOCERT India Pvt. Ltd
Sector-3, S-6/3 & 4, Gut No. 102
Hindustan Awas Ltd. Walmi-
Waluj Road Nakshatrawadi
Aurangabad – 431 002 (Maharashtra)

SGS India Pvt. Ltd.
Dr Manish PandeDivisional Manager –
Food, Retail& CSRS250 Udyog Vihar
Phase – IVGurgaon – 122 015 (Haryana)

Control Union Certifications
(Formerly known as Skal International
(India)) "Summer Ville" 8th Floor 33rd
– 14th Road Junction Off Linking Road,
Khar (West)Mumbai –400052 (Maharasthra)

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Chapter 17

BREEDING STRATEGIES FOR ORGANIC VEGETABLE PRODUCTION SYSTEM

T. Arumugam and N.A. Tamilselvi

17.1 INTRODUCTION

Modern agriculture largely depends on the use of inputs such as chemical fertilizers, pesticides, herbicides and labour saving but energy intensive farm machinery. Application of these high input technologies undoubtedly increased the production. However, those high input agriculture degrades some of the natural resources on which this system rest. Beyond the adverse effect on soil productivity and environment quality, it does not guarantee sufficient food production in the next decades in a sustainable way. Hence, there is an urgent need to develop farming techniques which are sustainable from environment, production and socio economic point of view. In the recent days, agricultural community is setting its hopes on sustainable agriculture, which will maintain the cycles of inputs and ecosystem balance.

There are different concepts of sustainable agriculture that often referred as organic, alternative, ecological or low input agriculture. Off which, organic farming is the most widely recognized alternative farming system which gained social, political and scientific recognition for its contribution to sustainable agriculture. Organic agriculture is a production system, which avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, it largely rely upon crop rotations, crop residues, animal manures, legumes, green manures, off farm organic wastes, mechanical cultivation, mineral bearing rocks and biological pest and disease control measures to maintain soil productivity and tilth to supply plant nutrition's and to control insects, weeds and other pests (USDA Report, 1980).

In reality, organic agriculture is a consistent system approach based on the perception that tomorrow's ecology is more important than today's economy. Organic farming is thus considered as a movement directed towards the philosophy of "Back to Nature" (Parvatha Reddy, 2008). It aims at low input farming and reducing the dependants on inorganic fertilizers, plant protection chemicals and weedicides.

17.2 CURRENT STATUS

The latest survey on certified organic agriculture worldwide shows 50. 9 million hectare of agricultural land are organic (including conversion areas) (FiBL statistics, 2015-16). On global scale, Organic agriculture is practiced in 172 countries by 2.4 million producers or farmers approximately and the countries with the highest numbers of producers are India, Ethiopia and Mexico (FiBL statistics 2015-16 and Anonymous, 2017). In India, the total area under organic certification is **5.71 million hectare** (2015-16). This includes 26% cultivable area with 1.49 million hectare and rest 74% (4.22 million hectare) forest and wild area for collection of minor forest produces.

India produced around **1.35 million MT** (2015-16) of certified organic products which includes all varieties of food products *viz.,* Fruits, Dry Fruits, Vegetables, Spices, Tea, Coffee Sugarcane, Oil Seeds, Cereals, Millets, Cotton, Pulses, Medicinal Plants *etc.,* The production is not limited to the edible sector but also produces organic cotton fiber, functional food products *etc.*, Among all the states, **Madhya Pradesh** has covered largest area under organic certification followed by Himachal Pradesh and Rajasthan. The total volume of export during 2015-16 was **263687 MT.** The organic food export realization was around **298 million USD.** Organic products are exported to European Union, US, Canada, Switzerland, Korea, Australia, New Zealand, South East Asian countries, Middle East, South Africa *etc.,* Oil seeds (50%) lead among the products exported followed by processed food products (25%), Cereals & Millets (17%), Tea (2%), Pulses (2%), Spices (1%), Dry fruits (1%) and others. (APEDA report, 2016).

17.3 REASONS FOR DEVELOPMENT OF VARIETIES/ HYBRIDS SUITABLE FOR ORGANIC FARMING

The characteristics of organic agricultural systems are their biodiversity at soil, crop, field, crop rotation or polyculture, landscape level and the greater focus on integration of crop and livestock production systems on the farm compared with conventional farming systems (Mader *et al.,* 2002). Organic farmers have long depended on conventional variety and seed production, which requires high levels of artificial fertilizers and agro-chemicals to obtain targeted yield. However, organic farming aims at a low input system and at refraining from agro-chemical inputs (Lammerts van Bueren, 2003). To date, there are only few varieties that were specifically bred for organic and low-input systems in developed countries. It is estimated that more than 95% of organic agriculture is based on crop varieties that were bred for the conventional high-input sector with selection in conventional breeding programmes (Lammerts van Bueren *et al.,* 2011). Recent studies have shown that such varieties lack important traits required under organic and low-input production conditions (Lammerts van Bueren *et al.,* 2002; Murphy *et al.,* 2007; Wolfe *et al.,* 2008).

A range of breeding goals desired for the organic sector, such as yield, resistance to biotic and abiotic stress and sensory qualities demanded by consumers which do not differ from conventional breeding goals, but it is essential that such traits are expressed under low-input conditions (Lammerts van Bueren *et al.,* 2011). Hence, development of genetic diversity focused crop breeding approaches may be essential to improve yield and quality parameters in foods from organic and low-input farming systems, especially in the context of the challenges expected due to global climate change (Ostergard *et al.,* 2009). Moreover, the worldwide standards of organic agriculture (OA) do not allow genetic engineering (GE) or any products derived from genetic engineering. The standards in OA are an expression of the underlying principles of health, ecology, fairness and care (Nuijten *et al.,* 2017).

Brandt *et al.* (2011) and Crowder and Reganold (2015) stated that organic farming systems produce lower yields compared to conventional agriculture. However, they are more profitable and environment friendly and deliver more nutritious fruits and vegetables that contain low to no chemical-synthetic pesticide residues, compared with conventional farming (Reganold and Wachter, 2016). Ponti *et al.* (2012); Seufert *et al.* (2012) and Kniss *et al.* (2016) accounted an average yield gap of approximately 20% between conventional and organic agriculture. However, Ponisio *et al.* (2015) and Kniss *et al.* (2016) reported that 20% yield gap does not count for all crops and all regions, as in some cases difference has not been noticed in some crops. Therefore, the future challenge is to further optimize productivity of organic farming systems to overcome average yield gap between conventional and organic agriculture. Another factor of limited yield under organic agriculture is the lack of cultivars adapted to low-input growing conditions without use of herbicides, pesticides and fungicides. Van Bruggen and Finckh (2016) stated that organic farmers loose potential yield due to lack of sufficient weed suppression, pest and disease resistance traits (e.g. onion against downey mildew and in potato against late blight).

It often takes 10 years or more from the initial inter-varietal crosses to develop a new crop variety. To realize the varietal improvements needed in organic farming in the coming decades, crosses between appropriate parental varieties have to be made now. Therefore it is essential to identify the primary limiting factors of existing varieties for organic production and target them in the breeding programmes for organic farming. In this circumstance, the main traits required for successful vegetable cultivation under organic farming or low-input conditions are described hereunder.

17.3.1 Nutrient-use efficiency

The greatest difference between organic and conventional systems relates to soil management practices used and to processes in the rhizosphere (Baresel *et al.*, 2008). Organic systems often rely on organic matter based fertilizer inputs and mineralization-driven N and P supplies to crops. Macronutrient availability patterns during the growing period therefore differ significantly from those in conventional systems. Warman (1998) stated that organic crops often experience limited macronutrient (N and P) availability especially during periods when soil temperatures and water availability reduce mineralization capacity by soil biota. However, regular organic matter inputs have shown to increase soil biological activity, biodiversity and mineralization capacity of the soil (Fliessbach *et al.,* 2007). Przystalski *et al.* (2008) and Van Bruggen and Finckh (2016) reported that organic farmers often apply 50 -80% of nitrogen through organic matter based fertilization compared to the amount of nitrogen in conventional farming systems. While nitrogen of organic matter will be slowly released and it also prevents nitrate leakage to surface and ground water. In addition, organic matter based fertilization have shown to suppress diseases (Ghorani *et al.,* 2008) and induce biochemical pathways in crops involved in pathogen defense and stress tolerance (Kumar *et al.,* 2004). Concomitant to this finding, Van Bruggen and Finckh (2016) enumerated that limited nitrogen supply reduces too luxurious vegetative growth that could limit the pests (e.g., aphids) and foliar diseases (e.g., mildew) as in cereal production. From comparative studies between conventional and organic/reduced-input systems, Van Bruggen (1995) concluded that in organic or reduced-input system, root diseases and pests are generally less of problem than foliar diseases, because foliar disease development is much more determined by climatic factors. Many root diseases can be eliminated by the broad rotation in organic systems. Therefore, an essential element in organic farming systems is to gain and maintain soil fertility with an active soil life contributing to the nutrient availability, good soil structure and crop specific manuring for buffering and resistance to unbalanced plant growth.

In this context it is likely that organic systems require crop genotypes that are able to form active symbiotic relationships with beneficial organisms in the rhizosphere and thereby establish mechanisms that increase nutrient-use efficiency (e.g., vigorous root systems, ability to form active mycorrhizal associations, reduced root losses due to pathogens, ability to maintain a high mineralization activity in the rhizosphere via root exudates, increased rooting depth and associated ability to recover N leached from the top soil).

According to Dawson *et al.* (2008), nutrient-uptake efficiency of plants can be improved by maintenance of photosynthesis under nutrient stress condition, nutrient uptake capacity, nutrient-utilization capacity and translocation efficiency will contribute to higher yield and quality under low input conditions. Therefore, adaptation of varieties to efficient nutrient use derived from slow-nutrient-releasing organic fertilizer is of special importance in organic farming, which is not addressed in conventional systems with no or less inorganic fertilizer. Nutrient-uptake efficiency of plants can be improved by plant-growth promoting-rhizosphere (PGPR) bacterial communities (Gosling *et al.*, 2006; Wissuwa *et al.*, 2009) and arbuscular mycorrhizas (AMs) known as "rhizosphere competence". PGPR-bacteria promotes N-uptake efficiency since they protect root systems against soil-borne pathogens attack (Cook, 2007), maintains efficient mineralization driven nutrient supplies to plant roots (Rengel and Marschner, 2005; Shaharoona *et al.*, 2008) and support the establishment of active AM associations (Dawson *et al.,* 2008). Similarly, Gosling *et al.* (2006) and Mader *et al.* (2000); Wissuwa *et al.* (2009), stated that AMs are essential for efficient phosphorus, micronutrient and water uptake of plants grown under organic farming and low-input conditions respectively.

Larkan *et al.* (2007) identified genes in tomato which has the ability to form mycorrhizal root symbiosis and Kumar *et al.* (2004) inferred that association of specific microorganisms on roots can influence gene expression in the plant. Greenwood *et al.* (2005 and 2006) and White (2007) studied P-use efficiency in *B. oleracea* and showed that there is genetic variation in this trait and that it is under quantitative control. Kage *et al.* (2003) reported that cauliflower varieties with proportionally more fine roots have shown more N-use efficiency. According to Kramer (1979) and Bertin and Gallais (2000) agronomic practices like fertilizer applications and environmental or climatic conditions like temperature, light intensity and soil moisture have a significant impact on nutrient-use efficiency (NUE). Hence, crop plants should be selected within the context of different agronomic and climatic environments.

17.3.2 Weed competition

Weed control also remains a problem in many crop plants. However, weed management in row crops grown from transplants, including many Brassica and some Allium crops, tends to be less problematic than in these crops grown from seed. This is due primarily to more rapid development and associated competitiveness against weeds as well as the greater suitability of transplanted row crops for inter-row mechanical weeding methods (Lammerts van Bueren *et al*., 2011). Broccoli seedlings are small and may take longer time for germination and establishment than competing weeds. For organic production, broccoli varieties suitable for direct seeding should have rapid emergence and growth habit and shade neighboring weeds. Since, *B. oleracea* has great diversity of cultivated morphological types, sufficient genetic variation should be present in these species for development of varieties with more weed competition under organic cultivation.

Allelopathy is another potentially important weed suppression trait that has received little attention in recent years. Fay and Duke (1977) and Wu *et al.,* (1999) stated that allelopathy is a chemical process where plants provide themselves with a competitive advantage due to direct or indirect effect on germination, growth or development of neighbouring plants. Hence, allelopathic potential of crop germplasm should be evaluated initially for development of varieties with allelopathic activity. Wu *et al.* (1999) suggested that identification of varieties with high allelopathic activity and transfer of such a characteristic into modern varieties could restore an important trait that has inadvertently been lost during the process of selection for higher yields.

In Brassicaceae, glucosinolate breakdown products have weed and pathogen suppressive effects (Lammerts van Bueren *et al*., 2011). Myrosinase catalyzes the conversion of glucosinolates to isothiocyanates and related compounds but is not released until plant tissue disruption/ (Vaughn and Boydston, 1997). The effect has been most clearly demonstrated in crops following ploughing under a cruciferous green manure crop. Jimenezosornio and Gliessman (1987) and Itulya and Aguyoh (1998) examined allelopathic effect of Brassica crops on weeds and observed no significant effect. It is unlikely that weed suppression through allelopathy could be directly used in broccoli, but varieties bred with increased glucosinolate levels in vegetative tissues could be part of a long-term weed control strategy in crop rotations (Lammerts van Bueren *et al*., 2011).

17.3.4 Tolerance/ resistance to mechanical weed control

Selection of genotypes with tolerance or resistance to mechanical weed control (especially tine weeders) also becoming an efficient component of breeding strategies for weed competitiveness. Especially in reduced-tillage systems, mechanical weed control is applied more frequently due to higher weed pressure. Tillage systems have a direct effect on soil-carbon balances, soil organic matter, rooting depths and loss of top soil by wind and water erosion. Types of tillage systems include no tillage, minimum tillage and deep ploughing. No tillage systems are dependent upon herbicides, so that soil erosion and carbon losses are reduced. However, in reduced or minimum tillage systems, herbicide-free protocols are feasible (Berner *et al*., 2008; Krauss *et al*., 2010) and could be further implemented into organic farming if varieties have increased competitiveness and/or resistance to mechanical weed control.

Rao and Dao (1994); Weisz and Bowman (1999) and Carr *et al*. (2003) observed varieties suitable for reduced tillage and no tillage systems are also perform well under conventional tillage systems and inferred that tillage system does not need to play a role in varietal selection.

According to Donner and Osman (2006) and Murphy *et al*. (2008) mechanical weed control is usually done with tine weeders early in the season, supplemented in some regions by inter-row cultivation. Therefore, the ability to tolerate damage and/or a rapid recovery following mechanical weed treatments is an important trait for varieties used in organic and low-input systems.

17.3.5 Resistance to major seed borne diseases

Resistance to seed-borne diseases in organic seed production is an important issue as few seed treatments are permitted for use under organic farming standards. According to Hetrick *et al*. (1995); Rengel and Marschner (2005) and Wissuwa *et al*. (2009) resistance to seed-borne diseases is an important trait because root systems are required for crops to express their genetic potential for nutrient-use efficiency and yield. Seed-borne diseases of tomato include tomato mosaic virus (ToMV), bacterial speck and bacterial spot (caused by *Pseudomonas syringae* and *Xanthomonas campestris* pv. *vesicatoria*, respectively) and fungal pathogens such as *Clavibacter michiganensis*. ToMV become a major threat to conventional and organic tomato production, whereas bacterial and fungal diseases are more serious problem in organic systems restrictions in the use of fungicides and antibiotics (other than sulphur and copper based products). The two basic strategies to control seed-borne diseases in tomato are: (1) the use of seed treatments (e.g., antagonistic micro-organisms, compost extracts, fermentation, acids and acidified nitrite) and hot water treatment and/or (2) use of resistant varieties.

ToMV become a major yield limiting constrain in greenhouse grown tomatoes because the virus is stable and easily spreads through handling. Seed treatment to inactivate the virus does not work well, particularly if the virus is present in the endosperm of the seed. Therefore, the uses of resistant varieties become a viable option for organic production systems. The ToMV resistance gene 'Tm-22' has been derived from *Solanum peruvianum* through embryo rescue technique and incorporated into commercial varieties (Hall, 1980). Another resistance gene 'Tm-1' from S. *habrochaites* provides resistance against the predominant strain of ToMV which can be incorporated into commercial varieties through conventional crossing technique (Pelham, 1966). Similarly, bacterial speck and bacterial spot resistance sources are available in tomato germplasm and should be incorporated into commercial varieties bred for organic production system. Bacterial wilt (*Rastonia solanacearum*) is also major seed borne problem in tomato and Indian Institute of Horticultural Research, Bangalore released a bacterial wilt resistant varieties *viz.,* Arka Abha (BWR-1) and Arka Alok (BWR-5) which could be used for organic cultivation.

The major seed-borne disease of broccoli is black rot (caused by *Xanthomonas campestris* pv *campestris*). As in tomato, it can be controlled by seed treatment with antibiotics and copper based products in conventional production systems. However, the best option for organic production would be use of resistance varieties. Tonguc and Griffiths (2004) found incomplete resistance in *B. oleracea*, but more complete forms of resistance have been identified in *B. napus* and *B. carinata*. They also inferred that early attempts to introduce resistance from *B. carinata* into *B. oleracea* were made using somatic hybridization and recently *in vitro* embryo culture was used to introgress resistance.

17.3.6 Disease resistance

Tolerance to diseases that may cause injuries and are likely to affect plant health and quality is crucial for minimizing the gap between yield potential and actual yield. This applies to conventional high-input as well as to low-input or organic farming. Stone *et al.* (2004) stated that *Fusarium* wilt (*Fusarium oxysporum* f.sp. *lycopersici*) and *Verticillium* wilt (*Verticillium dahlia*) of tomato may be of less concern in organic production systems compared with their impact on conventional ones due to the suppressive effects of organic matter based fertilization regimes. On the otherhand, viral diseases such as Tomato mosaic virus (ToMV) and tomato spotted wilt virus (TSWV) are more universal occur regionally and TSWV become independent of production system. Whereas late blight (*Phytophthora infestans*) is of less concern in conventional systems due to greater choice and efficacy of fungicides available compared with organic systems, where only protective copper fungicides can be used. Several sources of resistance for late blight are known (Myers, 2009) which can be used for development of late blight resistance varieties in tomato intended for organic production systems (Horneburg and Becker, 2008; Myers, 2009).

Although a number of diseases may affect broccoli regionally, head rot is a complex of soft rot bacteria (*Erwinia* and *Pseudomonas* spp.), can cause problems whenever water accumulates on the developing broccoli head. Darling *et al.* (2000) found head rot resistance in broccoli is associated with smooth, domed heads and small, tight beads. Blackleg (*Leptosphaeria maculans,* formerly *Phoma lingam*) and Alternaria (caused by various *Alternaria* spp., but mainly *A. brassicola*) are two diseases that cause significant economic losses in Europe and eastern USA where pesticide-based control options used by conventional growers are not available to organic growers (Lammerts van Bueren *et al.,*2002). Dixon (2007) recommended hot water treatment to disinfect the seed, but it is not completely reliable and may reduce germination. Resistance source have been observed among various Brassica species and needs to be transferred into *B. oleracea* background.

17.3.7 Insect resistance

Due to the avoidance of insecticide applications under organic farming, organic growers has to follow alternative measures includes cultural management tools such as establishment of beetle banks to maintain high predator or parasite populations; companion plants to repel or distract pests; mass trapping systems, pheromone-based mating disruption and barrier-based approaches to control invertebrate pests (use of insect-proof net houses).

Many Brassica vegetables were grown under row covers to prevent cabbage fly infestation (*Erioischia brassicae*), flea beetle (*Phyllotreta* spp.) and lepidopteran pests (*Plutella xylostella, Pieris rapae*) during early season. Biological control products such as *Bacillus thuringiensis* and Spinosad are widely used to control lepidopteran pests (diamond back moth) and aphids. Plant phenotypes or morphological traits may positively or negatively associated with insect pest populations. Eigenbrode (1995) found glossy (waxless) variants of white head cabbage (*B. oleracea*) showed less damage from lepidopteran pests, reduced whitefly (*Aleyrodes brassicae, Bemisia tabaci*) populations and resulted in fewer eggs laid by cabbage maggots. Moreover, the glossy phenotype also associated with reduced tissue damage from thrips. However, flea beetle damage was higher on glossy plants and both an increase and a decrease in aphid populations have been reported. Voorrips *et al.* (2008) observed a positive correlation between wax layer thickness and cabbage root fly infestation in white head cabbage and inferred that wax less trait would be best option in glasshouse production where only thrips and no other pests are predominant problem.

17.3.8 Abiotic stress resistance/ tolerance

Breeding for tolerance to abiotic stresses is another important issue. Apart from nutrient stress, drought, salinity, aluminium toxicity, cold and heat stress are other important abiotic stress factors that cause yield reductions (Witcombe *et al.,* 2008). With climate change, the importance of drought and the area under saline soils are expected to increase significantly. But, Breeding for drought and salinity tolerance has proved to be difficult (Blum, 2005) as the mechanisms of tolerance are very complex and poorly understood (Witcombe *et al.,* 2008; Cattivelli *et al.,* 2008; Ortiz *et al.,* 2008). However, tolerance to abiotic stresses is important not only for organic but also for conventional agriculture. In some cases such as drought stress, organic farmers may give higher priority as they want to build up a system that is less dependent on inputs.

17.3.9 Nutritive Value or quality

The demand for organic products is partially driven by the belief that organically grown products are healthier and more nutritious than conventionally grown products (Lotter, 2003). It is therefore plant breeder should consider the nutritional and quality parameters, while developing varieties for organic sector. Frossard *et al.* (2008) stated that significant variation in mineral and vitamin contents exists among varieties within crops and nutritional quality is often dependent on specific management practices. Similarly in broccoli, heterogeneity exists for important nutritional components (e.g., vitamin C, carotenoids, flavonoids and glucosinolates) and some breeding programmes has already selected for improving the contents of these nutritionally desirable compounds (Jeffery *et al.,* 2003). The traits associated with tomato fruit quality depend very much on the market type. In general, higher levels of carotenoids (lycopene, beta-carotene), vitamin C and flavonoids are considered beneficial. Tomatoes are a major source of carotenoids and vitamin C in the diet, but flavonoid content was fairly low compared to other vegetables. Jordan (2007) and Behrendt (2009) stated that flavour is one of the most difficult trait, tomato breeding programmes often include the selection steps designed to improve the tomato flavour. Tomato growers prefer good flavour, but cannot agree bad flavor, soft mealy texture, bland taste with low sugar content or a bad balance of sugar to acid ratio.

17.3.10 Breeding approaches

Over the last 40 years, organic farmers have mainly aimed at optimizing their farming systems by agronomic approaches. More and more the sector now also aims at genetic improvements to enhance yield stability under low-input conditions (Lammerts van Bueren *et al.* 2011). In vegetable sector, only a few organic farming focused breeding programmes have been started so far and farmers still largely depend on varieties bred for conventional, high-input farming systems. Although many breeding goals are identical for conventional and organic production, such as yield and disease resistance, the priorities can nevertheless be different. This is mainly due to the fact that conventional agriculture is able to compensate certain traits via inputs, including inorganic fertilizers and chemosynthetic crop protection chemicals that are not available for use in organic farming systems. Many traits desired for development of varieties suitable for organic and low-input farming systems should focuses on organic crop ideotype with overall yield stability and include morphological and physiological characteristics, such as plant and root architecture and vigour (Lammerts van Bueren *et al.,* 2011). For leafy vegetables, it is important that they have the ability to grow in early spring conditions when the soil temperature is low. Hence, more attention needs to be paid to the development of a better root geometry (deeper and finer rooting system) with efficient water and nutrient uptake and the ability to maintain steady plant growth without stress under fluctuating water and nutrient availability.

Furthermore, the organic sector demands breeding to focus on optimizing soil processes relevant for plant nutrition, soil fertility and crop disease resistance. Comparing to conventional farming systems, this implies a greater need for 'reliable' varieties, which means varieties with a greater flexibility to cope with such conditions. An essential element of organic farming is that it looks at agriculture as process based on a complex intertwining of agro-ecological, socio-economic and ethical principles. In addition, organic farmers are certified based on their farming process. Hence, organic farming looks at the breeding of new varieties in a holistic way. Thus, not only the varietal characteristics itself but also the process of varietal development must comply with the guiding principles of organic agriculture (Crespo and Ortiz, 2015).

As a consequence of rejecting certain breeding techniques like genetic engineering (GE) and techniques related to genetic engineering, appropriate breeding methods should be identified as a good alternative. The degree of overlap between varieties suitable for conventional and/or organic farming systems depends on the crop requirements and applied breeding techniques. In some specific crops, the problem to find suitable varieties that can perform well without high levels of mineral fertilizers and chemical-synthetic fungicides, herbicides and pesticides is larger than for other crops. Cultivars for OA also need to have high weed competition or tolerance, high level of tolerance against soil and seed borne diseases and especially high requirements for shelf-life, as synthetic conservatives are not allowed. There is not only a need for varieties that fit in an organic system with good yield potential and nutritional quality but also that allow organic systems to work, meaning that the resilience of the whole farming system is supported and enhanced. Luby *et al.* (2013) argued that the organic sector has not yet reached its full potential until growers have access to regional adapted and organically bred varieties that balance yield with nutritional quality. According to Lammerts van Bueren *et al.* (2011), many of the selection approaches that are used in conventional breeding programmes can also be utilized in organic farming focused breeding programmes and were described hereunder.

17.3.10.1 Sources of genetic diversity

The creation and exploitation of genetic diversity is the main requirement for successful plant breeding. Breeders differentiate between the primary gene pool (elite breeding lines), secondary gene pool (landraces, lines not adapted to local conditions or gene bank material) and tertiary gene pool (related species or wild relatives). A vast unexploited genetic diversity exists in all the vegetables which includes wild relatives, land races and germplasms/ accessions with biotic and abiotic stress (drought, high temperature, salinity, water logging and soil micronutrient imbalances) resistance/ tolerance was available and were not fully exploited. However, fair number of varieties and hybrids were developed by using the wild relatives. Achievements made by using these genetic resources in vegetables were listed in Table 1. Hence, the unexploited /untapped genetic variability available in the land races, wild relatives and germplasms/ accessions may effectively utilized for development of varieties/ hybrids suitable for organic cultivation. The vegetable varieties/ hybrids resistant to biotic and abiotic stress developed by using the wild recourses has been mentioned in Table 17.1 and 17.2. These may be utilized for organic cultivation without using plant protection chemicals. However, the package of practices may be optimized for organic cultivation of the same.

17.3.10.2 Exploiting genetic variation within released varieties

Genetic variation within released varieties is relatively small in self-pollinated crops. An alternative method employed by Phillips and Wolfe (2005), maintaining genetic diversity and evolutionary fitness within varieties, is to create composite cross populations. Composite cross populations are formed by assembling seed stocks with diverse evolutionary origins and characteristics, recombination of these stocks by cross pollination, bulking of F_1 progenies and subsequent propagation of the bulked progenies in successive natural cropping environments. Natural selection takes place if more adapted genotypes produce more progenies than less adapted ones. Composite cross populations can provide dynamic gene pools, which in turn provide a means of conserving genetic resources *in situ*. They can also allow selection of heterogeneous crop varieties. According to Phillips and Wolfe (2005), composite cross populations may have the potential to allow evolutionary changes based on biotic and abiotic environmental interactions and might be an alternative for selecting superior pure lines especially for low input systems characterized by unpredictable stress conditions.

17.3.10.3 Participatory plant breeding

Participatory plant breeding (PPB) programmes originated in developing countries to meet the needs of low-input, small-scale farmers in marginal environments that are not targeted by commercial breeding companies (Ceccarelli *et al.*, 2011). PPB involves breeders, farmers, as well as consumers, extension specialists, vendors, industry and rural co-operatives in plant breeding research. It is termed 'participatory' because all stakeholders can influence all major stages of the breeding and selection process. These stakeholders become co-researchers as they can help to set overall goals, determine specific breeding priorities, make crosses, screen germplasm entries in the pre-adaptive phases of research, take charge of adaptive testing and lead the subsequent seed multiplication and diffusion process (Sperling *et al.*, 2001). Due to special need of farmers and small organic market not always being attractive for commercial plant breeders, this approach gained greater attention in breeding programmes for development of varieties suitable for organic farming systems (Dawson *et al.*, 2008; Osman *et al.*, 2008).

Table 17.1: Vegetable varieties/ hybrids resistant to biotic stress

S.No	Crop	Variety/hybrid	Special features	Institute
1.	**Tomato**	Hisar Lalit (NRT 8)	Resistant to root knot nematode	HAU, Hisar
2.		Hisar Anmol (H 24)	Field resistant to tomato leaf curl virus	HAU, Hisar
3.		Arka Alok (BWR 5)	Resistant to bacterial wit	IIHR, Bangalore
4.		Arka Abha (BWR 1)	Resistant to bacterial wit	IIHR, Bangalore
5.		Arka Abhijit	Highly resistant to bacterial wit	IIHR, Bangalore
6.		Arka Shreshta	Resistant to bacterial wit	IIHR, Bangalore
7.		Arka Vardan	Resistant to root knot nematode	IIHR, Bangalore
8.		Kashi Vishesh	Resistant to TLCV	IIVR, Varanasi
9.	F_1 hybrid	Pusa Hybrid - 2	Highly tolerant to root knot nematode	IARI, New Delhi
10.		Pusa Hybrid - 4	Field resistant to root knot nematode	IARI, New Delhi
11.	**Brinjal**	Pusa purple cluster	Resistant to little leaf and bacterial wilt	IARI, New Delhi
12.		Pusa Bhairav	Resistant to phomopsis fruit rot	IARI, New Delhi
13.		Pusa Anupam (Kt-4)	Resistant to bacterial wilt	IARI, New Delhi
14.		Arka Nithi (BWR-12)	Resistant to bacterial wilt	IIHR, Bangalore
15.		Arka Keshav (BWR-21)	Resistant to bacterial wilt	IIHR, Bangalore
16.		Pant Samrat	Tolerant to shoot and fruit borer and resistant to bacterial wilt	PAU, Ludhiana
17.	F_1 hybrid	Arka anand	Resistant to bacterial	IIHR, Bangalore

S.No	Crop	Variety/hybrid	Special features	Institute
18.		Arka Neel kandh	Resistant to bacterial wilt	IIHR, Bangalore
19.	**Chillies**	Pusa Jwala	Tolerant to thrips, mites and aphids	IARI, New Delhi
20.		Pusa sadabahar	Resistant to CMV, TMV and leaf curl virus	IARI, New Delhi
21.		Pant C-1	Tolerant to mosaic and leaf curl virus	GPUAT, Pant Nagar
		Arka Suphal (PMR 57)	Resistant to powdery mildew, field tolerant to viruses	IIHR, Bangalore
22.		Arka Lohit	Resistant to powdery mildew	IIHR, Bangalore
23.	F_1 hybrid	Arka Harita	Tolerant to powdery mildew and viruses	IIHR, Bangalore
24.	Bhendi	Bhendi Hybrid CO 4	Resistant to YVMV	TNAU, Coimbatore
Cruciferous vegetables				
25.	Cabbage	Pusa Drum Head	Resistant to black leg	IARI, New Delhi
26.		Pusa Mukta (Sel. 8)	Resistant to black rot	IARI, New Delhi
27.	Cauli-	Pusa Shubhra	Resistant to flower curd and Inflorescence blight	IARI, New Delhi
28.		Pusa Snowball K 1	Resistant to black rot, curd and Inflorescence blight	IARI, New Delhi
29.	F_1 hybrid	Pusa hybrid 2	Field resistant to downy mildew	IARI, New Delhi
30.		Pusa Kartik Shankar	Resistant to downy mildew	IARI, New Delhi
Cucurbitaceous vegetables				
31.	Cucumber	Pusa Barkha	Tolerant to downy mildew	IARI, New Delhi

S.No	Crop	Variety/hybrid	Special features	Institute
32.	Musk-melon	Arka Rajhans	Tolerant to powdery mildew	IIHR, Bangalore
33.		Punjab Raseela	Moderately resistant to downy mildew	PAU, Ludhiana
34.	Water -melon	Arka Manik	Resistant to anthracnose and powdery mildew	IIHR, Bangalore
35.	Bitter gourd	Pant Karela	Highly resistant to red pumpkin beetle	GPUAT, Pant Nagar
36.	Winter squash	Arka Suryamukhi	Resistant to fruit fly	IIHR, Bangalore
Leguminous Vegetables				
37.	Garden	Kashi Nandhini pea	Resistant to anthracnose and powdery mildew	IIVR, Varanasi
38.	French bean	Pusa Parvati	Resistant to mosaic and powdery mildew	IARI, New Delhi
39.		Arka Anoop	Resistant to bacterial wilt	IIHR, Bangalore
40.	Cluster bean	Goma Manjari	Resistant to powdery mildew, bacterial wilt and leaf spot	CIAH, Bikaner
Cow pea				
41.		Pusa Komal	Resistant to bacterial blight	IARI, New Delhi
42.		Pusa Sukomal	Highly resistant to golden yellow mosaic virus and leaf spot	IARI, New Delhi
43.		Kashi Sudha	Resistant to golden yellow mosaic virus and Cercospora leaf spot	IIVR, Varanasi
44.		Kashi Kanchan	Resistant to golden yellow mosaic virus and Cercospora leaf spot	IIVR, Varanasi

S.No	Crop	Variety/hybrid	Special features	Institute
45.		Kashi Unnati	Resistant to golden yellow mosaic virus and Cercospora leaf spot	IIVR, Varanasi
46.		Kashi Gowri	Resistant to golden yellow mosaic virus and Cercospora leaf spot	IIVR, Varanasi
47.	Onion	Arka Pitambhar	Tolerant purple blotch, basal rot and thrips	IIHR, Bangalore
48.		Arka Lalima	Tolerant purple blotch, basal rot and thrips	IIHR, Bangalore
49.		Arka Kalyan	Moderately resistant to purple blotch	IIHR, Bangalore
50.	Potato	Kufri Himalini	Moderately resistant to late blight	CPRI, Shimla
51.		Kufri Shailja	Moderately resistant to late blight	CPRI, Shimla
52.		Kufri Girdhari	Highly resistant to late blight	CPRI, Shimla
53.		Kufri Himsona	Highly resistant to late blight	CPRI, Shimla
54.	Tapioca	Tapioca YTP 1	Resistant to cassava mosaic virus	TNAU, Coimbatore

In conventional systems, inorganic fertilizers and synthetic crop protection chemicals often encourage homogeneity across a diversity of agro-environments. Organic and traditional low-input farms are often more heterogeneous and experience greater diversity of weed, pest and disease pressure and use more diverse rotational designs and soil management, tillage, fertilization and crop protection protocols. To develop varieties suitable to these diverse agro-environments, Suneson (1956) recommended integration of evolutionary breeding with strong participatory selection components (Murphy *et al.*, 2005 and Dawson *et al.*, 2008). This type of breeding strategy utilizes a combination of natural selection (survival and more progenies of the fittest genotype due to adaptation to local conditions) and farmer selection (active selection of genotypes that fit the defined

Table 17.2: Vegetable varieties/ hybrids resistant to abiotic stress

S.No	Crop	Variety/hybrid	Special features	Institute
Solanaceous Vegetables				
1.	Tomato	Pusa Sheetal	Tolerant to low temperature	IARI, New Delhi
2.		Pusa Sadabahar	Tolerant to low and high temperature	IARI, New Delhi
3.	Cucumber	Pusa Barkha	Tolerant to high temperature	IARI, New Delhi
4.	Bush bean	Arka Jay	Tolerant to heat and drought	IIHR, Bangalore
5.		Arka Vijay	Tolerant to heat and drought	IIHR, Bangalore
6.	Carrot	Pusa Kesar	Tolerant to high temperature	IARI, New Delhi
7.	Potato	Kufri Surya	Heat tolerant	CPRI, Shimla
8.		Kufri Anand	Tolerant to frost	CPRI, Shimla
9.		Kufri Arun	Tolerant to frost	CPRI, Shimla

(**Source**: Hari Har Ram, 2012; Muthukumar and Selvakumar, 2013)

breeding goals) to develop varieties with optimal adaptation to specific organic farming systems. Such integrated breeding approaches are known as evolutionary participatory breeding (EPB), which utilizes the skills and knowledge of both breeders and farmers to develop heterogeneous landrace populations and has demonstrated to be an effective breeding method for both traditional and modern farmers throughout the world (Dawson *et al.*, 2008). The Oregon State University (OSU) has developed few open pollinated (OP) broccoli varieties with similar productivity and quality traits available in F1 hybrids and suitable for organic production using a farmer participatory approach.

17.3.10.4 Indirect phenotypic selection methods

Some morphologic traits have been correlated with quantitative biotic or abiotic stress resistance. However, indirect selection for such morphological traits has not yet been widely implemented in plant breeding programmes (Lammerts van Bueren *et al.*, 2011).

17.3.10.5 Marker aided selection

With the advent of molecular markers it became possible to dissect quantitatively inherited traits into single genes. A marker-assisted breeding approach has been used to develop high-flavonoid tomato lines. More than 50% of the sequenced tomato genome has been assembled (http://sgn.cornell.edu/about/tomato sequencing.pl; accessed 23 March 2010) and as annotated sequence becomes available, it will be possible to identify and directly select candidate genes.

17.4 FUTURE DIRECTION OF CROP IMPROVEMENT

The organic sector needs to further develop various appropriate breeding approaches that fit with International Federation for Organic Agriculture Movements (IFOAM) basic principles *viz.,* health, ecology, fairness and care—are very helpful to support the development of breeding approaches (IFOAM, 2015). Varieties that meet these four criteria can be called organic varieties (Renaud *et al.,* 2014). This will also require political dialog and public intervention in agricultural research to support new concepts of organic plant breeding in which the whole value chain up to the final consumers are included (Vanloqueren and Baret, 2008 & 2009). To facilitate such developments, interdisciplinary research is needed to integrate knowledge from the technical and social sciences (Nuijten, 2011). A pluriformity in breeding approaches suited for organic farming considering different agro-ecological and socio-economic contexts will allow breeding for local adaptation and niche markets. This will contribute to the maintenance of diversity of our crop plants and, thus, lower risks of total crop failure due to extreme weather events expected due to climate change.

In some cases, the size of the organic market is too small to be economically attractive for professional breeding companies. Participatory approaches could represent an efficient alternative to develop new varieties for organic farming and should be further developed to reduce the reliance on commercial conventional farming focused breeding companies. However, more recently developed collaborative strategies involving both breeding companies and farmers and other supply chain stakeholder should also be encouraged to utilize commercial breeding expertise and facilities where this is possible. This is an important opportunity not only to integrate farmers' and breeders' knowledge, but also the farmers' and breeders' eye. Finally, the introgression of traits urgently needed by the farmers to optimize organic farming systems and improve yield stability will also have a positive influence on conventional production systems that aim to reduce agrochemical input use while improving environmental impacts and long-term agricultural sustainability. Breeding for organic agriculture therefore deserves significantly more attention and support.

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Chapter 18

ORGANIC LIVESTOCK AND POULTRY PRODUCTION: STATUS, STANDARDS AND OPPORTUNITIES IN INDIA

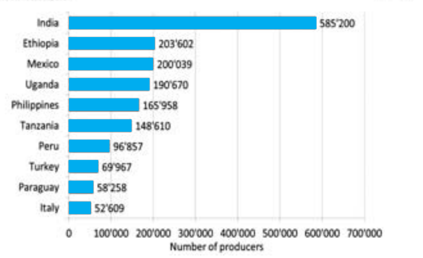
Mahesh Chander

Organic agriculture including organic livestock and poultry production is an emerging system of food production, which is expanding rapidly around the world. It is important that stakeholders in India are acquainted with the concept, standards, practices, requirements and guidelines of organic Livestock and Poultry production, to improve their understanding of this emerging system of food production. This chapter, therefore, deals with the status, standards, guidelines, practices and opportunities in India for organic animal husbandry including poultry production.

18.1 INTRODUCTION

Agro-chemicals like chemical fertilizers, pesticides, weedicides as also the drugs, synthetic feeds and antibiotics have significantly contributed to improving crop and livestock productivity world-over. But these agrochemicals are now increasingly held responsible for many health hazards & chronic diseases too. With growing literacy, education, awareness coupled with rising incomes, consumers are becoming more quality conscious. Moreover, the food scares like food borne diseases are alerting people of harmful consequences of consuming food laced with chemicals and harmful residues of pesticides and antibiotics. The negative consequences of these agrochemicals are not restricted to only physical health but also these are blamed for growing psychological/ mental problems in society. Many chronic diseases which are on the rise are being attributed partly to these agrochemicals, making the sustainability of chemical based farming and intensive livestock production questionable. As an alternative, therefore, organic agriculture is rapidly growing around the world including in India. Organic products are grown under a system of agriculture without the use of chemical fertilizers and pesticides with an environmentally and socially responsible approach. There are opportunities as well as challenges in organic livestock production in developing countries which need to be addressed. The organic livestock development opportunities in developing countries in Asia, Africa and Latin America can be enhanced with more scientific research in organic livestock production under local conditions and strengthening institutional support.

> *Organic agriculture is rapidly growing around the world. Currently it is being practiced in 50.9 Million ha across 179 countries with 2.4 million producers including significant number of organic farmers in developing countries like India. The global market for organic products has reached to US$ 81.6 billion. India continues to be the country with the highest number of producers (5,85,200) and 87 countries now have an organic legislation across the world (Willer and Lernoud 2017).In India, the cultivated area under certified organic farming has grown almost 17 fold in last one decade (42,000 ha in 2003-04 to 7.23 lakh ha in 2013-14). Alongside cereals, spices, cotton, tea etc, the Government of India is now keen to promote organic animal husbandry through focused attention on native breeds and local practices. In XII plan, the GOI has launched Paramparagat Krishi Vikas Youjana, under which Rs. 300 Crores (Union Budget 2015-16) were allocated to promote organic agriculture including organic animal husbandry. The organic livestock and poultry standards have also been notified for implementation since 1st June, 2015 (APEDA, 2015).*



The Government of India (GOI) has taken several initiatives to boost organic agricultural production in the country. The launching of National Programme of Organic Production (NPOP) in 2000-2001, setting up of National Centre of Organic Farming (NCOF) at Ghaziabad during 2003-04, ICAR Network Project on Organic Farming (2004) & the establishment of National Organic Farming Research Institute (NOFRI) under ICAR in Sikkim are some important milestones. These steps have resulted into significant increase in production and export of certified organic agricultural products from India.

> The total area under organic certification in India is 5.71 million Hectare (2015-16). This includes 26% cultivable area with 1.49 million Hectare and rest 74% (4.22 million Hectare) forest and wild area for collection of minor forest produces. The Government of India has implemented the National Programme for Organic Production (NPOP). The NPOP involves the accreditation programme for Certification Bodies, standards for organic production, promotion of organic farming etc. India produced around 1.35 million MT (2015-16) of certified organic products which includes all varieties of food products namely Sugarcane, Oil Seeds, Cereals & Millets, Cotton, Pulses, Medicinal Plants, Tea, Fruits, Spices, Dry Fruits, Vegetables, Coffee etc. The total volume of export during 2015-16 was 263687 MT. The organic food export realization was around 298 million USD. Indian Organic products are exported to European Union, US, Canada, Switzerland, Korea, Australia, New Zealand, South East Asian countries, Middle East, South Africa etc. (APEDA).

Most of the organic agricultural products currently exported from India are of plant origin except honey since the organic animal husbandry *per se* is yet to develop in India though animals are central to organic farming.

Animal welfare including stress free life to animals and prevention of cruelty against them, food hygiene and food safety, sanitary and phytosanitary (SPS) requirements, HACCP, ISO certification, OIE guidelines on animal welfare, CODEX standards etc are some of the issues which have become important in modern conventional systems of animal production. These food safety and quality enhancing mechanisms are further emphasized under the organic production management of livestock towards development of a human society that is not only more humane but also aware, educated and concerned about health, hygiene and welfare of the animals. The organic animal husbandry system has emerged only recently, which is still evolving. It is very sophisticated and knowledge intensive system of animal production requiring high level of knowledge and skills, directed to safeguard health and welfare of animals, human health and the environment on the whole.

18.2 ORGANIC FARMING: THE DEFINITION

Organic agriculture has been defined and explained in many ways but all converge to state that it is a system that relies on ecosystem management rather than external agricultural inputs. It is a system that begins to consider potential environmental and social impacts by eliminating the use of synthetic inputs, such as synthetic fertilizers and pesticides, veterinary drugs, genetically modified seeds and breeds, preservatives, additives and irradiation. These are replaced with site-specific management practices that maintain and increase long-term soil fertility and prevent pest and diseases (FAO, 2005). Moreover, organic farming denotes farming systems that adhere to the standards of organic farming. Organic agriculture including organic livestock production is gaining increasing attention globally, so it is important to develop better understanding of this emerging system of food production.

FAO/WHO Codex Alimentarius Commission defines organic farming as "a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems". This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants and people... [where] systems are based on specific and precise standards of production which aim at achieving optimal agro ecosystems which are socially, ecologically and economically sustainable.

According to Soil Association (UK), Organic farming is an agricultural system that encompasses: management practices which sustain soil health and fertility; the use of natural methods of pest, disease and weed control; high standards of animal welfare; low levels of environmental pollution; enhancement of the landscape, wildlife and wildlife habitat; and the prohibition of all genetically engineered food and products. Organic farming is an integrated system of farming based on ecological principles. It promotes biodiversity, biological cycles and soil biological activity. Organic farming uses environmentally friendly methods of crop and livestock production, without use of synthetic fertilizers, growth hormones, growth enhancing antibiotics, synthetic pesticides or gene manipulation.

The International Federation of Organic Agriculture Movements (IFOAM) has defined Organic agriculture as a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

'Organic' in organic agriculture is a labeling term that denotes products that have been produced in accordance with certain standards during food production, handling, processing and marketing stages, and certified by a duly constituted certification body or authority. The organic label is therefore a process claim rather than a product claim. It should not necessarily be interpreted to mean that the foods produced are healthier, safer or all natural. It simply means that the products follow the defined standard of production and handling, although surveys indicate that consumers consider the organic label as an indication of purity and careful handling. Organic standard will not exempt producers and processors from compliance with general regularity requirements such as food safety regulations, pesticide registrations, general food and nutrition labelling rules, etc. (FAO 2000).

18.3 ORGANIC ANIMAL HUSBANDRY

Organic animal husbandry has been defined as a system of livestock production that promotes the use of organic and biodegradable inputs from the ecosystem deliberately avoiding the use of synthetic inputs such as drugs, feed additives and genetically engineered breeding inputs, while ensuring the welfare of animals. There are four principles of organic farming viz; principle of ecology, principle of health, principle of fairness, and principle of care, which organic systems must always take into consideration. In order to achieve the animal welfare, environmental protection, resource-use sustainability and other objectives, certain key principles are adhered to under organic livestock production systems. According to the International Federation of Organic Agriculture Movements (IFOAM), the organic animal husbandry has multiple objectives, as given below:

i. To raise animals in a system that takes into consideration the wider issues of environmental pollution, human health on consumption of animal products allowing them to meet their basic behavioral needs and reduce stress.

ii. Diversify in keeping as many types of livestock on the holding as each furnishes different nutrients at the household level. Their nitrogen rich manure is used to increase vegetable production in the kitchen gardens, thus, improving the family diet. Other like donkeys are useful in transport, thus, reducing the consumption of non-renewable sources of energy e.g. petroleum based fossil fuels.

iii. Exploit the natural behavior of animals in their production systems to reduce stress e.g. chicken like perching at night and perching rails should be provided for this purpose. They should also be raised in deep litter system that allows them to scratch for ants and worms and dust bathe. Dark secluded nest should be provided as they like laying in dark secluded places. Goats being browsers in nature like having their forage suspended high enough so that they can attain an upright posture. Pigs have rooting tendency, for which water and mud facilitate their natural rooting behavior.

iv. Use of low external input which lessen the cost of production and allow for a sustainable system of production since most materials can be recycled in the farm and also locally available.

v. Bridging of nutrients gap in soil, crops and animals i.e. animals feed on crops and cultivated crops' by-products. The animals' waste in the form of farmyard manure is composted and taken back to the soil to replenish the lost soil nutrients through cultivation. This ensures the completion of nutrient cycle in the ecosystem.

In order to achieve the animal welfare, environmental protection, resource-use sustainability and other objectives, certain key principles are adhered to under organic livestock production systems, which include:

- *management of livestock as land-based systems so that stock numbers are related to the carrying capacity of the land and not inflated by reliance on 'purchased' hectares from outside the farm system, thus, avoiding the potential for nutrient concentration, excess manure production and pollution. As such, landless animal husbandry prevalent in India is not ideally suitable for organic livestock farming; unless, the landless livestock keepers go for land leasing.*

- *reliance on on-farm- or locally-derived renewable resources, such as biologically-fixed atmospheric nitrogen and home-grown livestock feeds, thereby reducing the need for non-renewable resources as direct inputs or for transport;*

- *reliance on feed sources produced organically, which are suited to the animal's evolutionary adaptations (including restrictions on* *use of animal proteins) and which minimize competition for food suitable for human consumption;*

- *maintenance of health through preventive management and good husbandry in preference to preventive treatment, thereby reducing the potential for the development of resistance to therapeutic medicines as well as contamination of workers, food products and the environment;*
- *use of housing systems which allow natural behaviour patterns to be followed and which give high priority to animal welfare considerations, with the emphasis on free-range systems for poultry;*
- *use of breeds and rearing systems suited to the production systems employed, in terms of disease resistance, productivity, hardiness, and suitability for ranging.*

18.4 ORGANIC ANIMAL HUSBANDRY: THE KEY CONSIDERATIONS

The major challenge in organic livestock production systems is to honour the organic principles in a wide range of diverse systems under a wide range of circumstances and conditions including systems which are not yet certified 'organic' at the moment. It's recommended that developing organic animal husbandry at all times require a thorough analysis of the problems, opportunities and existing local knowledge. There are four principles of organic agriculture *viz.* Principle of ecology, principle of health, principle of fairness, and principle of care, which organic systems must always take into consideration. Therefore, some key considerations in organic animal husbandry that producers and other stakeholders need to take into account are listed here under:

18.4.1 Origin of Livestock

Livestock and products from the livestock that are sold, labeled, or advertised as organic must be from livestock that originate from animals that were managed under continuous organic management from the last third of gestation or at hatching.

18.4.2 Livestock Feed

Livestock that are produced under organic management must have their total ration that is comprised of agricultural products including pasture, forage, and crops that are organically produced and handled organically. There are certain non-synthetic and synthetic substances that can be used as feed additives and supplements. Dairy cattle under 9 months of age are allowed 20 per cent of their feed coming from non-organic sources. Plastic pellets, urea, manure, mammalian or poultry slaughter by-products are not allowed. The list of allowed and non allowed feeding material is available as annexures with the organic livestock and poultry standards developed among others by Government of India.

18.4.3 Living Conditions

An organic livestock producer must create and maintain living conditions that accommodate natural behavior and health of the animal. The living conditions must include access to outdoors, shade, shelter, fresh air, direct sunlight suitable to the species, and access to pasture for ruminants.

18.4.4 Waste Management

Organic livestock producers are mandated to manage manure so that it does not contribute to the contamination of crops, soil, or water and optimizes recycling of nutrients.

18.4.5 Health Care

Organic livestock production practices require the producer to establish preventative health care practices. The health care practices include selecting the appropriate species and type of livestock, providing adequate feed, create an appropriate environment that minimizes stress, disease, parasites, administration of vaccines and veterinary biologics and animal husbandry practices to promote animal wellbeing in a manner that minimizes pain and stress. Producers can not provide preventative antibiotics. Producers are encouraged to treat animals with appropriate treatment, including antibiotics and other conventional medicines when needed but treated animals can not be sold or labeled as organic. Producers can not administer hormones or other drugs for growth promotion.

18.4.6 Record Keeping/Audit Trail

Organic livestock operations need to maintain records for a number of reasons. Apart from financial management of the organic livestock enterprise, records are important for the verification of organic status of animals, production, harvesting, and handling practices associated with the organic products and animals. Records are mandated to be maintained for 5 years, and must demonstrate compliance with the organic food production standards and acts, if any in place.

18.5 ORGANIC VS TRADITIONAL LIVESTOCK PRODUCTION SYSTEMS

Farmers in resource-constrained countries traditionally use few external inputs, such as allopathic medicines and antibiotics, and follow grazing-based extensive or semi-intensive production systems. In many ways, they are thus, closer to organic farming systems, though largely by default. Organic production systems, unlike traditional systems of production, are governed by a set of standards to be followed strictly by the producers of organic food. Compliance with these standards is verified by certification agencies authorized by the respective governments. A farm may be classified as organic, if it meets the criteria stipulated in a set of guidelines known as organic standards. The quality of production under organic management is ensured through certification procedures using internationally acceptable standards for organic production. Organic certification guarantees not only the quality of the product but also the quality of production. In case of conventional products, there is no way to guarantee the production procedure, but, in organic farming, production procedure is certified to be safe and sound as well as environment friendly. The traditional farming practices including animal husbandry practiced in India may be very close to the organic farming not by the conscious choice of the farmers but by default yet the products from such production systems may not qualify to be considered as 'organic', for the want of adherence to the basic standards. Nevertheless, such traditional production systems with low to negligible use of chemical inputs are ideal for conversion to organic farming in comparison to the input intensive conventional production systems. This is where lies the opportunity for India to benefit from its traditional production systems which are not yet much contaminated with the chemical fertilizers, pesticides, antibiotics and other hazardous chemicals.

Animal health and well-being through better living conditions, improved welfare measures and good feeding practices are ensured through a set of standards and the maintenance of written records by organic livestock farmers. Better management practices and prevention of illness are emphasized over treatment. Thus, the primary characteristics of organic livestock production systems are: well-defined standards and practices which can be verified, greater attention to animal welfare, no routine use of growth promoters, animal offal, prophylactic antibiotics or any other additives, at least 80% of the animal feed grown according to organic standards, without the use of chemical fertilisers or pesticides on crops or grass.

Under organic livestock production systems, it is expected that- organic milk, meat, poultry, eggs and products thereof come from farms that have been inspected to verify that they meet rigorous standards which mandate the use of organic feed, prohibit the use of antibiotics, give animals access to outdoor, fresh air and sunlight. The production methods are selected based on criteria that meet all health regulations, work in harmony with the environment, build biological diversity and foster healthy soil and growing conditions. After the production, animals are marketed that were raised without use of toxic persistent pesticides, antibiotics and paraciticides. Animal health, well being, better living conditions, welfare measures, feeding practices are to be ensured through a set of standards and maintenance of written records by the organic livestock farmers. Better managemental practices and prevention are emphasized over treatment. Thus, the primary characteristics of organic livestock production system are: a defined standard; greater attention to animal welfare; no routine use of growth promoters, animal offal or any other additives; at least 80% of feed grown according to organic standards, without the use of artificial fertilizers or pesticides on the crops or grass. To be precise, organic meat, milk and eggs means that are produced, harvested, preserved and processed as per organic standards. Anyone wishing to switch over or convert to organic farming need to follow the organic standards developed among others by Government of India under National Programme for Organic Production (NPOP). These standards have also been presented towards the end of this unit.

(http://www.apeda.gov.in/apedawebsite/organicORGANIC_CONTENTS/National_Programme_for_Organic_Production.htm

Organic production systems are knowledge and skill intensive, where the producers are expected to be knowledgeable about production norms, standards and practices for production and processing prescribed under approved standards by the designated authorities viz APEDA, BIS, FSSAI etc. It is expected from the organic producers that they are not only familiar with organic livestock standards, but also well versed in good agricultural/ livestock production practices, animal welfare standards, regulatory requirements as applicable to livestock and food production in general. At one end, there is traditional animal husbandry, while conventional production system in between and the most innovative one i.e. organic animal husbandry is the latest system. The farmers wishing to switch from traditional and conventional animal production systems to organic animal husbandry need information, knowledge and skills to follow organic livestock and poultry standards, where there exists currently a big gap. Field level extension functionaries need to have wider awareness and knowledge about organic animal husbandry standards for onward dissemination of information and orientation of the stakeholders involved in livestock production.

18.6 ORGANIC FOOD PRODUCTS & CONSUMERS

The organic agricultural products including of livestock origin are gaining increasing popularity. The farmers can cash upon this growing interest in eco-friendly, animal welfare oriented, safe, nutritious and tastier meat products (as perceived by consumers of organic products). The eggs and meat obtained from such venture can be promoted as specialty item to restaurants; hotels and ethnic food jaunts fetching higher returns, better when local/*deshi* birds are raised, which can better perform in free range system. Poultry can utilize the grazing lands/plantation areas (Rubber, coffee, coconut etc) by feeding on earth worms, small insects, green grass etc, while fertilizing the land with manure.

The free range poultry systems or pastured poultry is a sustainable agriculture technique that calls for the raising of laying chickens, broilers and turkeys on pasture, as opposed to indoor confinement. Humane treatment, the perceived health benefits of pastured poultry, in addition to superior texture and flavor, are causing an increase in demand for such products, which are believed to be having medicinal value, rich in antioxidants and least in chemical, medicinal or hormonal residues. Therefore, the growing interest in organic farming and meat & eggs drawn from free range systems might offer an attractive option in the form of market premiums for livestock farmers to venture into organic production.

The growing consumer interest in good quality food products in India signals the need for developing domestic market for local consumption of organic foods. With rising literacy, income and awareness on food quality generated by the mass media like print, radio & TV, people are increasingly becoming quality conscious. Also, they are increasingly showing their willingness to pay for good quality products. For example, people readily pay extra money for unadulterated milk, which is not necessarily organic milk *per se.* This trend indicates that there is good potential for organic livestock products for local consumption. The enterprising farmers are now ready to experiment on new ideas on production and marketing, wherein, organic livestock products like milk, meat, poultry & fish ideally fit. Just like marketing of FMCG and other industrial products market segmentation can be done by the farmers by supplying products to different categories of consumers with varying prices. The growing interest in eating out especially by visiting ethnic food jaunts, looking out for something unique, local and something which is natural and healthy while being environmentally safe offers hope for the production and supply of organic livestock products for domestic consumers. The domestic market development is the key for the development of organic animal husbandry and poultry farming in India. The growing market for organic cereals, vegetables, fruits, spices, pulses in Indian metros can be successfully extended to organic livestock and poultry products too.

Educating consumer and producer both is important to promote organic livestock production. Consumers need to be told that the safe milk and meat that they are looking for is the certified organic milk and meat, while farmers need to be made aware of this demand to be able for them to translate it into the new market opportunity. Also, there is a small but very concerned section of the society who does not consume livestock products owing to issues of animal cruelty, ill-treatment with them etc. The organic rearing of the farm animals sincerely addresses these issues and the certifiers approve that the due care has been taken in the process of production. These standards ensure that animals are kept free or never tied without specific purpose, allowed to express their physiological behaviour, fed with chemical free fodder, are not given hormonal injections and are reared in a completely stress free atmosphere. The information gap with respect to organic animal husbandry at the level of produces and consumers need to be bridged by suitable extension education interventions and encouraging the farmers, milk brands, cooperatives to enter this market on one side and consumers at the other end.

18.7 STRENGTH, WEAKNESS, OPPORTUNITIES AND CHALLENGES (SWOC) OF ORGANIC ANIMAL

18.7.1 Husbandry in India

Considering it an emerging and evolving system of livestock production, we have to analyse strength, weakness, opportunities and challenges, pertaining to organic livestock production in India, so as to understand its relevance for Indian farmers, consumers and economy on the whole.

18.7.2 Strengths

Integrated crop-livestock farming system predominant in India with well diversified livestock population in terms of species and breeds is ideal for organic livestock production. Besides, limited external input use including for animal production and maximum on- farm reliance brings it further closer to organic systems. The livestock production being largely extensive or semi-intensive, animal welfare too is not much compromised compared to factory type of animal production common in Western developed nations. The Indigenous Technical Knowledge (ITK) and *ayurvedic* medicines for health care are effective substitute for allopathic medicines, giving India an edge over western countries in the matters of organic livestock production.

18.7.3 Weaknesses

18.7.3.1 Feed and fodder

The inadequate supply of required organic feed and fodder may be a limiting factor while promoting organic livestock farming, since under organic livestock systems, animals are expected to be fed species specific organic diet in sufficient quantities. Besides, the feed and fodder requirement has to be met on farm or locally and it has to be grown following organic crop production methods. The fodder cultivation area in India has remained more or less static for many years and it is concentrated mostly in irrigated areas or so called green revolution belt of the country. Looking at the deficit in green & dry fodder in country, massive efforts are needed to ensure feed and fodder to livestock in required quantity, while considering organic animal husbandry.

18.7.3.2 Sanitary conditions

Prevention of diseases is paramount in organic systems, so that the medicine interventions like antibiotics etc are minimized to the extent possible. To minimize diseases, sanitation is important, for which the efforts are needed on massive scale to improve hygiene and sanitary conditions especially at production, processing and packaging stages. Looking at the prevailing conditions at production sites, processing units dealing with, India needs to do a lot so as to be eligible for organic livestock producing country.

18.7.3.3 Existence of diseases

Among others, the prevalence of Foot & Mouth Disease (FMD) in various parts of India is one limiting factor for export of livestock products, so its control is number one priority for India. The Disease Free Zones (DFZs) may be created, where; organic livestock production may be encouraged.

18.7.3.4 Traceability

Unlike in Western countries, milk and meat is sourced from numerous small farmers in India making the traceability a difficult option. Nevertheless, appreciably, Indian government has introduced a web-enabled application-Tracenet system for organic products being exported from India. Considering the logistic problems, small farms, farmers' educational levels, how far traceability mechanism will be feasible makes it a bit skeptical in case of animal products.

18.7.3.5 Small Farms

In India, livestock production is mainstay of landless and small scale farmers. However, the landless animal husbandry is not allowed under the organic systems, unless they go for land leasing to raise livestock. Contract farming may be a potential solution where many small farmers may contract out their farms to companies, which may produce organic food products on consolidated holdings with required expertise and resources. The stocking density is one significant issue by which the number of animals of given species is to be decided to be maintained in available land. The outdoor stocking density of livestock kept on pasture, grassland, or other natural or semi-natural habitats, must be low enough to prevent degradation of the soil and over-grazing of vegetation. Moreover, minimum Surface Area Indoors & Outdoors and other characteristics of housing in different species and types of production are prescribed in the standards to be followed strictly by the organic livestock producers.

18.7.3.6 Lack of knowledge, training and certification facilities

Easily accessible information in local languages, locally available training and certification facilities at an affordable cost to small farmers is not available in many parts of the country, restricting Indian farmers to switch over to organic production especially when there is weak domestic market and current poor prospects for exports in case of livestock products.

18.7.4 Opportunities

Market for organically produced foods including of animal origin is on the increase world-over. The demand for organic products has created new export opportunities for the developing countries. Also, the domestic consumers are now increasingly looking for better quality in food products. The 'organic' is more or less a symbol of purity and quality of food products now, especially when it is certified by the recognized certification agencies. It is expensive for intensive livestock producers to convert to organic production, but converting extensive, pasture-based systems could become economically more attractive, if price premiums could be captured for organic meat and livestock products (Scialabba & Hattam 2002).

India exports certified organic honey, which may be extended initially to small ruminants, for organic textile/garments including the materials like hides, leather and wool. The Indigenous Technical Knowledge (ITK) of farmers may provide effective option for veterinary care through proper validation, as also the negligible use of agro-chemicals especially in drylands and hilly regions, makes favourable environment for organic livestock production. Grass based extensive production systems prevalent in parts of India have good potential for conversion into organic animal husbandry. Moreover, Indian livestock breeds being less susceptible to diseases and stress, need less allopathic medicines/antibiotics. With rising literacy and the consumers‘ awareness and concern about animal welfare issues and health foods, domestic consumption of organic foods including of animal origin is likely to get a boost.

The organic agricultural products including of livestock origin are gaining increasing popularity. The farmers can cash upon this growing interest in eco-friendly, animal welfare oriented, safe, nutritious and tastier meat products (as perceived by consumers of organic products). The eggs and meat obtained from such venture can be promoted as specialty item to restaurants; hotels and ethnic food jaunts fetching higher returns, better when local/*deshi* birds are raised, which can better perform in free range system. Poultry can utilize the grazing lands/plantation areas (Rubber, coffee, coconut etc) by feeding on earth worms, small insects, green grass etc, while fertilizing the land with manure. The per animal health cost is usually very low in organic livestock farming as preventive methods are emphasized over expensive treatment and antibiotics and other routine prophylactic measures are reduced to minimum. Good quality milk including organic milk needs to incentivized by offering premium price to the clean milk producers.

18.7.5 Challenges

It is projected that by 2050, the global demand for animal food products can be met only by raising twice as many poultry, 78% more small ruminants, 58% more cattle and 37% more pigs, without further damaging natural resources (Rivera and Lopez, 2012). Hence, sustainable development based on balance of ecology, economics, norms and values are to be considered at various levels of the scale: between food and farming systems, regions, nations and continents (Zipp, 2003). This is where the real challenge lies: producing more food of good quality without further damaging or stressing the environment. For instance, FAO report “Livestock’s Long Shadow” concluded that directly and indirectly, 18 % of the global Greenhouse Gas (GHG) emissions could be linked to animal-based production (FAO, 2006). Not only GHG but also there are several factors which are making intensive livestock production questionable from sustainability standpoints. To deal with this complex issue of livestock in relation to sustainability *vis- a- vis* climate change and food security issues, some of the options are being studied & tried at different levels to reorient the existing farming systems as per the principles & practices of Conservation Agriculture, Climate-smart Agriculture, Sustainable Agriculture, Precision Livestock Farming & Organic Livestock Farming. It is in this context that importance of promoting organic dairying needs to be seen (Chander 2001 & Chander & Subrahmanyeswari, 2007).

To develop organic livestock production in India, it is important to understand the principles, methods, practices, and standards applicable to organic farming. The situation analysis for organic livestock farming possibilities in India and constraints are presented hereunder:

Organic animal husbandry is land-based activity, but livestock rearing also is the mainstay of many landless livestock keepers in India which are not eligible for organic livestock production as per the organic standards. So a good number of livestock keepers are not eligible for organic livestock farming in India. If focus is shifted from large number of dairy cattle to good quality milch animals, it would help improve animal feeding also since the availability of green & dry fodder is inadequate for the existing numbers of livestock.

Organic livestock production demands controlled disease environment, at least free from infectious diseases like foot & mouth disease (FMD), which restricts trade. The reduced opportunity for export discourages livestock producers to go organic. Disease-free zones need to be developed with a goal to control and finally eradicate the disease from the country. Small farmers find it difficult to comply with traceability requirements which are strictly adhered under organic production management systems. The farmer -friendly cheaper traceability systems need to be developed so that small scale farmers too can participate in organic dairying. Sanitary conditions at dairy production sites, slaughter houses and processing units need improvement. The demand for organic milk *per se* is very little currently but consumers are ready to pay premium prices for good quality hygienic milk. The duly certified organic dairy farmers can give assurance to consumers that their milk is of highest quality standards. With the rising quality consciousness among the consumers alongside their willingness to pay for good quality milk, the domestic market for such high quality organic milk and its products need to be developed.

Grazing land is shrinking due to reducing community land and also change in land-use pattern. Organic animal husbandry needs assured grazing opportunity to ruminants at least for 4hrs per day. Natural sources of essential amino acids (Methionin, for instance) are not available good enough to meet the requirements of livestock. The documentation on natural sources of amino acids is required to replace synthetic source of amino acid supply. Green fodder supply is insufficient to meet the requirement of the livestock. Animals survive in India on poor quality roughages. Whereas, in organic livestock farming, livestock need to be fed high quality organically grown fodder as per the requirement of the animal. Animal housing conditions need improvement for optimal productivity, disease prevention and to minimize risk of zoonotic diseases. Research and Development (R&D) investment in the area of organic animal husbandry needs to be augmented to make organic livestock farming a sustainable option. Manure handling in animal production is an important issue, especially processing of the biogas slurry. The biogas produces energy and at the same time reduces methane emissions, which result from inadequate handling of animal manure. The Biogas units need to be popularized in conjunction with efficient manure handling practices.

India has natural advantages in switching over to organic animal husbandry for domestic as well as export markets. The traditional animal husbandry practices followed by majority of farmers, Indigenous Technical Knowledge possessed by them, indigenous cattle breeds being hardy and tolerant to many diseases, limited or no antibiotic use, limited chemical fertilizers application, less dependence on market for inputs, etc. make India an ideally suited country for organic livestock farming. However, to move further on organic livestock farming, India has to work towards overcoming the limitations too. The high stocking density, feed and fodder scarcity, poor sanitation, prevalence of infectious disease like FMD and near absence of traceability systems affordable to small-scale farmers are some of the limitations to be overcome.

Indian National Standards for Organic Livestock, Poultry and Products developed under National Programme for Organic Production (NPOP)

(http://www.apeda.gov.in/apedawebsite/organic/index.htm)

18.8 ORGANIC LIVESTOCK, POULTRY & PRODUCTS

18.8.1 Scope

Livestock standards prescribed under these rules refer to any domestic and domesticated animal including bovine (including buffalo, Mithun and Yak), ovine, porcine, caprine, rabbits, poultry, insects and bees and/ or any other animal notified by the FSSAI from time to time, raised for food/fibre or in the production of food and fibre, their derivatives and by-products.

The products of hunting or fishing or wild animals shall not be considered part of livestock standards.

18.8.2 General principles

Organic livestock production in general is a land based activity and shall be an integral part of organic farm unit and management of livestock shall be in consistent with the principles of organic farming and shall base on:

a. Natural breeding

b. Protection of animal health and welfare

c. Fed with organic feed and fodder

d. Access to grazing in organic fields

e. Freedom to express natural behaviour

f. Reduction of stress and

g. Prohibition of use of chemically synthesized allopathic veterinary drugs, antibiotics, hormones, growth boosters, feed additives etc.

Landless livestock production where the operator does not have organically managed land and/ or has not established a written cooperation agreement with another certified organic operator in compliance of the rules specified in Appendix 1 of these rules is prohibited.

In cases where traditional rearing system of the farm and/ or adverse climatic conditions does not allow easy access to pastures, livestock may be produced through providing organic feed certified under these rules, provided the indoor and outdoor space requirements, specified under these rules are fully met.

18.8.3 Organic Management Plan

During the registration of the farm by the accredited Certification Body, the producer has to present an organic management plan which requires to be verified during the inspection. This plan shall be updated annually.

18.8.4 Choice of Breeds

The choice of livestock and poultry, breeds, strains and breeding methods shall be consistent with the principles of organic farming, taking into account, in particular, the following:

- their adaptation to the local climatic conditions;

- their vitality and resistance to diseases

18.8.4.1 Sources/ Origin

i. Animals must have been born or hatched from production units complying with these guidelines, or must be the offspring of parents raised under the conditions set down in these guidelines.

ii. Transfer of livestock and poultry between organic and non-organic units shall not be permitted. The accredited Certification Body shall ensure that brought in livestock and poultry from other units comply with these Guidelines.

iii. Livestock and poultry raised on non-organic production units shall be converted into organic unit as per these Guidelines.

iv. When a producer demonstrates to the satisfaction of the accredited Certification Body that the organic source livestock are not available, the accredited Certification Body may allow such livestock and poultry under the following circumstances:

- When the producer is establishing an organic livestock and poultry operation for the first time;
- When the producer wants to change the livestock and poultry breed/ strain or when new livestock and poultry specialization is developed;
- For the renewal of a herd, e.g., due to high mortality of animals caused by catastrophic circumstances;
- When the producer wishes to introduce breeding males into the farm. In all such cases product of such males shall qualify for organic only after completion of conversion period specified under clause 8 of these standards

18.8.5 Livestock Identification and Animal Record Keeping

18.8.5.1 Livestock identification

(a) Each animal/ herd/ batch shall bear unique identification number. Large animals including bovine, ovine, carpine, porcine etc shall bear individual number in the form of tag, while poultry birds and small mammals shall be identified with herd/ flock/ batch.

(b) Identification devices on the animals can be printed ear tags, RFID tags, Barcodes or any other suitable tag which is clearly visible.

18.8.5.2 Record keeping

Following data for each animal/ herd or batch shall be maintained and made available to the accredited certification body for verification during inspection:

i. Parent details

ii. Source and purchase details

iii. Animal details

iv. Breeding details

v. Feeding details

vi. Health care details including details of vaccination, medication, veterinarian prescription and withdrawal period etc.

vii. Production details

viii. Sale details

ix. Any other relevant details

18.8.6 Housing and Management

i. The housing and day-to-day management of the animal, maintenance of sanitation, hygiene and environment shall be planned to suit the specific behavioral needs of the livestock and poultry and shall provide for sufficient space to ensure free movement and opportunity to express normal patterns of behaviour;

ii. The animals should not be tied, however animals can be confined for specific reasons, such as, milking, for some medical procedures, controlled grazing, during night time and for health and safety of animal;

iii. Where the livestock and poultry normal behavior demands group living, animals shall not be kept in isolation, but shall have company of like kind; v

iv. As far as possible two different kinds of animals shall not be kept together, unless for specific purposes, such as, free range poultry birds in cow/buffalo shed for scavenging on ticks and other insects

v. The housing system shall ensure prevention of abnormal behaviour, injury and disease;

vi. Appropriate facilities to cover emergencies such as the fire, the breakdown of essential mechanical services and the disruption of supplies shall be available.

vii. Housing for Livestock and Poultry shall not be mandatory in areas where appropriate climatic conditions exist to enable animals to live outdoors without compromising their comfort, health and welfare. Conditions shall be inspected and permitted by the accredited Certification Body on producer and location- to- location basis. Outdoor open areas may be partially covered

viii. Housing conditions shall meet the biological and behavioural needs of the livestock and poultry by providing easy access to feeding and watering;

ix. Insulation, heating, cooling and ventilation of the building to ensure that air circulation, dust level, temperature, relative air humidity and gas concentrations are kept within limits which are not harmful to the livestock and poultry;

x. Plentiful natural ventilation and light to enter;

xi. Appropriate fencing not harmful to the animals

xii. Confinement shall be permitted under the following conditions:

xiii. Inclement weather to protect animals from injury;

xiv. Ensure health safety or welfare;

xv. Protect plant, soil and water quality;

xvi. Minimum requirement of surface area for indoor housing and for outdoor run and pens is given in Annex 1.

The outdoor stocking density of livestock kept on pasture, grassland, or other natural or semi-natural habitats, must be low enough to prevent degradation of the soil and over-grazing of vegetation.

18.8.7 Special conditions for Mammals

i. All mammals shall have access to open-air exercise or resting area, paddock, pen or run which may be partially covered or shall have space for protection from rains and hot sun.

ii. The accredited Certification Body shall grant exceptions for the access of males or bulls to open areas to avoid mixing with female animals for controlled breeding.

iii. Other animals may also not have access to open-air exercise area or run during the heavy rain period, harsh winter/ summer or the final fattening phase.

iv. Livestock shed shall have properly laid and smooth floor, although not slippery. The floor shall not be entirely of slatted or grid construction

v. The housing conditions shall aim at providing comfortable, clean and dry laying/rest area of sufficient size, consisting of a solid construction. Wherever possible, straw bedding shall be provided.

vi. The calves may be housed separately and never in the adult animal shed.

vii. Pigs must be kept in groups, except in the last stages of pregnancy and during the suckling period. Piglets may not be kept on flat decks or in piglet cages. Exercise areas must permit dunging and rooting by the animal. Breeding boars may be kept separately

18.8.8 Special conditions for Poultry

i. Housing of poultry in cages shall not be permitted.

ii. Water fowl/duck shall have access to a stream, pond or lake whenever the weather conditions permit.

iii. Poultry house floor shall be of solid construction covered with litter material such as straw, wood shavings, sand or turf. In case of layers, the floor area must be large enough to permit dropping collection. Perches/ higher sleeping areas of a size and number commensurate with the species and size of the group and of the birds and exit/entry holes of an adequate size must be provided.

iv. In the case of laying hens, manipulation of day length may be permitted through the use of artificial lights.

v. Poultry shall have access to open area as specified in Annex 1 and shall have freedom to move freely between indoor and outdoor area;

vi. Open air areas for poultry shall be mainly covered with vegetation and be provided with protective facilities and permit birds to have easy access to adequate numbers of drinking and feeding troughs.

vii. Where poultry are kept indoors due to restrictions or obligations imposed on the basis of provincial legislation they shall permanently have access to sufficient quantities of roughage and suitable material in order to meet their ethological needs.

viii. Multi-level aviary systems for layers shall have no more than three levels or tiers above ground level. Total floor space shall meet minimum indoor and outdoor surface area requirements specified in Annexure I. In all such cases access to the open air run, needs to be ensured under all-in and all-out system to avoid the mixing of birds among flocks.

ix. Buildings shall be emptied, cleaned and disinfected, between flocks, and runs shall be left empty to allow the vegetation to grow back.

18.8.9 Special conditions for Silkworms

Silkworm rearing is done under both open and domesticated conditions. Under open situations worms are reared on host plants either in wild or under cultivated conditions. In both cases the host plants shall be certified under wild harvest collection or under crop production as specified under Appendix 1 of these rules.

Under domestic rearing situations housing shall be clean, ventilated with adequate space for movement between rearing trays. Multilayer rearing system can also be adopted provided adequate space is kept between trays and arrangements are made to ensure that trays do not get contaminated with falling excreta of worms in above layers.

Accredited certification agencies shall define the adequate housing and rearing conditions keeping in view of the local practices used and conditions required according to the species used.

18.8.10 Special conditions for Rabbits

i. If required for comfort and safety, rabbits may be temporarily confined, for example overnight, in cages or hutches. Continuous confinement is prohibited.

ii. Rabbits shall have space to run, hop and dig, and to sit upright on their back legs with ears erect. The minimum indoor and outdoor space requirements are shown in Annex 1.

iii. The keeping of rabbits in cages shall not be permitted

18.8.11 Conversion Period for Animal Production

Simultaneous conversion of livestock and poultry and land used for raising feed/fodder within the same unit should be a preferred approach. When a livestock production unit, with entire herd, or flock of sheep/ goat or batch of poultry birds or small mammals such as rabbits, is in transition to organic production, pasture and feed produced on the land undergone a minimum period of 12 months of conversion period may be considered organic for feeding to organic livestock.

In case of silkworm rearing, there is no requirement for conversion period provided the larva are fed with organic feed grown in compliance of these rules for a minimum period of 12 months for their entire lifespan period. The conversion period shall be determined by the accredited Certification Body and the conversion period shall be accounted from the date of first inspection. In cases, where the land and livestock and poultry conversion to organic status is not simultaneous and the land alone has reached organic status and the livestock and poultry from a non-organic source is introduced, these must be reared according to these guidelines for at least the following compliance periods before their products are sold as organic:

18.8.11.1 Bovine including buffalo

i. Meat products: Twelve (12) months and at least 3/4th of their life span is spent in the organic management system

ii. Calves for meat production: Six (6) months when brought in as soon as they are weaned and less than six (6) months old

iii. Milk products: Six (6) months

18.8.11.2 Ovine and caprine (Sheep & Goat)

i. Meat products: Six (6) months;

ii. Milk products: Six (6) months

18.8.11.3 Pig

i. Meat products: Six (6) months.

18.8.11.4 Small mammals (such as Rabbits)

i. Meat products: From the second week after their birth to the entire life span as determined by the accredited Certification Body

18.8.11.5 Poultry

i. Meat products: from the second day to the entire life span as determined by the accredited Certification Body

ii. Eggs : Six (6) weeks

18.8.12 Feed

Livestock and poultry farms shall provide maximum diet from feedstuffs (*including 'in conversion' feedstuff*) produced as organic as per the requirements of these guidelines. Agricultural processed residues of organic origin, such as from grain fermentation, fruit processing, vegetable processing, etc., shall be permitted for purpose of feeding, provided that the overall feeding practices satisfy the daily energy and nutrient requirements of the concerned animals.

The agriculture land committed to cultivation of feed / fodder crops intended to be used as feed for livestock and poultry shall be organically grown.

During the operations, the products shall maintain their organic status provided that livestock and poultry are fed with at least 85% for ruminants and 80% for non-ruminants calculated on a dry matter basis, feed obtained from organic sources that have been produced in compliance with these guidelines.

Accredited Certification Body can grant permission to allow a restricted percentage of feedstuffs not produced according to these guidelines to be fed for a limited time, provided that it does not contain genetically engineered/modified organisms or products thereof.

Specific livestock and poultry rations shall take into account:

i. the need of young animals for natural feed, such as, feeding of maternal milk, milk from other mammal or milk replacer of organic origin that has maximum similarity with maternal milk, provided that it does not contain any genetically modified ingredient, antibiotics, hormone, etc.

ii. that in herbivores, substantial proportion of the dry matter and energy in the daily rations should consist of roughage, fresh or dried fodder, or silage; need for inclusion of cereals in the fattening phase of poultry and livestock and poultry must have ample, free access to water appropriate to maintain full health and productivity.

iii. Due to reasons of animal welfare, health and productivity, if supplements are to be added, it shall be permitted on advice of a qualified veterinarian. The permitted list of such supplements, feed materials (probiotics, and biologicals, immunolgicals and procuring aids etc.) and processing aids that comply the following criteria are listed in the APEDA document on Organic Standards.

18.8.13 General Criteria for feedstuff and nutritional components

Substances shall be permitted as per Annex 2. Such substances should significantly satisfy feeding requirements of the livestock and poultry fulfilling the physiological, behavioral and welfare needs of the concerned species; and such substances should not contain genetically engineered/ modified organisms and products thereof; and are non-synthetic and are primarily of plant, mineral or animal origin.

18.8.14 Specific Criteria for Feedstuffs and Nutritional Elements

i. The feedstuffs should not be prepared by using chemical solvents and chemical treatment. All the ingredients of the feed including supplements, fed to organic animals should be from organic sources.

ii. Feedstuffs of animal origin, with the exception of milk and milk products, fish, other marine animals and products derived thereof shall not be used. The feeding of mammalian material to ruminants is not permitted with the exception of milk and milk products;

iii. Synthetic nitrogen or non-protein nitrogen compounds shall not be used.

18.8.15 Specific Criteria for Additives and Processing Aids

i. The supplements should be derived from natural sources

ii. Feed processing aid supplements like binders, anti-caking agents, emulsifiers, stabilizers, thickeners, surfactants, coagulants if used should be from natural sources

iii. Antioxidants: only from natural sources shall be permitted

iv. Preservatives: only natural acids are allowed;

v. Colouring agents (including pigments), flavors, odor masking agents and appetite stimulants: only natural sources are allowed

vi. Probiotics, enzymes and microorganisms are allowed; but should not be from genetically modified sources.

vii. Any synthetic chemicals, such as, antibiotics, coccidiostat, medicine, growth promoters or any other substance supplemented for purpose to stimulate growth or production shall not be fed to the organic livestock & poultry.

viii. Silage additives, additives for enriching crop residues and processing aids may not be derived from genetically engineered/modified organisms or products thereof, and may be comprised of only: Sea salt; Coarse rock salt; Yeasts; Enzymes; Whey;

- Sugar; or sugar products such as molasses, jaggery, grain bran;
- Honey
- Lactic, acetic, formic and propionic bacteria, or their natural acid product when the weather conditions do not allow for adequate fermentation and their use to be approved by the accredited Certification Body.

18.8.16 Health Care

The organic livestock & poultry, in general, should follow the basic principles of preventive health and productivity management, wherein, the focus would be on preventing diseases, detecting underlying fertility and production problems and its correction primarily on correcting management, nutrition and sanitation.

i. The producer in consultation with veterinarian should draw a program of health management of animals and carry out testing of the herd as per the common diseases of herd/ flock. The health care shall be based on the following broad principles:

- the choice of appropriate breeds or strains of animals that can acclimatize, adapt to environment as per clause 4 of these standards;
- the setting up of the animal husbandry practices should be appropriate to the requirements of each species and should focus on encouraging strong resistance to disease and prevention of infections;
- the use of good quality organic feed, together with regular exercise and access to fodder/roughages, and/or open-air runs, so as to have positive effects on natural immunological defence of the animal;
- appropriate stocking density of livestock & poultry so as to avoid overcrowding and spread of infections or competition to feeding,

ii. The farm should have an established system of detection of sub-clinical, sick or injured animals and if, so detected, must be treated immediately. In cases where isolation is necessary it will be so carried out in suitable housing areas. The paramount interest in case of sickness would be animal welfare and mitigating pain and suffering, and hence the producer shall not withhold medication even if the use of such medication will cause the animal to lose its organic status,

iii. The use of veterinary medicinal products in organic farming shall comply with the following principles:

- All vaccinations required by law of the land shall be permitted. Where specific disease or health problems occur, or is predicted to occur, and there are no alternative permitted treatment or management practice exist, use of parasiticides, or therapeutic use of veterinary drugs are permitted under prescription and supervision of a registered veterinarian, provided that the mandatory withdrawal periods are observed. In drugs where withdrawal period is not prescribed in these guidelines, a minimum of 48 hours of withdrawal period shall be observed;

- For purpose of treatment and prevention of diseases and under-performances, herbal/phyto-therapeutic (excluding antibiotics), homeopathic or *ayurvedic* products shall be preferred to allopathic veterinary drugs or antibiotics, provided that their therapeutic effect is effective for the species of animal and the condition for which the treatment is intended;
- In case alternative therapeutic or preventive measures are unlikely to be effective in combating illness or injury, allopathic veterinary drugs or
- antibiotics may be used under the responsibility and supervision of a veterinarian,

iv. The use of allopathic veterinary drugs or antibiotics or drugs derived from genetically modified source for preventative treatments and for enhancing productivity or fertility is prohibited.

v. Hormonal treatment may only be used for therapeutic reasons and under veterinary supervision,

vi. Growth stimulants, agents or substances used for the purpose of stimulating growth or production shall not be permitted.

18.8.17 Breeding and Management

i. The major focus of livestock and poultry management shall be to provide care, comfort, and respect to the animals and ensure their welfare in the farming system,

ii. Livestock and poultry breeding methods shall be in accordance with and in compliance with the principles of organic farming and shall take into account:

- The breeds and strains most suited to local conditions;
- The preference for reproduction through natural methods, although artificial insemination may be used ;
- Embryo transfer techniques and the use of hormonal reproductive treatment shall not be used unless prescribed therapeutic directed towards correcting the physiological problem;
- That breeding techniques employing genetic engineering shall not be used.

iii. Mutilation, such as, tail docking, cutting of teeth, trimming of beaks and dehorning are not permitted. In exceptional cases, some of these may be authorized by the accredited Certification Body for reasons of safety (*e.g. dehorning in young animals, hoof trimming, cutting of pin teeth in pigs etc*) or if they are intended to improve the health and welfare of the livestock and poultry. Such surgical procedures shall be carried out by a registered veterinarian at the most appropriate age; and any suffering to and pain shall be reduced to a minimum. Wherever possible, anesthetic and analgesics shall be used. Physical castration is allowed only in order to maintain the quality of products and traditional production practices (*meat-type pigs, bullocks, capons, etc*).

18.8.18 Manure and Urine Excreta Management

i. The collection, handling and disposal of the dung and urine from shed, paddock, open run or grazing areas shall be implemented in a manner that:

- minimizes soil and water degradation;
- does not significantly contribute to contamination of water by nitrates, phosphates, and pathogenic bacteria;
- optimizes recycling of nutrients; and
- does not include burning or any practice inconsistent with organic practices,

ii. All manure storage and handling facilities, including composting facilities shall be designed, constructed and operated to prevent contamination of ground and/or surface water.

iii. Manure application rates shall be at levels that do not contribute to ground and/or surface water contamination. The accredited Certification Body shall establish maximum application rates for manure or stocking densities as per local conditions. The timing of application and application methods shall not increase the potential for run-off into ponds, rivers and streams.

18.8.19 Transport

i. During transport, the producer shall prevent stress, injury, hunger, thirst, malnutrition, fear, distress, physical & thermal discomfort, pain, disease during the transport and shall observe the protocols as prescribed under law of the land.

- All necessary arrangement be made in advance to minimize length of the journey and meet the animal's need during the journey;

- Animals must be fit for the intended journey;
- Means of transport as well as the loading and unloading facilities must be designed, constructed, maintained and operated so as to avoid injury and suffering and ensure the safety of the animals;
- Personnel that handle animals must be trained and competent as appropriate for this purpose and must carry out their tasks without using violence or any other method likely to cause unnecessary fear, injury or suffering;
- Transport must carry out without delay to the place of destination and the welfare conditions of the animals must be regularly checked and appropriately maintained;
- Sufficient floor area, height and other spacing requirements must be provided for the animals, appropriate to their size and intended journey; and
- Water, feed and rest must be offered to the animals at suitable intervals and should be appropriate in quality and quantity to their species, size and age.

ii. Efforts should be made to avoid or reduce following stress factors:-

- Stress due to gathering and handling
- Stress due to deprivation of, or changes in quantity or quality of food and water;
- Stress due to extremes of temperature or change in climatic conditions;
- Stress due to the groupings of animals strange to each other both within and between species
- Stress due to separation from others of the animals' own kind
- Stress due to unfamiliar surroundings, noises and sensations
- Stress due to overcrowding and isolations
- Stress due to fatigue
- Stress due to exposure to disease

iii. The use of electric stimulation or allopathic tranquilizers shall not be permitted during loading and unloading of animals.

18.8.20 Slaughter of Animals

i. The slaughter of livestock and poultry shall be undertaken in a manner, which minimizes stress and suffering, and shall be in accordance with the national rules framed for the purpose.

ii. Approved products for cleaning and disinfection of the buildings and installations.

iii. The slaughter, evisceration and packing of poultry should be conducted in such a manner as will result in hygienic processing, proper inspection and preservation for the production of clean and wholesome poultry and poultry products. Hygiene standards must comply the requirements laid down by the FSS Act with the exception that the chemicals not allowed under these rules shall be replaced with the substances allowed under these rules.

iv. Separate rooms should be provided for:

- Live poultry receiving and holding
- Washing and disinfection of coops.
- Slaughter and bleeding
- Feather removal
- Evisceration, chilling and packing
- Inedible products room

v. Water Supply: The quality of water should satisfy the requirements of potable water.

vi. Ventilation: Particular attention should be given to ventilation. Illumination should be sufficiently strong, properly situated and should not cause glare.

vii. Personnel hygiene: Personnel should wear special working clothes of washable material. Proper training shall be given regarding hygiene, frequent hand washing, disinfection etc.

viii. Activities such as stunning, bleeding, scalding, plucking, feet removal, evisceration and chilling, draining, grading etc. shall be done in accordance with national laws.

Market for organically produced foods including of animal origin is on the increase world-over. The demand for organic products has created new export opportunities for the developing countries. Also, the domestic consumers are now increasingly looking for better quality in food products. The 'organic' is more or less a symbol of purity and quality of food products now, especially when it is certified by the recognized certification agencies. In India, currently over 25 certification agencies are accredited by the APEDA for inspection and certification of the organic agricultural products. This means organic farming is receiving an increasing attention to meet the growing demand for such products. The Government of India has taken up organic farming as one of the priority area for attention since X plan onwards with substantial outlay. The ICAR has also recognized it as a system of agricultural production worth promotion in certain regions having potential for organic farming. Animals are central to organic farming, and in fact, organic farming can be sustainable only when livestock are maintained on the organic holdings. But very little work has so far been done in the area of organic animal husbandry in India. This fact makes it imperative that organic animal husbandry is paid due attention by the policy making bodies, research institutions, the SAUs and other development agencies involved with the R& D work on organic farming. The producers in India need to overcome the weaknesses and harness the strengths and opportunities, while developing their capacity in terms of knowledge, skills, infrastructure, animal feeding, hygiene, sanitation, disease control and assured certified supply chain required for organic livestock production. Large-scale commercial farms usually undertake most organic livestock production in industrialized countries; whereas, the small scale producers have limited resources and low risk bearing ability dominate Indian livestock sector. Nevertheless, they may cater to domestic consumers, if not exports initially. The emerging need of the quality conscious high end consumers in metros is required to be met by producing organic animal products locally. The local organic milk, meat and egg production may substitute import (if any)while generating employment, reducing foreign exchange demand, stimulating innovation, and making the country self-reliant in critical areas like food. Organic livestock production may be encouraged initially for domestic consumption, through research & development efforts including establishment of model organic livestock farms, processing units, traceability tools, and capacity building measures, besides consumer awareness on health foods. The SAUS/SVUs/Veterinary colleges, State Departments of Animal Husbandry/Livestock Development

Boards, the ICAR animal science institutes, Agricultural Technology Application Research Institutes (ATARI) including KVKs have to ensure that the researchers, academics, trainers and farmers are made aware of the organic production systems and standards developed and notified by the Government of India. Once awareness is created, information is made available to the farmers, it would then depend on them to make use of this new knowledge depending on the availability of remunerative markets for the organically produced food items of animal origin. The farming needs to be made profitable and if organic livestock production is profitable to farmers they would opt for it. We must provide them option should they like to switch over to organic looking at opportunity to earn profit from such farming, while it is already good for consumers to consume safe and high quality foods products.

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Chapter 19

ORGANIC FARMING IN TROPICAL TUBER CROPS: SCOPE, PROSPECTS AND PRACTICES

Suja G.

19.1 INTRODUCTION

India witnessed a remarkable growth in the agricultural front due to the technological revolution termed as "green revolution" (since mid 1960s) wherein high input farming practices using high yielding varieties combined with chemical fertilizers, pesticides, fungicides and herbicides as well as intensive irrigation could enhance the food grain production from 50.80 million tonnes during 1950 to 108 million tonnes during 1970-71 and 273 million tonnes during 2016-17. India rose from the level of begging bowl to the status of self sufficiency. However, the consequences of high input conventional agriculture, which envisages large chemical inputs and few carbon additions, on long term profitability and resource use, often referred to as post-green revolution problems or second generation problems were undesirable in certain locations: wide spread soil erosion, salinisation, decline in soil quality due to reduction in soil organic matter content, poor soil fertility, poor surface water quality, reduced water infiltration rates and unfavourable soil tilth all leading to ill health of soil, pesticide pollution, desertification, loss of biodiversity and adverse effects on human health. Besides, chemical based intensive agriculture resulted in prosperity of rich farmers especially in the irrigated tracts, neglecting the marginal and resource poor farmers in dry land areas and enhancing rural poverty.

Hence presently there is a growing interest to practice alternative agricultural systems that are less exploitative, less dependent on nonrenewable fossil fuels like fertilizers, pesticides etc., which can conserve the precious soil and water resources and protect the environment and human health. The National Organic Standards Boards (NOSB) defines Organic Agriculture as an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. Organic farming is therefore an alternate farming strategy that focuses on soil health, environmental protection and human health by largely excluding the use of synthetic chemicals and with minimum use of off-farm inputs. Though the use of chemical inputs cannot be altogether avoided, their use in agriculture needs to be reduced.

19.2 DEBATE: ORGANIC VS CONVENTIONAL AGRICULTURE

The simple question that is posed time and again when it comes to debating alternatives to current agriculture: Can organic agriculture feed the world? The right question to ask ourselves in order to nourish a more fruitful debate is then: Why does conventional agriculture fail to feed the world? (Titonell, 2013).

19.3 WHY DOES CONVENTIONAL AGRICULTURE FAIL TO FEED THE WORLD?

19.3.1 Unequal access to resources and diverging productivity worldwide

While world average yields of major food crops increased by a factor two in the last 50 years, the total amount of external N brought in through fertilisers increased seven times in the same period, the amount of P three times and the amount of water used for irrigation doubled (Foley *et al*., 2005).The most realistic estimates of food demand by 2050, considering changes in diets and population growth indicate that daily caloric requirements will increase from 19 to 33 PCal per day, worldwide. Or, a 70 per cent increase. Looking at the future, can we envisage replicating the green revolution as it happened in the past? (Titonell, 2013).

19.3.2 Energy crises

Since the onset of the green revolution, energy inputs in agriculture increased 50 times compared to traditional agriculture. Feeding an average person in the developed world costs about 1500 l of oil equivalents per year. More than 30 per cent of this energy is used in the manufacture of chemical fertilisers, 19 per cent for the operation of field machinery and 16 per cent for transport. Production of one kg of N contained in fertiliser requires the equivalent energy contained in 1.4 to 1.8 l of diesel fuel. In other words, producing food for 9 billion people with conventional agriculture will need close to 8 per cent of the total world oil reserve, which will exhaust our global oil reserves in about 12 years. On average, energy use by organic agriculture is about one third as compared to conventional agriculture due to higher efficiency in biological N fixation.

19.3.3 Hidden costs

Conventional agriculture incurs hidden costs by way of subsidies, costs in public health by the use of pesticides, cost of cleaning the ground water from excess nitrates associated with fertiliser use, costs incurred through biodiversity loss when pesticides are applied. If we take a systems perspective and internalise all the above-mentioned costs in the calculation of food prices, the price difference between conventional and organic food will narrow down, disappear or, in some cases, become more favourable for organic food.

19.3.4 Obesity outweighs hunger

The State of Food Insecurity report of 2012 estimated that of the 870 million people suffering from chronic undernourishment in 2010-2012 the vast majority of them (852 million) live in developing countries. Yet, for the first time in human history, obesity outweighs hunger. The current number of overweight people in the world is estimated at 1300 million (WHO Global InfoBase, 2012). About 65 per cent of the world population lives in countries where overweight and obesity kill more people that underweight. These trends reveal not just problems in the distribution of resources or inequity in access to food worldwide, but also the effect of current patterns of food consumption worldwide, notably the increasing intake of energy-dense foods that are high in fat, salt and sugars but low in vitamins, minerals and other micronutrients (WHO Global InfoBase, 2012).

19.3.5 Waste causes hunger

Due to poor practices in harvesting, storage and transportation, as well as market and consumer wastage, it is estimated that 30 to 50 per cent (or 1.2 – 2 billion tonnes) of all food produced never reaches the human stomach (Gustavsson *et al.*, 2011; IMECHE, 2013). Wastes may occur post harvesting, post processing and post consumption. In SE Asia, for example, postharvest losses of rice can range from 40 to 80 per cent.

19.3.6 Environmental externalities

The critical report commissioned by the top secretariat of the Consultative Group on International Agricultural Research (CGIAR) more than a decade ago (Maredia and Pingalli, 2001) provided quantitative estimates of the negative externalities of productivity-enhancing crop technologies in terms of loss of genetic diversity, salinity and water logging (45 million ha worldwide), changes in the level of water table, loss of soil fertility/erosion, water pollution, air pollution, food contamination, impacts on human and animal health and effects on pest population. The manufacture and use of N fertilizers represent 6 per cent of the country total anthropogenic emissions of greenhouse gases (GHG).

All these indicate that we need alternatives.

19.4 ORGANIC AGRICULTURE AS AN ALTERNATIVE

Presently world agriculture needs knowledge-intensive management systems to increase yields and access to food and incomes in the South, and knowledge-intensive design to reduce the dependence on external (fossil fuel) inputs in the North. The strategy should be intensify in the South, 'extensify' in the North, detoxify everywhere (Titonell, 2013). Organic farming creates opportunities for synergies between food production and ecosystem services. Most importantly, this can contribute to detoxify our food and environment.

19.5 ORGANIC AGRICULTURE, AN INNOVATIVE ADAPTATION TO CLIMATE CHANGE

Globally, organic agriculture could significantly reduce global agriculture emissions of green house gases: 20 per cent from avoided mineral fertilizer production and enhanced nutrient efficiency and 40-72 per cent from soil C sequestration (Scialabba, 2010). Organic agriculture reduces farmer's vulnerability by encouraging highly diverse farming systems, thus improving income diversity. Results show that organic agriculture has positive impacts on MDG goals 1, 7 and 8, focusing on income and food security (Setboonsarng, 2009).

19.6 CURRENT STATUS OF ORGANIC FARMING

19.6.1 World scenario

Organic agriculture is developing rapidly and statistical information is now available from 179 countries. As per the estimates in the year 2015, total area under organic farming is 50.9 M ha globally, including conversion areas, managed by more than 2.4 million producers, including smallholders. The countries with the highest numbers of producers are India, Ethiopia and Mexico. On a global level, the organic agricultural land area increased by 6.5 million hectares compared with 2014. The global sales of organic food and drink reached almost 81.6 billion US dollars in 2015. A growth rate of more than 10 per cent was recorded in the most advanced markets for organic products (FiBL and IFOAM, 2017).

The regions with the largest areas of organically managed agricultural land are Oceania (22.8 million hectares or 45 percent of the global organic farmland), Europe (12.7 million hectares or 25 percent of the global organic farmland) and Latin America (6.8 million hectares or 15 per cent). The countries with the most organic agricultural land are Australia (22.7 million hectares), Argentina (3.1 million hectares) and the United States (2.0 million hectares). The highest shares of organic agricultural land are in Liechtenstein (30.2 per cent) and Austria (21.3 per cent).

19.6.2 Indian scenario

The 10th Five-Year Plan encouraged the promotion of organic farming using organic wastes, integrated pest management (IPM) and integrated nutrient management (INM) practices (GoI, 2001) in India. The Government of India has also launched the National Programme for Organic Production (NPOP) in the year 2001. The NPOP standards for production and accreditation system have been recognized by the European Commission, Switzerland and the United States Department of Agriculture (USDA) as equivalent to their country standards. Currently, as per the available statistics, India's rank in terms of World's Organic Agricultural land was 15 as per 2013 data (Source FIBL & IFOAM Year Book 2015). The total area under organic certification is 5.71million hectare (2015-16). This includes 26 per cent cultivable area with 1.49 million hectare and rest 74 per cent (4.22 million hectare) forest and wild area for collection of minor forest produces. India produced around 1.35 million tonnes (2015-16) of certified organic products, which includes all varieties of food products namely sugarcane, oil seeds, cereals & millets, cotton, pulses, medicinal plants, tea, fruits, spices, dry fruits, vegetables, coffee etc. The production is not limited to the edible sector, but also produces organic cotton fiber, functional food products etc.

Among all the states, Madhya Pradesh has covered largest area under organic certification followed by Himachal Pradesh and Rajasthan. The total volume of export during 2015-16 was 263687 MT. The organic food export realization was around 298 million USD. Organic products are exported to European Union, US, Canada, Switzerland, Korea, Australia, New Zealand, South East Asian countries, Middle East, South Africa etc.

Oil seeds (50 per cent) lead among the products exported followed by Processed food products (25 per cent), cereals & millets (17 per cent), tea (2 per cent), pulses (2 per cent), spices (1 per cent), dry fruits (1 per cent) and others.

19.6.3 Kerala scenario

The organic farming policy has been launched by the Government of Kerala and the mission is to convert Kerala into an organic state within 5-10 years. This is to be achieved focusing on potential crops and areas in a phased and compact manner with the aim of converting a minimum of 10 per cent of the cultivable land into entirely organic every year and thus achieving the target within 5-10 years. About 7000 farmers practice organic farming in Kerala as per NPOP standards, covering a total area of 5750 ha.

19.7 IS ORGANIC FARMING FEASIBLE IN INDIA ?

In India, about 62 per cent of cropped area is rainfed, where there is little or no use of fertilizers and other agro-chemicals due to poor resources with small holder farmers. Thus promotion of organic farming in India is advocated initially in these rainfed areas particularly in the hilly areas of northern and north-eastern regions and dry land areas of the country. The Fertilizer Association of India has identified altogether about 50 districts in the states of Orissa, Jharkhand, Uttranchal, Himachal Pradesh, Jammu & Kashmir, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh as low fertilizer consuming districts with fertilizer consumption ranging from 1.79 kg ha^{-1} to 19.80 kg ha^{-1} as against the national average of 90.2 kg ha^{-1} (Das and Biswas, 2002). This means that there is immense scope for organic farming in these selected areas and for selected crops in India, like pulses, oilseeds, tuber crops etc., for which conventionally little or no fertilizers and agro-chemicals are used. On the other hand, some areas under tea, coffee, cashew, nuts and spices may be easily brought under organic farming with a thrust on export of organic produce. In other words, rather than promoting organic farming *en masse*, it would be appropriate to carefully delineate areas or crops where fertilizer use is nil or nominal or demarcate export oriented crops that can give reasonable yield of high quality produce without the use of chemicals. *It is worthy to mention that tuber crops hold great promise in this regard.*

19.8 TUBER CROPS: UNDERGROUND CROPS WITH HIDDEN TREASURES

Tropical tuber crops, including cassava, yams (greater yam, white yam and lesser yam), sweet potato and aroids like elephant foot yam, taro and tannia form the most important staple or subsidiary food to about 500 million global population. Tuber crops are the third most important food crops of man after cereals and grain legumes. These crops possess high photosynthetic ability, capacity to yield under poor and marginal soils and tolerate adverse weather conditions. They are also recognized as the most efficient in converting solar energy, cassava producing 250 x 10^3 kcal ha^{-1} and sweet potato 240 x 10^3 kcal ha^{-1}, as compared to 176 x 10^3 kcal $ha^{-1}$for rice, 110 x 10^3 kcal ha^{-1} for wheat and 200 x 10^3 kcal ha^{-1} for maize; hence the tropical root crops are known to supply cheap source of energy.

They can serve as substitute for cereals due to higher carbohydrate and calorie content. The higher biological efficiency and the highest rate of dry matter production per unit area per unit time make tuber crops inevitable components of our food security systems. Besides they have potential as sources of alcohol, starch, sago, liquid glucose, vitamin C and as raw materials for many other industrial products and animal feed. In times of famine, tuber crops have come in handy to overcome catastrophes and provide relief from hunger.

Tuber crops are cultivated in India mainly as rainfed in the southern, eastern and north-eastern states. These crops form a source of livelihood to small and marginal farmers and tribal population in these areas. Cassava production is mainly from the states of Kerala, Tamil Nadu, Andhra Pradesh and NEH regions. Sweet potato is cultivated mainly in the states of Orissa, Bihar, Jharkhand, Eastern Uttar Pradesh, West Bengal, Madhya Pradesh, Maharashtra and Karnataka. Other tuber crops like yams (greater yam, white yam and lesser yam) and aroids (elephant foot yam, taro and tannia), popular as vegetables, are not yet commercially cultivated, being confined only to the home gardens in almost all the States (except elephant foot yam which is cultivated on a commercial scale in Andhra Pradesh).

19.9 PROSPECTS OF ORGANIC FARMING IN TROPICAL TUBERS

Organic farming is a viable strategy targeting on sustainable production and soil, environmental and human health hand in hand. Conventional agriculture using chemical inputs results in higher yield, but it is ecologically unfriendly as it has some negative impacts on food, soil, water and environmental quality. Indiscriminate use of chemical fertilizers for decades has lowered the organic carbon status of our soils to less than one per cent. Moreover pesticide residues cause concern over the safety of food. Organic farming helps to promote biodiversity and soil biological activity and strongly advocates the use of on-farm generated resources. Reduced energy use and CO_2 emissions are the other benefits of organic farming. It offers opportunities for employment generation, waste recycling and export promotion. The clean and safe organic foods fetch a higher premium price in world markets.

Most of the tuber crops are grown by small and marginal farmers in rainfed areas and tribal pockets and hence use of chemical fertilizers and insecticides are limited except in the case of cassava in the industrial production areas of Tamil Nadu (Salem, Dharmapuri, Namakkal, South Arcot districts) and Andhra Pradesh (Rajahmundry district). Tuber crops in general and aroids in particular, like elephant foot yam do respond well to organic manures and there is considerable scope for organic production in these crops. Further the tropical tuber crops are well adapted to low input agriculture. They are less prone to pest and disease infestations. Research work done in India and elsewhere had shown that the use of chemical fertilizers are beneficial in maximizing production of these group of crops. Eperimental evidences clearly shows that satisfactory productivity can be obtained even in the absence of chemical fertilizers by the proper supplementation of nutrients through organic sources. Moreover presently there is a great demand for organically produced ethnic vegetables, particularly aroids and yams, among affluent Asians and Africans living in developed nations (Europe, United States of America and Middle East).

19.10 ISSUES IN ORGANIC TUBER PRODUCTION

Many methods and techniques of organic agriculture have originated from various traditional farming systems all over the world, where there is the non use of chemical inputs. To the maximum extent possible organic production systems rely on crop rotations, crop residues, animal manures, legumes, green manures, farm wastes, mineral bearing rocks and aspects of biological pest control to maintain soil productivity, to supply plant nutrients and to control pests, diseases and weeds. Being highly responsive to organic manures and having fewer pests and disease problems as compared to cereals and vegetables, the main issue in organic production of tuber crops is the proper scientific use of a wide variety of cheaper and easily available organic sources of plant nutrients (Suja, 2008).

19.11 STRATEGIES FOR ORGANIC TUBER PRODUCTION

19.11.1 Building up of soil fertility of the land

Before the establishment of an organic management system, the fertility status of the land must be improved by growing green manure crops like cowpea twice or thrice during a year and incorporation of the green leaf matter at the appropriate pre-flowering stage. This will help to re-establish the balance of the eco-system and offset the yield decline, if any, during the initial period of organic conversion, as tuber crops are highly nutrient depleting crops (Suja *et al.*, 2009). Virgin land or barren land, if available, also will be highly suitable for organic farming of tubers.

19.11.2 Use of planting materials produced by organic management

Varieties cultivated should be adapted to the soil and climatic conditions and as far as possible resistant to pests and diseases. Local market preference also should be taken into account. The planting materials should be produced by adopting organic management practices.

19.11.3 Meeting nutrient needs in organic tuber production

The potential organic sources of plant nutrients for tropical tuber crops are farmyard manure, poultry manure, composts like vermicompost, coir pith compost, mushroom spent compost, saw dust compost, press mud compost, green manures, crop residues, ash, oil cakes like neem cake etc. Table 19.1. indicates the average nutrient contents in these organic sources.

Table 19.1. Average nutrient contents of some organic manures

Organic manures	N (%)	P_2O_5 (%)	K_2O (%)
Farmyard manure	0.50	0.20	0.40
Gren manure cowpea	2.80	0.52	2.02
Poultry manure	1.2-1.5	1.4-1.8	0.8-0.9
Vermi compost	1.50	0.40	1.80
Coir pith compost	1.36	0.06	1.10
Press mud compost	1.30	2.20	0.50
Mushroom spent compost	1.84	0.69	1.19
Sawdust compost	1.00	0.50	0.50
Biogas slurry	1.41	0.92	0.84
Neem cake	0.95	0.29	0.59
Bone meal	3.50	21.00	-
Ash	1.40	0.29	4.65
Municipal compost	1.20	0.036	0.90

Vermicompost, produced by chemical disintegration of organic matter by earthworms, is an ideal blend of plant nutrients with the worm enzyme and probiotics to boost the crop performance. It contains higher amount of nutrients, hormones and enzymes and has stimulatory effect on plant growth. If farmers can produce vermicompost utilizing on-farm wastes, organic farming of tuber crops becomes profitable.

Coir pith, a by product of the coir industry, an organic waste obtained during the process of separation of fibre from coconut husk, is normally resistant to bio-degradation due to its high content of lignin and accumulates to act as an environmental pollutant. Extraction of 1 kg of coconut fibre generates 2 kg of coir pith, and in India, an estimated 5,00,000 MT of coir pith is produced per annum. The Coir Board in collaboration with TNAU has developed the technology for converting coir pith into organic manure using PITHPLUS, a spawn of edible mushroom, *Pleurotus sajor caju*. Coir pith compost developed from coir waste is a good organic manure and a soil conditioner and can be applied to tuber crops.

The practice of green manuring for improving soil fertility and supplying a part of N requirement of crops is age old. About 15-20 t ha^{-1} of green matter can be obtained from green manure crops like cowpea when grown in systems involving tuber crops. Nitrogen contribution by green manure crops varies from 60-280 kg ha^{-1}.

Biofertilizers offer a cheap and easily available source of nutrients, especially N and P, besides enhancing the efficiency of native and applied nutrients in the soil. The commonly used N biofertilizer for tuber crops is the N fixing bacterium, *Azospirillum lipoferum*, which can partially meet the N demand of the crop. Powdered neem cakes also serve as an organic N source. These organic N supplements unlike the fertilizer N do not suffer much loss in the fields and enhances the N recovery. Phosphorus-solubilizing and mobilizing organisms such as phosphobacterium and mycorrhizae are helpful in augmenting P availability of the soil. Besides, natural reserves of rock phosphate are permitted for use as P fertilizer. Potassium for these crops can be supplied by using K rich organic amendments such as wood ash, rice straw and composted coir pith. K solubilizers can also be used for enhancing the K availability and meeting the K requirements. Harnessing the above mentioned easily available organic sources of plant nutrients conjointly and judiciously to meet the nutrient needs of highly nutrient exhausting crops like tropical tubers will definitely help to maintain/promote productivity in organic farming in the absence of chemical inputs.

19.11.4 Pest, disease and weed management

When compared to cereals and vegetables, tuber crops have fewer pest and disease problems. Barring a few major ones, like cassava mosaic disease (CMD), cassava tuber rot, sweet potato weevil (SPW), *Phytophthora* leaf blight in taro, collar rot in elephant foot yam, the others are of minor significance. In general for the management of pests and diseases, non-chemical measures or preventive cultural techniques can be resorted to. This includes use of tolerant/ resistant varieties, use of healthy and disease free planting materials, strict field sanitation (against almost all), deep ploughing (eg. tuber rot), rogueing the field (eg. CMD), use of pheromone traps (eg. SPW), use of trap crops (eg. SPW, root knot nematodes), adapted crop rotations, use of neem cake (collar rot, tuber rot), use of bio-control agents like *Trichoderma, Pseudomonas* (collar rot, leaf blight) etc. Normally two hand weedings are advocated in tuber crops for efficient weed management. Since most of the tuber crops (except sweet potato) take about 75-90 days for sufficient canopy coverage, raising a short duration intercrop (like green manure/ vegetable/grain cowpea, vegetables, groundnut etc in cassava, cowpea in yams and aroids) can also help to a great extent to reduce weed problem. Mulching the crop using any locally available plant materials (green leaves, dried leaves etc.) immediately after planting (in yams and aroids) will help to conserve moisture and regulate temperature, apart from weed control.

19.12 A DECADE OF RESEARCH ON ORGANIC FARMING OF TUBER CROPS

19.12.1 Methodology

Seven separate field experiments were conducted at the ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, India, for more than a decade (2004-2017) to compare organic vs conventional farming in cassava, elephant foot yam, taro, yams and Chinese potato in an acid Ultisol (pH: 4.3-5.0). In cassava, the experiment was laid out in split plot design with three varieties, H-165 (industrial variety), Sree Vijaya and Vellayani Hraswa (domestic varieties) in main plots and five production systems, traditional, conventional, integrated and two types of organic in sub plots. The impact of conventional, traditional, organic and biofertilizer farming was evaluated in RBD in elephant foot yam. Comparative response of five varieties of elephant foot yam (Gajendra, Sree Padma, Sree Athira and two locals) under organic and conventional farming was also evaluated in another experiment. Like wise, the response of three varieties of taro (Sree Kiran, Sree Rashmi and local) to the various production systems was studied. All the three trailing genotypes of edible *Dioscorea* (white yam: *D. rotundata* (var. Sree Priya), greater yam: *D. alata* (var. Sree Keerthi) and lesser yam: *D. esculenta* (var. Sree Latha)) were evaluated under conventional, traditional and organic systems in split plot design. The dwarf genotype of white yam (var. Sree Dhanya) as well as Chinese potato (var. Sree Dhara) were also evaluated in two separate experiments under conventional, traditional, organic and integrated systems in RBD. The field experiment on organic production of arrowroot (with the same treatments) was done for two years. The on-station developed organic farming technologies for cassava, elephant foot yam, yams and taro were on-farm validated. Varietal response, tuber yield, economics, tuber quality, soil physico-chemical and biological properties were evaluated.

Chemical inputs were not used for an year prior to the start of the investigations. In "conventional plots" farmyard manure (FYM) + NPK fertilizers were applied. Farmers practice of using FYM and ash was followed in "traditional plots". In "organic farming plots", FYM, green manure, crop residues, ash, neem cake and/or biofertilizers were applied to substitute chemical fertilizers. In "biofertilizer farming", FYM, mycorrhiza, *Azospirillum* and phosphobacterium were applied. In "integrated farming", FYM, chemical fertilizers and biofertilizers were used. Organically produced planting materials was used for the study.

Pooled analysis of yield data of 5 years was done. Proximate analyses of tubers for dry matter, starch, total sugar, reducing sugar, crude protein, oxalates and total phenols, mineral composition of corms viz., P, K, Ca, Mg, Cu, Zn, Mn and Fe contents, chemical parameters of soil viz., soil organic matter (SOM), pH, available N, P, K, Ca, Mg, Cu, Zn, Mn and Fe status, physical characters of the soil such as bulk density, particle density,

Field experiment on organic production of elephant foot yam

Field experiment on organic production of yams

Field experiment on organic production of taro

Field experiment on organic production of dwarf white yam

On-farm validation of taro and yams

On-farm validation of elephant foot yam

Field experiment on organic production of Chinese potato

Field experiment on organic production of arrowroot


Validation trials on organic farming of lesser yams (left) and greater yams (right) at ICAR-CPCRI, Kasaragod


Validation trials on organic farming of dwarf white yam (left) and cassava (right) at ICAR-CPCRI, Kasaragod

water holding capacity and porosity, plate count of soil microbes viz., bacteria, fungi, actinomycetes, N fixers, P solubilizers and the activity of dehydrogenase enzyme were determined by standard procedures. Economic analysis was done. The analysis of variance of data was done using SAS (2008) by applying analysis of variance technique.

19.13 INSIGHTS FROM TUBER CROPS

19.13.1 Response of varieties to organic management

The industrial as well as edible varieties of cassava, the elite and local varieties of elephant foot yam and taro and all the three species of *Dioscorea* responded similarly to both the systems (Suja *et al*., 2012a; 2013b). However, the industrial variety of cassava, Gajendra variety of elephant foot yam and the trailing genotypes of *Dioscorea* yielded more under organic farming than conventional practice.

19.13.2 Yield and economics

Organic farming resulted in 10-20% higher yield in cassava, elephant foot yam, white yam, greater yam, lesser yam, dwarf white yam and Chinese potato ie., 8, 20, 9, 11, 7 per cent, 9 and 10.5 per cent respectively (Fig. 1) (Suja *et al.*, 2012b; Suja *et al.*, 2013c; Suja and Sreekumar, 2014). This is contrary to some of the reports that crop yields under organic management are 20–40 per cent lower than for comparable conventional systems (de Ponti *et al.*, 2012; Seufert *et al.*, 2012)

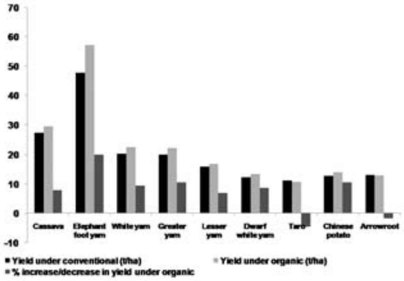

Fig.1. Organic vs conventional farming in tuber crops: tuber yield

Yield trend over 5 years and pooled analysis indicated the significantly superior performance of organic farming in elephant foot yam (Suja *et al.*, 2012b). In yams, up to third year, organic farming proved superior, thereafter it was on par or slightly lower than conventional practice. Pooled analysis indicated that organic farming was on par with conventional practice, but with slightly higher yield (Suja and Sreekumar, 2014). Taro preferred chemical based farming as slight yield reduction was noticed under organic

Table 19.2: Economic analysis: Organic vs conventional system in tuber crops

Crop	Gross income (Rs. ha^{-1})		Gross cost (Rs. ha^{-1})		Net income (Rs. ha^{-1})		Benefit: Cost ratio	
	*Con	Organic	Con	Organic	Con	Organic	Con	Organic
Cassava	407700	439800	105831	106575	301869	333225	3.85	4.13
Elephant foot yam	953400	1142000	319812	344150	633588	797850	2.98	3.32
Taro	281540	363580	155500	189420	126040	174160	1.81	1.92
Greater yam	858140	928960	394600	430020	463540	498940	2.17	2.16
Lesser yam	328640	385640	294600	330020	34040	55620	1.12	1.17
Dwarf white yam	404640	491520	268600	303900	136040	187620	1.51	1.62
Chinese potato	504400	557600	118086	144600	386314	413000	4.27	3.86
Arrowroot	391500	384300	176483	210400	215017	173900	2.22	1.83

farming (5 per cent). This was because taro leaf blight could not be controlled by organic measures (Suja *et al.*, 2017). In arrowroot, yield under organic practice was slightly lower than conventional practice (-2 per cent). Cost-benefit analysis indicated that the net profit under organic farming was 20-40 per cent higher over chemical farming (Suja *et al.,* 2016) (Table 19.2).

19.13.3 Tuber quality

In general, the tuber quality was improved in these crops under organic management with higher dry matter, starch, crude protein, K, Ca and Mg contents. The anti-nutritional factors, oxalate content in elephant foot yam and cyanogenic glucoside content in cassava were lowered by 21 and 12.4% respectively under organic farming (Suja, 2013; Suja *et al.,* 2014).

19.13.4 Soil quality indicators

The water holding capacity was significantly higher under organic management in elephant foot yam (14 g cm^{-3}) and yams and higher in taro over conventional practice (11-12 g cm^{-3}). The WHC was improved significantly by 8-28 per cent in the organic system. There was significant improvement in pH in organic farming (1.0, 0.77, 0.46, 1.20, 1.14 and 0.45 unit increase over conventional system) in cassava, elephant foot yam, yams, taro, Chinese potato and arrowroot. The SOM increased by 14-40 per cent in organic plots over conventional plots in these crops. In elephant foot yam, exchangeable Mg, available Cu, Mn and Fe contents were significantly higher in organic plots. Organic plots showed significantly higher available K (by 34 per cent) in yams and available P in taro. Available N and available P (in Chinese potato) and exchangeable Ca (in arrowroot) increased significantly under organic management.

The population of bacteria was considerably higher in organic plots than in conventional plots; 41 per cent and 23 per cent higher in elephant foot yam and yams respectively. Organic farming also favoured the fungal population by 17-20 per cent. While the N fixers showed an upper hand in organically managed soils by 10 per cent over conventional management under elephant foot yam, P solubilizers remained more conspicuous under organic management of yams (22 per cent higher than conventional management). The count of actinomycetes was favoured by 13.5 per cent in taro. The dehydrogenase enzyme activity was higher by 23 per cent and 14 per cent in organic plots in elephant foot yam and

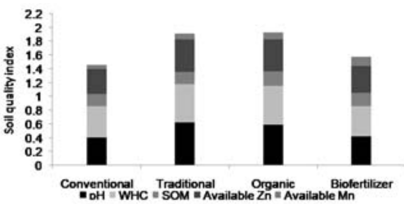

Fig. 2. Soil quality index: Organic vs conventional in elephant foot yam

yams (Suja *et al.*, 2015). In elephant foot yam the organic system scored significantly higher soil quality index (SQI) (1.930), closely followed by the traditional system (1.913). SQI of conventional (1.456) and biofertilizer systems (1.580) were significantly lower (Fig. 2) (Suja *et al.*, 2012a). The SQI was driven by water holding capacity, pH and available Zn followed by SOM (Suja *et al.*, 2013c).

19.13.5 The Package

Use of organically produced seed materials, seed treatment in cow-dung, neem cake, bio-inoculant slurry**,** farmyard manure incubated with bio-inoculants, green manuring, use of neem cake, bio-fertilizers and ash formed the strategies for organic production (Fig. 3) (Suja *et al.,* 2016a). The organic farming package for elephant foot yam is included in the Package of Practices Recommendations for crops by Kerala Agricultural University (KAU, 2011) and for yams and taro included in POP Crops (2016) of KAU.

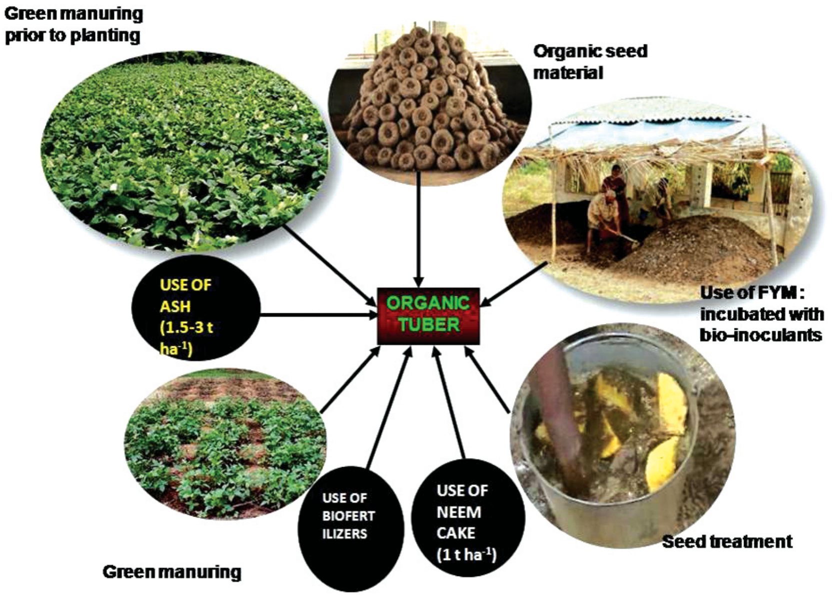

Fig. 3. Essential components of organic tuber production

19.14 ORGANIC PRODUCTION OF TUBER CROPS IN COCONUT BASED CROPPING SYSTEMS

On-station developed (at ICAR-CTCRI) organic production technologies for cassava and yams were validated in organically raised 48 yr old coconut plantation at ICAR-CPCRI, Kasaragod for two consecutive seasons (2015-2017) under the Network Project on Organic Horticulture.

Table 19.3: Technologies for organic production of tuber crops

Crops	Conventional practice		Organic practice
	FYM ($t\ ha^{-1}$)	NPK ($kg\ ha^{-1}$)	
Cassava	12.5	100:50:100	FYM @ 12.5 $t\ ha^{-1}$, *in situ* green manuring (green matter @ 15-20 $t\ ha^{-1}$), crop residue incorporation (generates dry biomass @ 3 $t\ ha^{-1}$), *Azospirillum* @ 3 $kg\ ha^{-1}$, phosphobacteria @ 3 $kg\ ha^{-1}$ and K solubilizer @ 3 $kg\ ha^{-1}$
Elephant foot yam	25	100:50:150	Seed treatment in FYM + neem cake + *Trichoderma* slurry. Application of FYM @ 36 $t\ ha^{-1}$ (FYM: neem cake mixture (10:1 ratio) incubated with *Trichoderma harzianum*), *in situ* green manuring with cowpea (green matter @ 20-25 $t\ ha^{-1}$), neem cake @ 1 $t\ ha^{-1}$, ash @ 3 $t\ ha^{-1}$
Taro	12.5	80:25:100	FYM @ 15 $t\ ha^{-1}$, *in situ* green manuring with cowpea (green matter @ 15-20 $t\ ha^{-1}$), neem cake @ 1 $t\ ha^{-1}$, ash @ 2 $t\ ha^{-1}$, *Azospirillum* @ 3 $kg\ ha^{-1}$, mycorrhiza @ 5 $kg\ ha^{-1}$and phosphobacteria @ 3 $kg\ ha^{-1}$
Tannia	12.5	80:50:100	FYM @ 20 $t\ ha^{-1}$, *in situ* green manuring with cowpea (green matter @ 15-20 $t\ ha^{-1}$), neem cake @ 1 $t\ ha^{-1}$, ash @ 2 $t\ ha^{-1}$
Yams (Trailing)	10	80:60:80	FYM @ 15 $t\ ha^{-1}$, *in situ* green manuring (green matter @ 15-20 $t\ ha^{-1}$), neem cake @ 1 $t\ ha^{-1}$, ash @ 1.5 $t\ ha^{-1}$, *Azospirillum* @ 3 $kg\ ha^{-1}$, mycorrhiza @ 5 $kg\ ha^{-1}$ and phospho bacteria @ 3 $kg\ ha^{-1}$
Dwarf white yam	10	80:60:80	FYM @ 15 $t\ ha^{-1}$, *in situ* green manuring with cowpea (green matter @ 15-20 $t\ ha^{-1}$), neem cake @ 1 $t\ ha^{-1}$, ash @ 1.5 $t\ ha^{-1}$, *Azospirillum* @ 3 $kg\ ha^{-1}$ and mycorrhiza @ 5 $kg\ ha^{-1}$

Crops	Conventional practice		Organic practice
	FYM ($t\ ha^{-1}$)	NPK ($kg\ ha^{-1}$)	
Chinese potato	10	60:60:100	FYM @ 10 $t\ ha^{-1}$, green manure @ 15-20 $t\ ha^{-1}$), neem cake @ 1 $t\ ha^{-1}$, biofertilizers (*Azospirillum*, P solubilizer and K solubilizer @ 3 $kg\ ha^{-1}$ each)
Arrowroot	10	50:25:75	FYM @10 $t\ ha^{-1}$, green manure @ 10-15 $t\ ha^{-1}$, biofertilizers (*Azospirillum*, P solubilizer, and K solubilizer @ 3 $kg\ ha^{-1}$ each)

Yield under organic mode (0.76 and 0.98 respectively of conventional) was on a par with chemical system in both cassava (8.14 and 10.71 $t\ ha^{-1}$) and yams (*Dioscorea* spp.) (6.81 and 6.91 $t\ ha^{-1}$) intercropped in coconut based on average yield data. The three species of *Dioscorea* (*D. alata, D. esculenta* and *D. roundata*) and three varieties of cassava responded similarly to organic and conventional management. Of the three species of *Dioscorea*, *D. alata* and *D. esculenta* were more responsive (+8-10 per cent) to organic management, but organic management lowered yield by 30 per cent in dwarf white yam (*D. roundata*). The three varieties of cassava, Sree Vijaya, Vellayani Hraswa and H-165, exhibited similar yield reduction (-22 per cent, -27 per cent, -23 per cent respectively) under organic management over conventional system.

19.15 CONSTRAINTS IN PROMOTION OF ORGANIC FARMING

In India the availability of organic manures is a major constraint. It is estimated that to feed 1.4 billion population by the year 2025, a minimum of 301 million tonnes of food grains is needed. To produce this much, it will be necessary to harness 30-35 million tonnes of NPK from fertiliser carriers and an additional 10 million tonnes from organic and biofertiliser sources (NAAS, 1997; Suja *et al.*, 2016b). Thus, only about 25-30 per cent nutrient needs of Indian Agriculture can be met by utilizing organic sources solely (Suja, 2008; Chhonkar and Dwivedi, 2004). Organic manures are bulky (high cost of handling and transportation), low analysis, slowly available and variable in composition. The availability of cattle dung for organic farming will be further limited as this is a major source of fuel in rural households. Apart from these, green manuring and recycling of farm wastes as manures has not become popular as these are more time and space consuming and their impacts on productivity are not rapidly discernible. Presently certification procedures are cumbersome and expensive (Chhonkar and Dwivedi, 2004; Suja, 2008; Suja *et al.*, 2016b).

19.16 FUTURE THRUST

Some of the future line of action for promotion of organic farming has been identified (Suja, 2008; Chhonkar and Dwivedi, 2004; Suja *et al.,* 2016b). Proper delineation and identification of prospective areas and crops (like tuber crops) may be helpful for effective promotion of organic farming. There is a need to undertake systematic research on the comparative values/ advantages of organic farming over conventional farming on a long term basis for promotion of organic farming. Package of practices recommendations for organic farming has to be popularised. The extent of availability of potential organic sources needs to be ascertained along with measures that may be helpful in improving the convenience of their use. Environmental impact, especially water and air quality effects, of organic farming need assessment.

Weed management options particularly under climate change by nonchemical and biological methods are limited and needs evaluation. The benefits accruing through organic farming on crop yield, quality, market preference and price advantage may be properly understood and promoted among the farmers and consumers (Suja, 2008; Suja et al., 2016b).

In order to attain sustainable food-cum-livelihood-cum environmental security in India we may require an array of alternatives to chemical intensive agriculture. Instead of seriously debating on organic vs conventional agriculture it is better to examine critically the costs and benefits of the different alternative management options. It has been conclusively proved in tuber crops that organic management is an alternative viable option for sustainable and safe food production with less soil degradation and environmental pollution. Tuber crops, especially elephant foot yam and yams are prospective candidates for organic farming. Elephant foot yam is the most responsive followed by greater yam, white yam, lesser yam and taro. Generation of sufficient biomass, addition of crop residues, green manuring, farm waste recycling, fortification of manures through proper composting, adoption of crop rotations involving legumes, establishment of biogas plants and development of agro-forestry for alternate source of fuels are some of the strategies that will help to promote organic farming of tuber crops. These practices would help a great deal in supplementing/rationalizing the use of inorganic fertilizers, which cannot be totally eliminated in Indian Agriculture.

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Chapter 20

RECENT DEVELOPMENTS IN MACHINERY FOR ORGANIC AGRICULTURAL SYSTEMS

Kanchan Kumar Singh and Panna Lal Singh

20.1 INTRODUCTION

Organic farming is an alternative agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices. Organic farming continues to be developed by various organic agriculture organizations today. It relies on fertilizers of organic origin such as compost, manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Biological pest control, mixed cropping and the fostering of insect predators are encouraged. In general, organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances.

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organization for organic farming organizations established in 1972. Organic agriculture can be defined as: "An integrated farming system that strives for sustainability, enhancement of soil fertility and biological diversity whilst, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms and growth hormones".

This paper describes various cost effective and energy efficient tillage and crop establishment technologies under organic agricultural systems by attaining the goal of increasing productivity and meeting food security needs while at the same time efficiently using natural resources, including water, providing environmental benefits and improving the rural livelihoods of farmers. The resource conservation technologies (RCTs) and organic farming are rapidly gaining popularity among farmers as they result in higher production at less cost with significant benefits to the environment and more efficient use of natural resources. This ultimately results in higher profits, cheaper food, and improved farmer livelihoods. Crop diversification is also easier as less land is needed to produce staple cereals, freeing up land for other crops.

20.2 WHAT IS ORGANIC FARMING?

Organic farming system in India is not new and is being followed from ancient time. It is a method of farming system which primarily aimed at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (bio fertilizers) to release nutrients to crops for increased sustainable production in an eco friendly pollution free environment. As per the definition of the United States Department of Agriculture (USDA) study team on organic farming "organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection". FAO suggested that "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs".

20.3 MACHINERY FOR SEEDING AND PLANTING

The importance of maintaining trash cover has long been recognized. However, this often interferes with the placement of seed in firm and moist soil, therefore, farmers frequently burn the fields which are not an eco-friendly practice. Seed could be placed in the soil in anchored stubble condition after partial burning for removal of loose straw. Uniform spreading of straw during harvesting itself by mounting a device at the rear of combine and then using drills under loose straw condition or chopping loose as well as anchored stubbles with a rotary shredder followed by residue drills are some of the viable options. The seeding machinery needed for such varied conditions and their limitations are discussed below.

20.3.1 Zero-Tillage

This is RCT where the seed is placed into the soil by a seed drill without prior land preparation. This technology is more relevant in the higher yielding, more mechanised areas of north-western India, where most land preparation is now done with four-wheel tractors. However, in order to extend the technology in other parts, equipment for 2-wheel hand tractors and bullocks is being modified. Surveys and crop cuts have shown that zero till produces 400 - 500 kg/ha more grain than traditional systems. This is attributed to earlier, timely planting, less weeds, better plant stands and improved fertilizer efficiency because of placement with the seed drill.

20.3.2 Reduced tillage

The strip and rotary till drills have been developed that prepare the soil and plant the seed in one operation. This system consists of a shallow rotavator followed by a seeding system. Soil moisture was found to be critical in reduced tillage system. The rotavator fluffs up the soil, which then dries out faster than with normal land preparation. The seeding coulter does not place the seed very deep, so soil moisture must be high during seeding to ensure germination before the soil dries appreciably.

20.3.3 Bed planting

In bed planting systems, wheat or other crops are planted on raised beds. This practice has increased in the last decade. Farmers have given the following reasons for adopting the new system: management of irrigation water is improved, bed planting facilitates irrigation before seeding and thus provides an opportunity for weed control prior to planting, plant stands are better, weeds can be controlled mechanically between the beds early in the crop cycle, seed rates are lower, after wheat is harvested and straw is burned, the beds are reshaped for planting the succeeding crops, burning can be eliminated, herbicide dependence is reduced and hand weeding is easier as well as less lodging occurs.

20.3.4 Bed Planter-cum-Zero Till drill

The Zero Till drills are now manufactured by over 60 recognized manufacturers who have manufactured over 25,000 drills and supplied to different states. These drills are available in two-in-one version also, as raised bed planter-cum-ZT drill. The loose straw after combining could be collected with field balers, the drill can be used directly without any surface manipulation of residue and a system for combining, field baling and zero-tillage could be a viable option.

20.3.5 Happy and Turbo Seeders

The Happy and Turbo Seeder technology provides an alternative to burning for managing rice residues and allows direct drilling of wheat in standing as well as loose residues. Both on-farm and on-station trials were conducted to evaluate the feasibility of direct-drilling of wheat in the presence of heavy loads of rice residue using the Happy and Turbo Seeders and the effects of tillage and residue management methods on crop productivity and soil physical properties.

20.4 ORGANIC CONSERVATION TILLAGE

Improvements in crop performance and soil quality can result following conversion from clean or conventional tillage to conservation tillage systems, defined broadly as any set of practices that reduce soil or water loss compared with a conventional system based on soil inversion. Minimum tillage and reduced tillage are often used interchangeably with conservation tillage in this broad context. More narrowly, conservation tillage is defined as any set of practices that leaves at least 30 per cent of the soil surface covered by crop residue after seeding (Lal *et al.*, 1994). Zero tillage, also referred to as no tillage, direct seeding and direct drilling, includes those cropping systems where soil disturbance is limited to what occurs when seeding using disk openers sometimes preceded with narrow cutting coulters mounted onto the planting unit. Zero tillage is the conservation tillage system which retains the greatest amounts of crop residue on the soil surface, and the benefits are most pronounced in dry regions following adoption of ZT where the soil water conservation that occurs is a particular advantage (Carr *et al.*, 2013). Recognizing this, Peignéet *et al.* (2007) argued that adoption of ZT and other conservation tillage practices should enhance microbial activity and C sequestration, reduce nutrient leaching and erosion, and lower fuel use on organic farms. They pointed out several cultural practices that could be adopted during and following conversion to conservation tillage systems for weed control, but acknowledged that achieving an adequate level of suppression over the long term could be a challenge. Soil compaction and nutrient deficiency problems also might develop following adoption of conservation tillage practices on organic farms. These researchers suggested a-staged approach whereby soil and climate best suited to conservation tillage first was identified, followed by careful planning of crop rotations to maximize opportunities for nutrient cycling and weed suppression, as has been detailed by others (Anderson, 2010). Cover crops likely would be an important component in at least some of these crop rotations, possibly as weed-suppressive mulch.

20.5 ORGANIC ZERO TILLAGE

Cover crops are an integral component of organic ZT systems. Cover crops offer several ecosystem services when incorporated into rotations with market crops, including soil and water quality improvements (Snapp *et al.*, 2005) and nutrient cycling advantages (Snapp *et al.*, 2005; Cherr *et al.,* 2006). However, the primary use of cover crops in organic ZT is to create vegetative mulch for weed suppression. As little as 2,700 kg $ha^{-1}$of above-ground dry matter produced by fall-seeded cover crops can suppress annual weed density the following spring and early summer by as much as 75 per cent (Teasdale, 1996) although at least 7,000 kg $ha^{-1}$of residue may be needed to suppress annual broadleaf weeds by 80 per cent (Teasdale and Mohler, 2000). Teasdale (1996) concluded that cover crop residue could provide good early season weed suppression but that full-season weed control was not provided. Likewise, cover crop residue was unable to suppress growth of well-established perennial weed species.

An early challenge in the development of organic ZT was devising methods for killing cover crops that involved little if any soil disturbance. Rollers received the greatest attention. Creamer et al. (1995) reported better results when cover crops were killed using a roller compared with a flail mower, but a blade plough was attached to the roller and shallow soil disturbance occurred. Ashford and Reeves (2003) were perhaps the first North American researchers to consider terminating cover crops mechanically but without tillage using a roller-crimper, borrowing an idea first developed and used in South America following the introduction of conventional ZT. A roller-crimper essentially is a rolling drum with blades of various designs attached to it. The blades are dull and used to crush rather than cut the cover crops. Roller-crimpers had been developed and used in South America following the introduction of conventional ZT.

20.6 MACHINERY FOR PLANT PROTECTION

20.6.1 Manure spreader

A manure spreader or muck spreader or honey wagon is an agricultural machine used to distribute manure over a field as a fertilizer. A typical (modern) manure spreader consists of a trailer towed behind a tractor with a rotating mechanism driven by the tractor's power take off (PTO).

20.6.2 Liquid slurry applicator

Some of the N in manure is present as ammonium, which is directly available to crops but is even more available as nitrate after soil bacteria nitrify the ammonium. However, ammonium also can be lost as ammonia gas. This loss by volatilization is highest when manure is exposed to air, especially at the alkaline pH of manure. Rapid incorporation of manure is the best way to limit ammonia volatilization. Organic N continues to supply plant-available N over several years, although at declining amounts. In the first year, perhaps 35 per cent of the organic N in swine manure becomes available (Koelsch and Shapiro, 2006). This declines to about 15 per cent the next year. As a result, repeated application of manure to a field provides cumulative effects. After two years of manure application at the same rate of organic N, available N will equal about 50 per cent of the annual rate of organic N application (35 per cent + 15 per cent).

20.6.3 Weed management

Organic weed management promotes weed suppression, rather than weed elimination, by enhancing crop competition and phototoxic effects on weeds. Organic farmers integrate cultural, biological, mechanical, physical and chemical tactics to manage weeds without synthetic herbicides. Organic standards require rotation of annual crops, meaning that a single crop cannot be grown in the same location without a different, intervening crop. Organic crop rotations frequently include weed-suppressive cover crops and crops with dissimilar life cycles to discourage weeds associated with a particular crop. Research is ongoing to develop organic methods to promote the growth of natural microorganisms that suppress the growth or germination of common weeds. Other cultural practices used to enhance crop competitiveness and reduce weed pressure include selection of competitive crop varieties, high-density planting, tight row spacing, and late planting into warm soil to encourage rapid crop germination.

With proper integration of various cost effective and energy efficient tillage and crop establishment technologies, the future organic agriculture may be shaped to bring out the desired level of agricultural production to fulfil food security needs. At the same time higher water productivity with restoration of environment for improving the rural livelihoods and nutritional security of farmers may be achieved. These technologies are rapidly gaining popularity among farmers due to higher energy efficiency at lower cost of production.

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Chapter 21

POST-HARVEST PRODUCTION, PROCESSING AND VALUE ADDITION OF ORGANIC CROP PRODUCES

Amit Nath

21.1 INTRODUCTION

Organic farming is a holistic approach based upon a set of processes that leads to sustainable ecosystem, safe and nutritive food, animal welfare and social justice. It is based on minimizing the use of external inputs and avoiding the use of synthetic fertilizers and pesticides. It is the process of farming system employing management practices, which seek to nurture ecosystem, achieve sustainable productivity and provide weed, pest and disease control through a diverse mix of mutually dependent life forms. Thus, organic farming encourages a balanced host/predator relationship through augmentation of beneficial insect populations, biological and cultural pest control, recycling of plant and animal residues. Soil fertility is maintained and enhanced in a sustainable manner by a system which optimizes soil biological activity and the physical and mineral nature of the soil as the means to provide a balanced nutrient supply for plant and animal life as well as to conserve soil resources with the recycling of plant nutrients as an essential part of the fertilizing strategy. Pest and disease management is attained by means of crop selection, rotation, water management and tillage. Besides these, it has been demonstrated extensively that plant products from organic farming are substantially better in quality like, bigger in size, look, flavour, and aroma and animal products to be of better quality when they are fed with feed and fodder produced organically. The underground water of the area where such farming system is in practice has been found to be free of toxic chemicals.

Optimal quality organic produce that combines the desired textural properties, sensory shelflife, and nutritional content results from the careful implementation of recommended production inputs and practices, careful handling at harvest, and appropriate postharvest handling and storage.

Consumer awareness of the relationship between foods and health, together with environmental concerns, has led to an increased demand for organically produced foods. In general the public perceives organic foods as being healthier and safer than those produced through conventional agricultural practices (Jolly *et al*., 1989). Organic food products, especially the fruits and vegetables are slowly gaining momentum in the foreign markets like USA, Europe and Japan and fetching premium prices. The areas under organic farming are slowly increasing due to the awareness of impact of chemicals on the environment and human health.

The organic foods market has become one of the rapidly growing sectors of most developed agricultural economies around the world, especially in the European Union. Despite there being no unambiguous evidence those organic foods are healthier than conventional foods. Organic foods contain less harmful additives but more primary (e.g., vitamin C, dry matter, minerals) and secondary nutrients (i.e., phyto-nutrients) than conventional foods. In other words, organic foods at least, carry no additional risk of food poisoning (Heaton, 2001). On the basis of the precautionary principle alone, choosing organic foods appears to be an entirely rational decision. Consumers perceive foods labeled as organic to be healthier than conventional foods (Grankvist & Biel, 2001).

Human food choice is a complex function of a multitude of inûuences (Furst *et al*., 1996). These determinants include sensory aspects of food (e.g., taste, odor, texture characteristics), combined with the inûuence of non-food eûects (e.g., cognitive information, the physical environment, social factors) (Eertmans *et al*., 2001). Although various food choice models reûect the complexity of understanding food choice behavior (Caplan *et al*., 1998), few studies have investigated the potential inûuence of the food-related personality traits (Eertmans *et al*., 2005), speciûcally those associated with the organic foods choice.Hughner *et al.* (2007) conducted a survey and found that consumers prefer organic food for its greater nutritional value, its better taste, its safety for health,and because its production does not endanger the environment.

Consumers are increasingly choosing organic foods due to the perception that they are healthier than those conventionally grown (Yiridoe *et al*., 2007). Some of the recent literature also supports this belief, showing that organic foods contain higher levels of micronutrients, although there have been conûicting results. An analysis by Hunter *et al.* (2011) involving 33 studies found that organic produce contained overall 5.7% higher micronutrients than comparable conventionally grown produce . Numerous comparative studies on the nutrient and bioactive compounds in conventionally and organically grown foods have been conducted on animal products (Heuer *et al*., 2001), vegetables (Singh *et al*., 2009), cereals, and fruits (Rosen, 2010).

However, controversy remains, regarding whether or not organic foods have a nutritional and/or sensory advantage when compared to their conventionally produced counterparts. Advocates for organic produce claim it contains fewer harmful chemicals, is better for the environment and may be more nutritious. There are fundamental differences in organic and conventional production practices, but limited information is available detailing how various practices influence the nutritional quality, especially in terms of health-related antioxidants of other food crops.

21.2 POSTHARVEST QUALITY OF ORGANIC PRODUCES

Achieving an economically rewarding enterprise via the marketing of organic produce must begin well before harvest. Seed selection can be a critical decision factor in determining the postharvest performance of any commodity. Individual cultivars have variable inherent potential for firmness retention, uniformity, disease and pest resistance, and sensory shelf life, to list a few key traits. Cultivars chosen for novelty or heirloom traits may be suitable for small-scale production and local marketing but would be unsuccessful if shipment to more distant markets was attempted. In addition to genetic traits, environmental factors such as soil type, temperature, wind during fruit set, frost, and rainy weather at harvest can have an adverse effect on storage life, suitability for shipping, and quality. Cultural practices may have dramatic impacts on postharvest quality. For example, poor seedbed preparation for carrots may result in sunburned shoulders and green core with many of the specialty carrots favoured by consumers at farmers markets.

Planning for postharvest food safety should be included in any crop management plan. Good Agricultural Practices (GAP) need to be developed and formalized for each crop and specific production field to minimize the risk of chemical (ex. heavy metals carryover), physical (ex. sand and soil, wood, plastic or metal shards), and biological (ex. *Salmonella*, *Listeria*, mycotoxins) hazards and contaminants. Prior land use, adjacent land use, water source and method of application, fertilizer choice (such as the use of manure), compost management, equipment maintenance, field sanitation, movement of workers between different operations, personal hygiene, domestic animal and wildlife activities, and other factors have the potential to adversely impact food safety.

It is worth noting that many elements of a GAP plan are likely to be incorporated into the existing organic crop management program and activities. Programs in place to ensure produce quality may be directly applicable to food safety with minor modifications. Applying food safety programs, in turn, have been shown to directly benefit postharvest quality.

Once prerequisite production programs are in place, a systematic evaluation and implementation plan of Good Agricultural Practices during harvest operations and any subsequent postharvest handling, minimal or fresh-cut processing, and distribution to consumers must be developed. Considerations for these activities are covered below.

21.3 HARVEST HANDLING FOR ORGANIC PRODUCES

The inherent quality of produce cannot be improved after harvest, only maintained for the expected window of time characteristic of the commodity. Part of successful postharvest handling knows what this window of opportunity is under your specific conditions of production, season, method of handling, and distance to market. Among the benefits of organic production, it is often more common to harvest and market near or at peak ripeness than in many conventional systems. However, organic production often includes more specialty varieties that have reduced or even inherently poor shelf life and shipping traits. As a general approach, the following practices can help to maintain quality:

1 Harvest during the coolest time of the day to maintain low product respiration.

2 Avoid unnecessary wounding, bruising, crushing, or damage from humans, equipment, or harvest containers.

3 Shade harvested product in the field to keep it cool. Covering harvest bins or totes with a reflective pad greatly reduces heat gain from the sun and reduces water loss and premature senescence.

4 If possible, move product into a cold storage facility or postharvest cooling treatment as soon as possible. For some commodities, such as berries, tender greens and leafy herbs, one hour in the sun is too long.

5 Don't compromise high quality product by intermingling damaged, decayed, or decay-prone product in a bulk or packed unit.

6 Only use cleaned and, as necessary, sanitized packing or transport containers.

These operating principles are important in all operations but carry special importance for many organic producers due to limited postharvest cooling opportunities.

21.4 POSTHARVEST STORAGE FOR ORGANIC PRODUCES

Temperature is the single most important tool to maintain postharvest quality. Other than field cured or durable products, removing field heat as rapidly as possible is highly desirable. Harvesting cuts off a vegetable from its source of water. However, it is still alive and will lose water, and therefore turgor, due to respiration. Field heat can accelerate the rate of respiration and therefore the rate of quality loss. Proper cooling protects quality and extends both the sensory (taste) and nutritional shelf life of produce. The capacity to cool and store produce creates greater market flexibility. There is a tendency by growers to underestimate the refrigeration capacity needed for peak cooling demand. It is often critical to reach the desired short-term storage or shipping pulp temperature rapidly to maintain the highest visual quality, flavor, texture, and nutritional content of fresh produce. The most common cooling methods are:

21.4.1 Room cooling

An insulated room or mobile container equipped with refrigeration units. Room cooling is slow compared with other options. Depending on the commodity, packing unit, and stacking arrangement the product may cool too slowly to prevent water loss, premature ripening, or decay.

21.4.2 Forced-air cooling

Fans are used in conjunction with a cooling room to pull cool air through packages of produce. Although the cooling rate depends on the air temperature and the rate of airflow, this method is usually 75–90 per cent faster than room cooling.

21.4.3 Hydrocooling

Showering produce with chilled water is an efficient way to remove heat, and can serve as a means of cleaning at the same time. Use of a disinfectant in the water is essential and the some of the currently permitted products are discussed in the following section. Hydrocooling is not appropriate for all produce. Waterproof containers or resistant waxed-corrugated cartons are required. Currently waxed corrugated cartons have limited recycling or secondary use outlets and reusable, collapsible plastic containers are gaining popularity.

21.4.4 Top or liquid icing

Icing is an effective method to cool tolerant commodities and is equally adaptable to small or large-scale operations. Ensuring that the ice is free of chemical, physical, and biological hazards is essential.

21.4.5 Vacuum cooling

Under vacuum, water within the plant evaporates and removes heat from the tissues. This system works well for leafy crops, such as lettuce, spinach, and celery, which have a high surface-to-volume ratio. Water may be sprayed on the produce prior to placing it vacuum. The cost of the vacuum chamber system restricts its use to larger operations. In large cooling operations handling both conventional and organic commodities, it is common to hydrocool (also water-spray vacuum cooling) organic produce at the beginning of daily operation, after a full cleaning and complete water exchange. This practice is intended to prevent carry-over or cross-contamination of organic produce with synthetic pesticide or other prohibited residues. This will generally require at least overnight short-term storage.

Other postharvest issues involving combined steps of unloading commodities from harvest bins, washing, and precooling must also be evaluated for adherence to organic standards. Some operators use flotation as a method of reducing damage at the point of grading and packing. Entire bins are submerged in a tank of water treated with a chemical flotation aide that allows the picked product to be gently removed and separated from the container. Lignin sulfonates are allowed in certified organic handling as a flotation aid for water-based unloading of field bins or other density separation applications.

21.5 SHELF LIFE OF ORGANIC FRUITS AND VEGETABLES

All fruits and vegetables are living organs. They use oxygen and produce carbon dioxide during respiration, the process by which carbohydrate and other substrates, such as organic acids, proteins and fats, are metabolized. Respiration thereby provides the energy necessary for cells to maintain structure and for ripening processes such as colour and flavour development. The substrates cannot be replenished once the fruit or vegetable has been removed from the plant, and therefore faster respiration rates will result in loss of food nutritional value, loss of saleable weight, poorer flavour, and thus reduced product quality.

Horticultural products can be regarded as "water inside pleasing packages" or "water with a mechanical structure". Therefore, water loss or transpiration is a major factor affecting quality of fruits and vegetables. In addition to lower saleable weight, loss of water can affect quality in many ways, including wilting, shriveling, flaccidness, soft texture and loss of nutritional value. The rate of water loss, and the impact of this loss, will vary by product (Table 21.1). For example, maximum permissible losses can range from 3 per cent for lettuce to 10 per cent in onions. Products vary in potential for water loss by morphological differences such as cuticle thickness and composition and presence or absence of stomata and lenticels, which are structures that allow gases and moisture to move in or out of the plant. For some products these differences are affected by development stage. Also, within products, morphological differences exist among varieties. Water is another product of respiration. Water loss can be reduced by cooling products, maintaining a high relative humidity in the storage environment, controlling air circulation, and where permitted, the use of surface coatings or plastic film(Chris and Jacqueline, 2012).

Table 21.1. Transpiration losses for fruits and vegetables stored at various relative humidity's (Chris and Jacqueline, 2012).

Crops	Storage Temperature (°F)	Percentage weight loss per day			
		95% RH	90% RH	85% RH	80% RH
Apples	32	0.011	0.022	0.033	0.044
Carrots	32	0.315	0.630	0.945	1.260
Cabbage	32	0.058	0.116	0.175	0.233
Celery	32	0.460	0.920	1.380	1.840
Grapes	32	0.032	0.064	0.096	0.128
Lettuce	32	1.930	3.860	5.790	7.730
Peaches	32	0.150	0.300	0.450	0.600
Pears	32	0.018	0.036	0.054	0.072
Potatoes	45	0.070	0.141	0.211	0.282
Tomatoes	45	0.060	0.119	0.180	0.240

Because active metabolism continues after harvest, a number of desirable and undesirable changes occur in storage and shelf life conditions. These changes include development of pigments; for example, lycopene synthesis in tomato, anthocyanin synthesis in strawberry, and development of carotenoids (yellow and orange colors) in apricots and peaches. These compounds also contribute to the antioxidant status of these fruit and associated health benefits. Other changes include softening to edible ripeness, loss of chlorophyll (green color), and development of aroma and flavor characteristics. The same processes can be positive in some situations and negative in others; loss of chlorophyll is desirable in tomatoes, but undesirable in cucumbers and broccoli. Conversion of starch to sugars is desirable for apples, but undesirable for potatoes, while conversely, conversion of sugars to starch is desirable for potatoes but undesirable for peas and sweet corn.

21.6 FRUIT AND VEGETABLE VARIETIES FOR ORGANIC PRODUCES

Quality for most crops cannot be improved during storage, only maintained, and therefore any consideration of storage must take into account, the importance of variety and preharvest factors. Growers usually select varieties on the basis of marketability (visual qualities specific to the market of choice) and yield, because these factors directly affect the bottom line. However, varieties can vary greatly in storage and shelf life. The absence of postharvest chemical treatments for organic growers makes it even more important that varieties are selected with these factors in mind. Variety selection should also include resistance to postharvest diseases and physiological disorders. In organic farms, the crops are grown without the use of synthetic plant protection products and readily soluble mineral fertilizers. In organic farming, animal manures, green manures, compost and a varied crop rotation are applied instead of readily soluble mineral fertilizers, which leads to optimalsoil biological activity. Due to the exclusion of the use of chemical protection products in organic farming, activation of natural mechanisms of plant defence system against diseases and pests takes place. Natural protective substances inplants are so called secondary metabolites, which also represent an essential elementof daily human diet.

Differences in storage potential within specific products result from different physiologies and biochemistries of each variety. In some cases, genes which control processes such as low ethylene production, low respiration and slower softening are bred into the commodity. For example, the rinmutant has been bred widely into most commercial tomato varieties. Also, breeders have sometimes favored slower ripening selections with better resistance to the handling abuses during harvest, handling and transport that result in bruising and skin damage. While the result has sometimes been development of varieties that have tougher skins and sometimes reduced eating quality. Qualities associated with extended shelf life can also provide assistance to organic growers.

21.7 POST HARVEST LOSS MANAGEMENT IN ORGANIC PRODUCE

Fruits and vegetables are perishables since they maintain an active metabolism in the postharvest phase. The factors causing early termination of their storage life are relatively high respiration rates and senescence, transpiration, and high susceptibility to fungal infection. Storage diseases are responsible for substantial postharvest losses. Currently, the most important means of maintaining quality and prolonging the shelf-life of organic produce is low temperature storage, as organic producers have no access to chemical programs, unlike the growers and storage operators of regular crops. Pre-storage treatment with hormetic (hormesis is the stimulation of beneficial responses by low levels of stressors which are otherwise harmful) doses of UV-C has been shown to control diseases and delay senescence in fresh fruits and vegetables by the induction of natural defense mechanisms of the produce. In addition, UV-C induced responses typically persist even when the treated produce is subsequently exposed to other stresses during storage. However, UV-induced effects are localized and not systemic, which necessitates the exposure of the entire surface of crops of varying sizes and shapes to elicit the beneficial responses. Overcoming this challenge can lead to an effective preservation technology, as an adjunct to refrigeration, for fresh crops. The UV light therapy technology is used to extend preservation of fresh organic fruits and vegetables by induction of disease resistance and delayed senescence. The organic sector, which emphasizes sustainability and is dedicated to minimizing waste, can benefit significantly from this environmentally-friendly technology. The ability to preserve crops longer than low temperature alone will allow and the reduced economic losses arising from postharvest losses could encourage growers to increase production of their crops and serve expanded and further markets, leading to improved profitability of the sector. In addition, there is also a potential to enhance health-promoting phyto-compounds in the treated produce that could lead to increased consumer demand for organic produce.

21.7.1 Pre-harvest sprays to reduce post harvest losses

Pre-harvest sprays of chemicals have been applied to reduce postharvest losses in different fruits and vegetables. Thiophenate methyl (0.05 per cent) was found to effectively control postharvest losses in Dashehari mango. A pre-harvest spray of 10 to 15 ppm giberellic acid (GA_3) proved useful for on-tree storage of mango by controlling maturity and delaying ripening. Three sprays of Benomyl or Topsin-M or Carbendazin (0.05 per cent) at 15-day intervals before harvest were found to control postharvest losses in Nagpur mandarin. A pre-harvest spray of 0.6 per cent Calcium chloride ($CaCl_2$), 10 to 12 days prior to the harvest, improved the shelf life of grapes. An additional 2,720 kg/ha mango yield was obtained as a result of the pre-harvest spray of bavistin (0.5 per cent). Use of GA_3 50 ppm as a dip was found to induce seedlessness in gulabi grapes. Spraying of 2 per cent urea on to banana bunches increased bunch weight by 2–5 per cent. Pre-harvest heat treatment by reducing the ventilation in green houses increased the soluble solids content, fruit skin color and reduced the chilling injury of tomatoes. Application of 25 per cent of etherel along with 2 per cent urea in addition to 0.04 per cent sodium carbonate solution (50 ml) facilitated uniform flowering and fruiting in high density pineapple plantations. Growth of pole beans under green house conditions doubled the yield and enriched the quality of pods. Different chemicals, growth regulators and fungicides *viz.* calcium chloride, calcium nitrate**,** gibberellic acid-3, 6-BAP, carbendazim and benomyl (alone or in different combinations) may be used to minimize the post harvest losses in fruits and vegetables.

21.7.2 Pre-Cooling

Pre-cooling technology is extensively applied in the postharvest handling of horticultural produce. Pre cooling of mangoes to 12–15°C with 500 ppm Bavistin has been shown to increase their shelf life. Exposure of flowers to a temperature of 2–4°C prior to cold storage, results in prolonging their shelf-life and improved the quality.

21.7.3 Grading

Systematic grading coupled with appropriate packaging and storage, will extend postharvest shelf life, wholesomeness, freshness, and quality, will substantially reduce losses and marketing cost. Horticultural produce must be sorted and graded on the basis of parameters such as maturity, size, shape, color, weight, freedom from insects and pests, pesticide residues and ripeness. Horticultural crops like onion, potato, tomato, chillies, okra and french beans are graded on the basis of size, shape, weight and maturity stage. Elimination of off-grade and diseased horticultural crops prevents the spread of diseases. Common horticultural crops are generally graded on the basis of size and weight (Nath, 2013).

21.7.3 Packaging and Transportation

Large quantities of horticultural crops are transported in open trucks. Window type conical bamboo baskets designed for stacking and aeration have been developed by the CFTRI, Mysore for transportation of produce by rail. The use of polyethylene film bags for wrapping horticultural crops like capsicum, broccoli, assam lemon, tomatoes etc for transport, has been found to be most suitable for reducing wastage. Losses in first grade tomatoes can be reduced from 15 to 3 per cent by using upright cone baskets together with dry grass as a packaging material between the layers of fruits. Packing of tomatoes in sealed unventilated polyethylene provides a modified atmosphere which extends storage life. Printed plastic bags are used to reduce light transmission to potato tubers. Plastic oven ventilated bags of 25 and 50 kg of capacity are used for onions and potatoes. Palletization and containerization will go a long way in establishing both internal and international trade on a firm footing (Nath, 2013).

21.7.4 Storage

Storage life is governed by several factors. These include variety, stage of maturity, rate of cooling, storage temperature, relative humidity, rate of accumulation of CO_2, prepacking and air-distribution systems. Optimum storage temperature and relative humidity requirements for different horticultural crops are mentioned in Table 21.2.

Table 21.2. Storage temperature and relative humidity requirements for important horticultural crops

Crops	Temperature (°C)	RH (%)
Tomato (ripe), brinjal, cucumber, bottle gourd,	8.5-10.0	85-95
Tomato (mature green), pumpkin, ginger, sweet potato	11.0-13	80-90
French bean, okra	7.0-9.0	85-95
Asparagus, lettuce	3.0-4.0	85-95
Potatoes, tamarillo, lima bean, cowpeas	4.0-5.5	80-90

21.8 POST-HARVEST SPRAYS AND EDIBLE COATINGS FOR ORGANIC PRODUCES

Composite coating of polysaccharides (cellulose, pectin, starch, alginate, and chitosan), proteins (casein, soy) and lipids (waxes, mineral oils) have been extensively used in controlling spoilage of horticultural crops . Antioxidants such as BHA(Butylated hydroxyanisole) and BHT (Butylated hydroxytoluene) are added to protect against oxidative rancidity, degradation and discoloration. Post harvest spraying of chemical, fungicides and growth regulators viz., calcium chloride, calcium nitrate, potassium per magnate ($KMNO_4$), gibberellic acid-3, 6- BAP, carbendazim, benomyl etc. (alone or in different combinations) will also extend the shelf life of various horticultural crops during storage (Nath, 2013).

21.9 PROCESSING AND VALUE ADDITION FOR ORGANIC PRODUCES

During the peak season and also to avoid market glut, organic fruits and vegetables may be processed, preserved and marketed during off season which will thereby minimizes the post harvest losses. Different value added products can be prepared such as RTS, squash, jam, jelly, candy, canned fruits, tomato sauce and ketch up, puree and paste, frozen and dehydrated product of capsicum, cabbage, French bean; oil, oleoresin, powder, pickle etc of ginger and turmeric (Nath, 2013).Organic processing standards prohibit the use of chemicals, many synthetic preservatives, artificial colourings and sweeteners and other food additives, whichare widely used in the processing of conventional foods (Beck et al., 2006).Organic processing aims to minimize the use of additives. Conventional food processing allows several hundreds of different types of food additives while organic processing allows only around 40 different additives and they are mostly natural substances. In organic processing 3 colourings, 4 preservatives, 13 antioxidants and other miscellaneous acids, salts, emulsifiers and stabilisers from plant and animal origin are permitted for use. Flavor enhancers and non-sugarsweeteners are forbidden

The processing industry for extraction of oil and oleoresin from fresh organically produced ginger has been established recently in two states i.e. Manipur and Mehalaya to process the surplus ginger from this region. In Sikkim the fresh large cardamom capsules, which are highly perishable and contain moisture upto 85 per cent are immediately cured to retain only 10-13 per cent moisture on dry weight basis. The retention of natural colour and flavour during curing process is most important. The flavour constituents are highly volatile and easily lost due to direct heat and higher temperature (>55 ^{o}C). Whereas the packed hot humid condition of curing chamber may result in discoloration and oozing of capsules. Earlies the curing was done only by Kilm system in which over the kiln a thin structure of bamboo just like a mesh is put on which freshly harvested fruits are spread for curing, wet and freshly cut wood which does not burn well and give a lot of smoke is used for fuel in the kiln so that temperature does not rise high. For good curing low temperature is required. This smoking will continue upto three days for complete curing. Approximately 25 per cent of fresh weight of fruit is recovered after curing. The colour of capsules remain dark pink brown and cannot be stored for longer time now a days Flue pipe system is used which has been found better than the kiln system since the colour of capsules remains a shiny pink. In Flue pipe system, flue from the furnace passes through the pipes. The harvested wet cardamom is spread over wire meshes fixed above the flue pipes. The product is dried over by the movement of hot air. It takes about 24-30 hours for product to dry. Cardamom produced by this system retains its colour and flavour, which fetches good price in the market. Recently an improved version of the flue curing system has been devised by CFTRI, Mysore that is known as natural convection (NC) dryer. The flue ducts can be easily dismantled and can be transported to other plantations. It has been the result of studying the previous systems. It has a drying area of 9 m^2 with a capacity of 300 kg raw capsules per shift which normally takes 24 hrs of continuos burning the fuel efficiency is also better with a ratio of 2.75:1 of fuel to raw capsule by weight. But such advance system is not available in the region. Hence, it is necessary to adopt an appropriate curing technique which involve indirect heating with optimum temperature range (50-55^oC) when other states of the region like Arunachal, Nagaland, Manipur and Meghalaya are also going to cultivate large cardamom at commercial scale.

Recently organically produced passion fruit is being promoted on commercial scale in many states like, Mizoram, Nagaland, Manipur, Meghalaya and Sikkim. The state governments in these states are going to install the processing units for production of concentrated juice, squash etc. However the processing plants are already have been installed in Mizoram. But for making a processing unit viable and profitable, raw material should be available in such a way that it runs for at least 10 months in a year. This is possible by crop diversification and product diversification.

21.10 QUALITY STATUS OF ORGANIC PRODUCES

Literature demonstrated the inconsistent differences in the nutritional quality of conventionally and organically produced vegetables with the exception of potentially higher levels of certain minerals, ascorbic acid and less nitrates in organic foods (Bourn and Prescott, 2002). However, these data are difficult to interpret, since cultivar selection and growing conditions varied widely and different methods of sampling and analysis were used in the investigations reviewed. Additionally, the majority of these studies did not assess levels of phenolic antioxidants, as their role in human health was not yet appreciated. However, it is generally agreed that the levels of secondary metabolites have the potential to differ the most between these two agricultural practices, since they are produced in response to stress (Brandt and Molgaard, 2001).

Different studies hadexamined the role of agriculture in the context of influencing the production of phenolic antioxidants in plants (Table 21.3). For example, in two studies conducted by Carbonaro and Mattera, (2001) higher levels of total phenolics were found in organic peaches and pears when compared with their conventional counterparts. In a study of five vegetables common in the Japanese diet, Ren *et al*. (2001) demonstrated that organically grown spinach contained 120 percent higher antioxidant activity while Welsh onion, Chinese cabbage and qing-gen-cai contained 20-50 percent higher antioxidant activity compared to their conventionally grown counterparts (Ren *et al.*, 2001). Asami *et al.* (2003) also found consistently higher levels of total phenolics and ascorbic acid in organic strawberries, marionberries and sweet corn.Conversely, Hakkinen and Torronen (2000) reported that organic cultivation had no consistent effect on the levels of phenolic compounds in strawberries.

Contemporary literature illustrates an apparent trend toward higher levels of phenolic antioxidants, ascorbic acid and soluble solids in organic foods. However, there are still far too few studies completed to establish a consensus regarding the health benefit of organic foods. Ultimately, more research examining relationships between agricultural production and the synthesis of phyto-chemicals in specific crops is needed.

It has been hypothesised that an important aspect of all life is the ability to maintain form and structure (reducing entropy), and that this aspect of a crop at harvest will inûuence how it performs in storage (Abele, 1987 and Hoppe, 2000). A better keeping quality of organically grown produce is sometimes claimed to be sufficient to overcome any initial yield disparity with non-organically grown produce (Pettersson, 1978). Many researchers have therefore compared the storage capabilities and qualities of organically and non-organically grown produce, and valid studies reviewed here have yielded the following results:

Dlouhy (1981) reported that organically grown potatoes had 29 per cent lower storage losses than non-organically grown potatoes (14.9 versus 20.9 per cent respectively). Forced-storage degradation tests on carrots, beetroots and potatoes indicated better product quality from lower fertilization levels or organic fertilisation than non-organic fertilisation, while under optimal storage conditions only small differences occurred (Abele, 1987). DeEll & Prange (1993) recorded the percentages of marketable apples remaining after four and eight months storage were higher for non-organically grown apples than organically grown apples(mainly dependent on external appearances and linked by the authors to fungicide use by the non-organic orchards). No signiûcant differences due to production methods

Table 21.3. Literatures on different quality parameters of organic products studied and their findings

S.No.	Experimental materials/Crops	Parameters Analyzed	Findings	References
1	Marionberry, strawberry, corn	Total phenolics (TP), ascorbic acid (AA)	Increased TP and AA inorganic and sustainable practices	Asami *et al.,* 2003
2	Peach, pear	Polyphenoloxidase activity (PPO), TP	Increased TP and PPO activity in organic fruit	Carbonaro and Mattera, 2001
3	Peach, pear	PPO activity, TP, AA, citric acid (CA), á-tocopherol (TH)	Increased TP and PPO activity in organic fruit; AA and CA higher in organic peaches, á-TH higher in organic pear and lower in peach	Carbonaro *et al.,* 2002
4	Human excretion Metabolites following organic vs conventional diets	Quercetin (Q), kaempferol (K), hesperetin (H), naringenin, isorhamnetin (I)	Organic foods had higher Q, trends of higher K andlower I; Higher urinary excretion of Q and K in organic diet	Grinder-Petersen *et al.,* 2003
5	Vaccinium berries, strawberry	Q, K, ellagic acid, p-coumaric acid	No consistent difference between organic and conventional techniques	Häkkinen and Törrönen, 2000
6	Qing-gencai, Chinese cabbage, spinach, welsh onion, green pepper	Antioxidant and antimutagenic activity, flavonoids (Q, K, H, caffeic acid, myricetin, quercitrin, esperitin, apigenin, baicalein)	Higher antioxidant activity in organic spinach, onion, cabbage, qing-gen -cai, nodifference in green pepper; antimutagenic activity higher in organic samples; Generally higher flavonoids in organic samples	Ren *et al.*, 2001

were found for core browning or weight loss in storage. However, senescent breakdown, 'the browning and softening of apple ûesh beginning immediately under the skin associated with ageing and advanced maturity', tended to be less in the organically grown than the non-organically grown apples.

Mader *et al* (1993) studied the 'storability' of beetroot (percentage marketable, percentage rotten roots, weight loss) and they found similar for all farming systems (unfertilised, organic, non-organic and integrated). Vogtmann *et al* (1993) reported that organically grown carrots and cabbage performed better in storage (measured by dry matter losses, colour, appearance, fungal growth, maintenance of structure, smell) than non-organically grown carrots and cabbage. Raupp (1996) studied the organically grown potatoes had better storage qualities(percentage dry matter loss and darkening) than non-organically grown potatoes, while storage qualities of organically and non-organically grown beetroots were inconsistent (similar percentage dry matter loss but less spoilage losses for non-organically grown beetroot: four per cent compared to 13–19 per cent for organic).

Organically grown potatoes suffered 15 per cent fewer storage losses (due to respiration and fungal damage) than the non-organically grown potatoes (averaged22.7 versus 26.7 per cent respectively) (Granstedt & Kjellenberg, 1997). Weibel *et al* (2000) carried out forced-storage degradation tests (measuring water loss and fungal contamination) found no significant differences between apples from organic and non-organic (integrated) orchards.

While these studies suggest a better or at least equal keeping quality of organically grown produce, agriculture makes extensive use of controlled atmosphere storage facilities and post-harvest fungicide applications to reduce storage losses. Time since harvest, storage conditions and post-harvest waxing or fungicidal treatment of non-organically grown produce can all confuse the consumer perception of the relative keeping qualities of organically and non-organically grown produce.

21.11 THRUST AREAS FOR POST HARVEST AND VALUE ADDITION OF ORGANIC PRODUCES

Considering the limited and dwindling land and water resources, slow growth in productivity and ever increasing population, minimizing post harvest losses of organic produces is one of the most effective and economical ways of increasing per capita food availability. Post harvest technology of organic produces should be location specific. However, the present requirement is to develop need based and market driven post harvest technology of organic produces for loss prevention and generation of raw materials of horticultural origin. Post harvest losses could be substantially reduced by adopting improved equipments and processes.

21.12 CONSTRAINTS OF POST HARVEST MANAGEMENT OF ORGANIC PRODUCES

1. Produce handling and marketing is in the hands of middlemen who do not bother about marketing standards, grading and scientific packaging of organic produces separately.
2. Post harvest quality control of organic produces is almost non-existent resulting in considerable damage and wastage.
3. Wide gap in technologies available and applied in organic produces.
4. Absence of pre-cooling and cold storage facilities for organic produces.
5. Long distance between production and major consumption areas having rough, rugged and poorly maintained road.
6. Inadequate facilities in the markets for organic produces.
7. Lack of market intelligence and market information for organic produces.
8. Inadequate storage facilities for organic produces.

21.12.1 Processing constraints

1. Absence of processing facilities for organic produces
2. Non-availability of raw materials for organic produces
3. High cost of basic packaging raw material for organic produces
4. High transportation cost for organic produces.
5. Lack of trained manpower in post harvest handling and processing for organic produces.

The post harvest management of organic fruits and vegetable crops is in underdeveloped stage in country and there is an urgent need to look into more closely at some basic aspects of post harvest management of organic produces. This will help to increase the per capita availability, improve the economic condition of the farmers and ensure even distribution of fruits and vegetables throughout the country.

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Chapter 22

QUALITY PARAMETERS AND BIOCHEMICAL CHARACTERISTICS OF PRODUCES UNDER ORGANIC FARMING

A.B. Singh

22.1 INTRODUCTION

Quality parameters of food grains, fruits and vegetables are generally controlled genetically but agricultural practices, like use of fertilizers, irrigation, tillage operations, climatic conditions and soil conditions during the growing season, weather conditions at harvest and harvesting techniques influence the produce quality. Organic manures application plays a vital role in maintenance of chemical, biochemical and biological properties of soils, besides, supplementing macro and micro nutrients to crop. Quality of the agricultural produce, particularly fruits and vegetables improves when the nutrients are supplied through organic manures than in the form of fertilizers. This is because of the supply of the all the growth principles substances like enzymes, hormones, growth regulators etc., besides, all the essential plant nutrients from the organic manures. As a result, the metabolic function get regulated more effectively resulting in better synthesis of proximate constituents and consequent improvement in the produce quality.

Healthy soils equal healthy food equals healthy people" is a fundamental tenet of many ecological farming systems. A clear understanding of the relationships between farming systems and crop nutritional quality is very important for designing agricultural management strategies which enhance environmental quality and sustainability while improving consumer's health. It is well known fact that fertilizers and organic manures are not substitute for each other however, their role is complementary. The accurate measurement of quality is essential for meeting both regulatory requirements and the consumers need. Growers often enquire for data on the nutritional quality of organic food (grains, fruits, vegetables) to that of conventionally raised food.

22.2 ACCORDING TO SOIL ASSOCIATION THE SIX ASPECTS OF FOOD QUALITY ARE

Sensual: how good it feels to eat. Taste, smell, texture, look, feel; that wonderful blend of sensations when you bite into a freshly picked apple.

Authenticity**:** the food which consumers expect. Food which has not been synthesized or adulterated in production, processing or storage. Bread, where the browness is real, not an added ingredient to white bread.

Functional: how appropriate food is to its specific purpose. For example, the way different varieties of potatoes are more or less suitable for boiling, baking, roasting or frying.

Nutritional: how it contributes to a balanced diet. Recognizing individual food's value by the vitamins, protein or trace elements present.

Biological**:** how it interacts with the body's functioning. Allergic reactions to additives, the effects of agri-chemical residues; beneficial role of live yoghurt on the gut flora, etc.

Ethical: environmental, social and political values. How food production treats animals, the environment, and the people producing the food.

Environmental and cultural practices that influences the nutritional composition and the resultant food quality

Environmental	Cultural practices
• Geographical area	• Green manuring & composting·
• Soil type	• Variety
• Soil moisture	• Seed source
• Soil health(humus content, fertility, microbial activity)	• Length of growing season • Irrigation
• Weather & climatic conditions (temp., rainfall, flooding, drought)	• Fertilization • Post harvest handling
• Pollution	(especially temperature & RH)

A report appeared in Agricultural Outlook 2003, showed that there is change in the consumption pattern of consumers over the years. Consider quality more than the price and sweetness, freshness and price are in the order. Fruits with high sugar content are much appreciated in the market.

Table 22.1: Consideration factors of consumers in purchasing fruits

Year	Sweet--ness	Fresh--ness	Price	Safety	Place of origin	size	Colour	Shape	Nutrition
1993	29.0	27.2	26.5	10.0	-	2.4	1.2	0.3	3.5
2003	47.3	28.6	15.1	2.61	1.8	1.6	1.5	0.9	5.5

Agricultural outlook (2003)

There are various methods/ techniques for determining quality of grains/ seed. It can be broadly classified as destructive or non-destructive depending on the type of quality test. They can also be classified as physical, chemical and biochemical methods.

22.3 PHYSICAL METHOD

22.3.1 Grain appearance

Attributes of interest to the consumers are visual appearance, size, shape and color. Bold grain with attractive color, shape and luster fetch higher price in the market. Portable mini spectrometers are used to measure the colour of fruits and vegetables. Other equipments used are penetrometer (measures firmness), texture analyser (texture), callipers (size) etc.

22.3.2 Vitreous kernel

It is often related to hardness of the grain, which in turn is a rough index of protein and gluten content in the grain. Using X ray film, viewer can check the vitreousness in the grain and video densitometry can also be used.

22.3.3 Sieves

Are used for the assessment of foreign matter from the grain. Damaged and infected kernel and foreign matter affect the overall quality of product.

22.3.4 Test weight

It contributes to milling quality of wheat. Grain weight considered being a function of grain size and its density while test weight determines the plumpness of the grain. Electronic counter is used to measure test weight i.e. weight of 1000 grains.

22.3.5 Hardness

Hardness of grain mainly contributes to the quantity of flour. Hard grain gives more flour than the soft grain. In case of wheat, the flour derived from hard grain absorbs more water than soft one which influences crumb softness and shelf life of the product. Wheat hardness Index can be calculated by using barbender hardness tester. Near infrared reflectance (NIR) is extensively used for testing the hardness of grain.

22.3.6 Moisture content

The standard test method (ISO 712) for the determination of moisture content in cereals is by moisture loss in a hot-air oven.

22.3.7 Bulk density

The bulk density of grain is the weight per unit volume. Moisture content and presence of foreign matter has an appreciable effect on the bulk density. Consequently it is standard practice to remove as much foreign matter as possible by sieving samples before carrying out bulk density determinations.

22.3.8 Ash content

High ash content (>0.4 per cent) in flour adversely affects the quality of end product. It can be determined by heating the sample in Muffle furnace with temperature regulator up to temperature 500 ^{0}C – 550 ^{0}C.

22.4 CHEMICAL METHOD

Amongst chemical constituents of grain/ seeds- carbohydrates, proteins, fats/lipids, vitamins, antioxidants, anti- nutrients and pigments are important constituents of quality parameters.

22.4.1 Carbohydrates

The quality of carbohydrate in food is measured based on glycemic index (GI). GI of food is a ranking of foods based on their immediate effect on blood glucose (blood sugar) levels. Choosing low GI carbs - the ones that produce only small fluctuations in our blood glucose and insulin levels - is the secret to long-term health reducing risk of heart disease and diabetes and is the key to sustainable weight loss. Carbohydrate in food that breakdown quickly during digestion have the highest GI e.g. Fructose 23, Glucose 100, Honey 58, Lactose 46, Maltose 100 and Sucrose 65, amongst the above sugars fructose with low GI is the best sugar.

Amongst the rice brown rice followed by basmati is best for consumption. Cherries have low GI value while it is highest in watermelon. Onions, lettuce, broccoli have lower GI.

22.4.2 Proteins

Protein content in foods vary according to their origin, their amino acid composition (particularly content of essential amino acids), their

Table 22.2: Glycemic index (GI) of grains, fruits and vegetables

Food **Cereals**	GI	Food **Vegetables**	GI
Basmati Rice	58	Beets	69
Brown Rice	55	Cabbage	10
Long grain white rice	56	Carrots	49
Short grain white rice	72	Onions	10
Fruits		Pumpkin	75
Banana	55	Beans	
Cherries	22	Broad beans	79
Grapes	46	Chick peas	33
Mango	55	Red kidney beans	27
Papaya	58	Soya beans	18
Pine apple	66	White beans	31
Water melon	103	Broccoli	10
Apple	38	Lettuce	10
Orange	44	Green peas	48
Kiwi	52	Sweet potato	54

digestibility, texture, etc. Good quality proteins are those that are readily digestible and contain the essential amino acids in quantities that correspond to human requirements. Protein quality can be assessed by following methods:

- Protein Digestibility Corrected Amino Acid Score (PDCAAS): is a method of evaluating protein quality based on the amino acid requirement of the humans being.
- Biological value (BV): is a measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body.
- Protein efficiency ratio (PER): is based on the weight gain of a test subject divided by its intake of a particular food protein during test period.

  PER= gain in body mass (g)/ protein intake (g)

x= % methionine defficiency in to samples with reference to whole egg protein

x = 100- % chemical score

$$\% \text{ Chemical score} = \frac{\text{methionine (g/16 g N)} \times 100}{3.36 \text{ (egg methionine g/16g N)}}$$

For tryptophan 4.0 and cysteine 2.24 g/16 g N (Block and Mitchell (1946).

The PDCAAS value is different in measuring the quality of protein from the PER and the BV methods. The PER was based on the amino acid requirement of growing rats, which noticeably differ to that of humans. Food proteins differ in their nutritional quality depending on their amino acid profile and digestibility. Cereal grains, in general, are deficient in the essential amino acids lysine and threonine or tryptophan which limit the nutritional quality of cereal- grain protein. On the other hand, pulses are rich in lysine, but are limiting in sulphur- containing amino acids, mainly methionine. When cereals are taken in combination with pulses, the deficiency of one is made good by the excess in another.

22.4.3 Fats/lipids

Fatty acid composition depends on the sources of the oils. Oils with high unsaturated fatty acids are best for consumption. The unsaturated to saturated fatty acid ratio was The highest in safflower oil followed by sunflower oil. It was the least in coconut oil.

- Temperature : higher linoleic : Oleic in sunflower at low temperature during rabi
- Light: higher linoleic : Oleic in rapeseed under low light
- Fertilizer: Cotton seed oil, acid saponification and iodine values decreased with increased nitrogen

22.4.4 Anti-nutritional factors

Some of the compounds in grains/seeds are responsible for lowering the quality of produce

22.4.4.1 Heat labile factor

Trypsin inhibitors, Phyto-haemagglutinins (lactines), Goitrogens and Anti-vitamin and metal -binding factors, phenols and tannins

22.4.4.2 Heat stable factor

Cyanogens, Lathyrogens (Osteo and neuro) and Flatulence factors.

22.4.4.3 Vitamins

There are many indispensable vitamins, which we mainly get from grains/seeds. Thus estimation of vitamins is very important to know the nutritional value of particular grain/seeds.

22.5 NUTRITIONAL ASPECTS OF PRODUCE QUALITY

The quality of harvested crop can be categorized according to the purpose for which the crop was produced.

Nutritive value**:**	The content and composition of constituents are used as criteria.
Processing quality**:**	It is determined the appearance of the produce and the content of certain constituents, which positively affect recoverability.
Marketability**:**	It consists mainly of organoleptic as well as visible characteristics e.g. shape, taste, colour etc.
Transportability/ storability:	It is closely related to marketability of the produce.
Freedom from pest or disease:	Lesion, discolorations, mouldiness not only affect the consumer but also often hazardous to health or reduce storability. In addition to above, the qualities of produce have become increasingly important issues due to

i) High nitrate, phenols, tannin, trypsin inhibitors, oxalate, phytate and heavy metals content in vegetables and grains.

ii) Changing food habits, functional food *viz.*, lycopene in tomato, allicin in garlic or iso-flavones in soybean are associated with prevention or treatment of cancer, diabetes, hypertension and heart diseases.

iii) Adverse effect of some pollutants S, Cd, Pb, Hg, As and NO_3 in human health and the foods such as milk animal and poultry food and water pollution are becoming source of such problems.

22.6 CEREALS PRODUCE QUALITY UNDER ORGANIC FARMING

Consumer awareness of the relationship between foods and health, together with environmental concerns, has led to an increased demand for organically produced foods. In general the public perceives organic foods as being healthier and safer than those produced through conventional agricultural practices. It is also reported that organic grains have less protein than conventional grains, but this protein is of a higher quality, i.e., it has more pure protein and essential amino acids, and lower free amino acids (Worthington, 2001; Woese *et.al.*, 1997).

Table 22.3: Effect of various organic manures combinations on wheat grain quality

Treatment	Mineral (%)	Protein (%)	Tryptophan (g /16 g N)	Methionine (g /16 g N)	Grain yield (kg/ ha)
Cattle dung manure + poultry manure	1.55	12.14	1.30	1.58	3942
Cattle dung manure + vermicompost	1.55	11.61	1.32	1.53	3770
Poultry manure + vermicompost	1.58	11.90	1.34	1.57	3860
Cattle dung manure + vermicompost+ poultry manure	1.54	11.74	1.39	1.59	4130
Control	1.50	11.31	1.28	1.52	2925
CD (0.05)	NS	0.20	NS	NS	219

Table 22.4: Chemical and bread production characteristics of wheat grain

	Protein content (% dm)	Total Phenols GE mg/g	Ash (% dm)	Gluten Index (%)	SDS (ml)	W (J 10-4)	P/L index
			2004				
Conventional	14.6	0.50	1.64	99.3	69.3	117	0.29
Organic	11.4	0.44	1.71	97.3	54.0	82	0.84
	*	n.s.	n.s.	**	n.s.	*	*
			2005				
Conventional	13.3	0.53	1.78	80.1	51.0	145	0.48
Organic	10.3	0.49	1.84	83.6	30.0	49	0.85
	*	n.s	n.s.	n.s.*	n.s	*	*

Mazzoncini et al (2007) *significant for $p<0.05$, P-resistance to stretching, L-extensibility

Singh *et al* (2008) have observed that the higher value of protein and amino- acids were recorded under various combinations of organic manure application as compared to control. Nutritionally better quality of wheat grains obtained in organically treated plots may be ascribed to the availability of the essential nutrients in the organic matter due to its continuous mineralization.

22.7 PULSES/LEGUMES CROP QUALITY UNDER ORGANIC FARMING

There has been progressive decline in the per capita availability of pulses from 60 g per day in 1951 to 27 g in 2001. The per cent contribution

Table 22.5: Effect of various organic manures and their different combinations on chickpea quality

Treatment	Mineral (%)	Protein (%)	Methionine (g /16 g N)	Cysteine (g/16 g N)
Cattle dung manure + poultry manure	2.7	19.9	1.67	1.44
Cattle dung manure + vermicompost	2.8	19.3	1.66	1.46
Poultry manure + vermicompost	2.8	19.3	1.69	1.47
Cattle dung manure+ vermicompost+poultry manure	2.8	20.1	1.73	1.52
Control	2.7	18.2	1.46	1.34

Singh *et al* (2008)

Table 22.6 : Quality of soybean as influenced by management practices

Treatment	Protein (%)	Oil (%)	Methionine (g /16 g N)
100 % Organic	36.8	19.1	1.71
75 % Organic Innovative	36.4	18.8	1.66
50 % Organic + 50 % Inorganic	35.8	18.7	1.63
75 % Organic + 25 % Inorganic	35.9	18.7	1.65
100 % Inorganic	35.5	18.6	1.58
State recommended dose	35.6	18.1	1.56
CD(P=0.05)	0.1	0.03	0.03

Table 22.7: Effect of different nutrient sources application on pomegranate quality parameters

Treatment	TSS (%)	Sugar (%)	Acidity (%)	Vitamin C mg/100g	Carotene Mg/100g	Tannin (%)
Control	15.5	10.4	0.31	16.0	2.10	0.48
Vermicompost	16.8	11.7	0.26	17.5	2.29	0.42
Phosphocompost	16.7	12.0	0.24	17.7	2.25	0.41
Cattle dung manure	17.4	12.5	0.25	17.8	2.37	0.40
RDF (400:250:200 g NPK plant^{-1})	16.5	11.5	0.27	17.4	2.29	0.47
50% RDF+ 50% CDM	17.3	12.6	0.25	17.9	2.48	0.40
CD (P=0.05)	0.09	0.11	NS	0.12	NS	NS

of pulses to total food production has declined from 11.01 per cent in 1970 to 6.5 per cent in 2001-2002. Among various essential amino-acids, tryptophan, methionine and cysteine amino-acids are considered to play an important role in various metabolic processes. Methionine and cysteine which are essential sulphu-containing amino-acids in most of the food legumes considered to be a source of transmethylation reaction, are of vital importance in plants and animals. In the on going experiment of organic farming experiment, higher values of protein, oil and methionine were recorded in 100% organic treatment than others. This may be due to supply all growth-promoting substances, like enzymes, hormones, growth regulators etc besides all the essential plant nutrients from the manures. This might have been instrumental in effective regulation of the metabolic functions leading to better synthesis of proximate constituents and consequent improvement in the quality of the produce. The results are in conformity with the findings of Ramamurthy and Shivashankar (1995). (Devi *et al* 2013) reported that the application 75 per cent RDF with vermicompost at the rate of 1 t ha^{-1} and PSB produced significantly higher oil and protein content of soybean seed. This could be due to better availability of desired and required nutrients in the crop root zone resulting from its solubilisation caused by the organic acids produced from the decaying organic matter and also the increased uptake by soybean.

22.8 FRUITS AND VEGETABLES CROPS

There are various physical, chemical and biological parameters used in the analysis of fruits and vegetable quality study-

It has been observed that pomegranate fruit quality parameters such as sugars, TSS and ascorbic acid content increased significantly with the application of INM, organic and inorganic management systems. The maximum TSS was recorded in cattle dung manure treatment. The minimum juice acidity was recorded due to application of organic, inorganic and integrated nutrient sources, while, it was maximum in control. Higher accumulation of ascorbic acid was recorded in INM treatment followed by organics and inorganic treatments and was the lowest in control.

Understanding how environment, crop management and other factors particularly soil fertility, influence the composition and quality of food crops is necessary for the production of high quality nutritious foods. Healthy soils equals' healthy food equals healthy people" is a fundamental tenet of many ecological farming systems. There is a need to systematically work on produce quality improvement in relation to balanced nutrition of crops. The accurate measurement of quality is essential for meeting both regulatory requirements and the consumers need. Growers often enquire for data on the nutritional quality of organic food (grains, fruits, vegetables) to that of conventionally raised food. It would be interesting to compare the organic manures alone and in association of inorganic fertilizers on quality improvement of a variety of field crops, fruits and vegetables. There is a real need for evaluating the role of organic farming practices especially the nutrient inputs on the quality of the economic produce.

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Chapter 23

CARBON SEQUESTRATION AND GHG EMISSION UNDER ORGANIC PRODUCTION SYSTEMS

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23.1 INTRODUCTION

Organic agriculture proved its potential to reduce the GHG emissions through carbon sequestration and use of less input (Gattinger *et al*., 2012). Therefore in the context of climate change, conversion from conventional agriculture to organic agriculture is being considered as one of the appropriate farming system that could serve the twin objectives of climate change mitigation and environment protection (Lal, 2004a; FAO, 2011). Promotion and adaptation of organic farming in developing country like India can be one of the effective mitigation strategies of climate change. Soil carbon sequestration at a global scale is considered the mechanism responsible for the greatest mitigation potential within the agricultural sector, with an estimated 90% contribution to the potential of what is technically feasible (Smith *et al.* 2007 and Smith, *et al.* 2008). However, global soil carbon stocks of agricultural land have decreased historically and continue to decline (Lal 2004). Thus, improved agronomic practices that could lead to reduced carbon losses or even increased soil carbon storage are highly desired. This includes improved crop varieties, extending crop rotations, notably those with grass–clover or forage legume leys that allocate more carbon below- ground, avoiding or reducing use of bare (unplanted) fallow (Freibauer *et al.* 2004) and the application of organic fertilizer such as compost or waste products from livestock husbandry in the form of slurry or stacked manure (Diacono and Montemurro 2010). Although these practices are not common in current modern agriculture, they are core practices of organic agriculture, where crop production relies in large part on closed nutrient cycles by returning plant residues and manures from livestock back to the land and/or by integrating perennial plants, mainly grass–clover mixtures, into the system. It is therefore hypothesized that the adoption of organic agriculture will lead to a reduction in soil carbon losses or even to higher soil carbon concentrations and net carbon sequestration over time (Niggli *et al.*2009).

An increase in the atmospheric concentration of carbon dioxide (CO_2) from 280 parts per million (ppm) in the pre-industrial era to 390 ppm in 2010 and other greenhouse gases (GHGs),such as nitrous oxide (N_2O) and methane (CH_4), may accentuate radiative forcing and alter the Earth's mean temperature and precipitation (IPCC, 2007). The strong impact on radiative forcing, there is increasing emphasis on identifying strategies that will reduce the rate of enrichment of atmospheric CO_2 by offsetting anthropogenic emissions. The focus, therefore, is on sequestration of CO_2 from the atmosphere or point sources. There is a strong interest in stabilizing the atmospheric abundance of CO_2 and other GHGs to mitigate the risks of global warming.

Three strategies are available for lowering CO_2 emissions to mitigate climate change (Schrag, 2007): (i) reducing global energy use; (ii) developing low or no-C fuel; and (iii) sequestering CO_2 from point sources or atmosphere using natural and engineering techniques. Organic agriculture offers a unique combination of environmentally-sound practices with low external inputs while contributing to food availability (Zundel *et al.,* 2007). Recent studies have highlighted the substantial contribution of organic agriculture to climate change mitigation and adaptation (Niggli *et al.,* 2009; Scialabba and Muller-Lindenlauf, 2010,in print). The potential of organic agriculture to mitigate climate change is mostly claimed on the basis of assumptions concerning the soil carbon sequestration potential of organic management. Terrestrial carbon sequestration is proposed by scientists as an effective mitigation option because it combines mitigation with positive effects on environmental conservation and soil fertility (Smith, 2007). In principle, organic farming basically depend upon the crop rotations, crop residues, animal manures, farm organic waste, mineral grade rock additives and biological system of nutrient management and pest and disease control. It avoids the use of chemical fertilizers, pesticides, hormones, feed additives etc. Therefore, organic agriculture is looked as one of the solutions for climate change mitigation because it emits much lower levels of greenhouse gases (GHG), and also effectively sequesters carbon in the soil (Panwar *et al.,* 2010; IFOAM, 2009).

In addition to this organic agriculture also makes farms and people more resilient to climate change, mainly due to its water efficiency, resilience to extreme weather events and lower risk of complete crop failure. According to the Codex Alimentarius Commission, "organic agriculture is a holistic production management system that avoids use of synthetic fertilizers, pesticides and genetically modified organisms, minimizes pollution of air, soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people." To meet these objectives, organic agriculture farmers need to implement a series of practices that optimize nutrient and energy flows and minimize risk, such as: crop rotations and enhanced crop diversity; different combinations of livestock and plants; symbiotic Nitrogen fixation with legumes; application of organic manure; and biological pest control. All these strategies seek to make the best use of local resources. Hence, organic systems are inherently adapted to site specific endowments and limitations. Essential practices of organic agriculture used to supply nutrients without mineral fertilizers are known to have positives effects on soil carbon, in particular manure application or legume cultivations. Currently, approximately 8.3 Pg C yr^{-1} is emitted by fossil fuel combustion (IPCC, 2007; WMO, 2010) and 1.6 Pg C yr^{-1} by deforestation, land-use change and soil cultivation. The total for anthropogenic emissions is 9.9 Pg C yr^{-1}, of which 4.2 Pg C yr^{-1} is absorbed by the atmosphere and 2.3 Pg C yr^{-1} by the ocean. The remainder may be absorbed by unidentified terrestrial sinks. Niggli *et al.* (2009) estimated the global average sequestration potential of organic croplands to be 0.9-2.4 Gt CO_2 per year, which is equivalent to an average sequestration potential of about 200 to 400 kg C per hectare and year for all croplands. Critiques mention that organic agriculture hinders no-tillage, which is considered to be another strategy with high soil carbon sequestration potential. No-tillage is difficult to implement in organic agricultural systems because of the accompanied insurgence of weeds that cannot be treated with herbicides such as done in conventional systems. High carbon sequestration potential is also reported in grassland soils (Smith *et al.*, 2007). As pastures are the favoured feeding strategy for organic cattle, organic livestock production is an option for profitable maintenance of grasslands. Combined with a limited livestock density to prevent overgrazing, organic grassland farming could be a way to optimize carbon sequestration in grasslands (Rice, 2001; Liebig, 2005). The global carbon sequestration potential by improved pasture management practices was calculate to 0.22 t C ha^{-1} $year^{-1}$ (Watson *et al.,* 2000). Organic agricultural projects sequester carbon both in above ground (e.g. trees, hedges, permanent crops) and in below-ground (soil organic carbon) stocks. For grassland and annual crops, the primary carbon stock is below ground. Most of these ecosystems have large annual carbon uptake rates, but much of the gain is exported in the form of agricultural products and their associated waste materials; this gain is rapidly released to the atmosphere. In agroforestry and perennial crops, additional remarkable amounts of carbon are stored above ground in wooden plant biomass (Watson *et al.*, 2000).

23.2 EFFECT OF CLIMATE CHANGE ON AGRICULTURE

- With increased carbon dioxide and higher temperatures, the life cycle of grain and oilseed crops will likely progress more rapidly.
- The marketable yield of many horticultural crops, such as tomatoes, onions and fruits, is very likely to be more sensitive to climate change than grain and oilseed crops.
- Climate change is likely to lead to a northern migration of weeds. Many weeds respond more positively to increasing carbon dioxide than most cash crops.
- Disease pressure on crops and domestic animals will likely increase with earlier springs and warmer winters.
- Projected increases in temperature and a lengthening of the growing season will likely extend forage production into late fall and early spring.
- Climate change-induced shifts in plant species are already under way in rangelands. The establishment of perennial herbaceous species is reducing soil water availability early in the growing season.
- Higher temperatures will very likely reduce livestock production during the summer season, but these losses will be partially offset by warmer temperatures during the winter season (Backlund *et al.*, 2008)

23.3 IMPACTS OF ORGANIC AGRICULTURE

Organic agriculture has various positive environmental effects, chiefly enhancing biodiversity (Hole *et al.*, 2005; McNeely, 2001) and reducing the energy use for agricultural production (Ziesemer, 2007). Organic agricultural practices show ways of efficient nutrient management, which is going to become even more important in times of limited resources. Organic agricultural practices can contribute to a more efficient use of nitrogen by planting legumes and catch crops and integrated livestock production. Integration of landscape elements and higher soil organic matter contents increase the water capturing capacity of the agricultural system and lower the risk of soil erosion. Hence, the risk of yield losses by extreme weather events is lowered (Lotter, 2003). Abstention from all chemical pesticides avoids the risk of health damage by chemicals for farmers and consumers. Water quality is increased both by lower nitrate leaching and abstention from agro-chemicals (Stolze *et al.,* 2000). Cropping systems productivity under Organic agriculture system is good, natural ecosystems are saved, in particular forests, resulting in higher overall sequestration rates from both cropped soils and forested areas. In organically managed soils, carbon sequestration occurs in deeper soil layers, most likely through the cultivation of deep rooting legumes.

23.3.1 Capacity of organic practices to enhance C storage

There is scientific evidence that organic agriculture can sequester more carbon than conventional agricultural practices or inhibit the carbon release. All available studies showed higher carbon stocks in organic systems as compared to conventionally farmed sides. To avoid leakage, organic agricultural systems should achieve yields comparable to conventional systems, which are likely for areas where currently low-input agriculture is practiced or where soil quality is degraded.

23.3.2 GHG emission from organic production systems

It is believed that shifting from conventional crop production systems to organic crop production systems would significantly lower the emission of greenhouse gases because organic production systems produce smaller amount GHG emissions than conventional industrial farming systems (Meredith, 2008; Mullar, 2009; Pandey and Singh, 2012). Global adoption of organic agriculture has the potential to sequester up to the equivalent of 32% of all current man-made GHG emissions (Jordan *et al.*, 2009). FAO also stated that organic systems contribute less to GHG emissions due to use of lower energy inputs and sequesters more carbon in the biomass than conventional systems (Ziesemer, 2007). Eyhorn *et al.* (2007) reported that organic farming is a low-risk farming strategy with reduced input costs, therefore, lower risks with partial or total crop failure due to extreme weather events or changed conditions in the wake of climate change and variability. Aher *et al.* (2012) reported that organic yields match with the conventional yields and organic farming uses 45% less energy and is more efficient than the conventional farming systems.

Introducing organic farming is considered an interesting and sustainable option for greenhouse gas (GHG) mitigation in agriculture. In contrast to the adoption of single GHG mitigation practices, organic farming as a systems approach provides many other co-benefits, such as adaptation to climate change, biodiversity and soil conservation, and the improvement of rural livelihood at the same time (Muller A, *et al.* 2012).

As Nitrogen is far more limited in organic systems, there is a strong incentive to avoid losses and enhance soil fertility (Stolze *et al.*, 2000).

Catch and cover crops as well as intercropping, which are all common practices in organic farming, extract plant available Nitrogen unused by the preceding crop and keep it to the system. Therefore, they reduce the level of reactive Nitrogen in the topsoil, which is the main driving factor for N_2O emissions (Ruser *et al.,* 2001; Smith *et al.,* 1998). A comparative study showed lower overall emissions of the organic system as compared to the conventional system, even though very high emissions occurred after incorporation of legumes (Flessa *et al.,* 2002). Thus there seems to be a trend towards lower N_2O emissions in organic agricultural systems.

Methane emissions from enteric fermentation can be higher in organic systems with cattle. The quantity of methane emitted per product unit depends on the animal diet and the cow breed's performance. High milk yields per cow reduce emissions per product unit. High energy feedstuff (e.g. grains, soy) can additionally reduce emissions because methane emissions mainly derive from the digestion of fibre from roughage. In developed countries, organic management usually achieves lower milk yields per cow than conventional production.

However in developing countries, where two thirds of the enteric methane emissions occur, organic systems achieve higher milk yields, as more careful management improves the relatively low performance of traditional systems (Badgley, 2007). Furthermore, the roughage fed in organic systems mostly derives from grasslands, which by that can be productively used and conserved for nature conservation and carbon sequestration. Feeding cattle with grains in stead of roughage to lower methane emissions can become a risk for food security and should be considered critically. To sum up, for organic agriculture projects including cattle, methane emissions must be carefully assessed but also counter-balanced with positive carbon effects derived from grassland conservation. Emissions of N_2O are likely to be lower under organic management. Where cattle production is included, methane emissions must be counterbalanced with positive carbon effects.

23.4 STATUS OF ORGANIC AGRICULTURE IN INDIA

India having the total geographical area of 328.73 million hectares consists 142.02 million ha net sown area and 63.26 million hectares net irrigated area. Organic farming is a state of art in India and is being followed by the farmers from the ancient times and the crop production system was mostly organically managed till the introduction of chemical fertilizers and pesticides in Indian agriculture (Pandey and Singh, 2012; Wani *et al*., 2013) It is also known by the various names *viz.,* Vedic krishi, biodynamic farming, nature farming, eco-farming, traditional organic farming and homa farming etc. In India only 30% of total cultivable area is covered with fertilizers where irrigation facilities are available and in the remaining 70% of arable land, which is mainly rain-fed, negligible amount of fertilizers is being used and mostly managed by farm yard manures or compost (Maity and Tripathi, 2004). Area under organic farming in India increased from 42,000 hectares in 2003-04 to more than 4.43 million ha in 2010-11. The cultivated area under organic farming accounts to 0.77 million ha while remaining 3.65 million ha was wild forest area (Yadav, 2012). Among the states, Madhya Pradesh comprise largest area under organic farming followed by Himachal Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Uttarakhand, Karnataka, Gujarat, Tamil Nadu and Orissa. The area under all most all states increased from 2007-08 to 2010-11 except in the state of Gujarat. But area under organic farming increased several fold in the state of Madhya Pradesh as compared to other states of the country. In case of north east states of India, Mizoram consist of the highest area under organic farming (38674.62 ha), followed by the Nagaland (29715.28 ha), Manipur (10871.3 ha), Sikkim (7393.09 ha), Assam (6223.12 ha), Meghalaya (2254.12 ha), Arunachal Pradesh (1897.27 ha) and 281.06 ha in Tripura. The north east region of India is blessed with rich biodiversity, rich soil organic carbon and has low fertilizer consumption. These are the major strength for large scale adoption of organic farming. Yadav (2012) reported that about 18 million hectares of land is available in the north east (NE), which can be exploited for organic production. Among crops cotton is the single largest crop accounting for nearly 40 percent of total organic area followed by rice, pulses, oilseeds and spices. India is the largest organic cotton grower in world, and accounts for 50% share of total world organic cotton production (Bhattacharyya and Chakraborty, 2005). India has great potential to grow crops organically and have emerged as a major supplier of organic products in the world's organic market.

23.5 AGRICULTURE CONTRIBUTION TOWARDS THE CLIMATE CHANGE

It is now accepted that anthropogenic activities are responsible for increased concentration of greenhouse gases (GHGs) in the atmosphere and is the major causes of global warming (IPCC, 2001). Intergovernmental panel on climate change (IPCC) clearly reported that global mean surface air temperature would increase by 1.1 to 6.4 °C by 2100 under different emission scenarios (IPCC, 2007a). Similarly, Indian network on climate change assessment has also reported an all-round warming (1.7°C to 2.0°C) and increase in rainfall (3% to 7%) over the Indian subcontinent by the

2030s (INCCA, 2010). Krishna Kumar *et al.* (2011) also projected to rise in mean air temperature and rainfall by 2080s in the India. In developing countries like India, climate change and its probable impact on agriculture pay a special attention because agriculture play a vital role in the country's economy. Agriculture accounts for the 14% of the nation's GDP and 11% of its exports and about half of the population still relies on agriculture as its principal source of income. Similarly, agriculture is a source of raw material for a large number of industries (MOA, 2012). Climate change may affect adversely the crop production system, water availability and can induce the food security problems for millions of peoples in the future (Sinha *et al.,* 1998). In India, agriculture contributes about 17.6% of the country's total GHGs emission (INCCA, 2010). An intensive agricultural practice during the post green revolution era without caring for the environment has supposedly played a major role towards enhancement of the greenhouse gases. Due to increase in demand for food production the farmers have started growing more than one crop a year through repeated tillage operations using conventional agricultural practices (Patle *et al.*, 2013b). Since post green revolution era, Indian farming basically shifted from the conventional agricultural practices to towards the mechanized practices and depend greatly on agricultural input such as chemical fertilizers, pesticides, irrigation and heavy farm machineries which are mainly dependent on fossil fuels (West and Marland,2002, Lal, 2004a, Patle *et al.,* 2013b).

With manufacturing of fertilizers and pesticides as the two major inputs of green revolution technologies, an important point of consideration was the need for fossil fuels and/or expensive energy which are associated with serious environmental and health problems. This fact further got the attention of the world when the Intergovernmental Panel on Climate Change (IPCC) found that agriculture as practised today (conventional agriculture, modern agriculture or GR agriculture) accounts for about one fifth of the anthropogenic greenhouse effect, producing about 50% and 70%, respectively of the overall anthropogenic methane and nitrogen oxides emissions (Charyulu and Biswas, 2010). Crop productivity has increased substantially through utilization of heavy inputs of soluble fertilizers – mainly nitrogen and synthetic pesticides. However, only very minimal was taken up by crops (approximately 17-22 %). The remainder was lost to the environment. Between 1960 and 2000, the efficiency of nitrogen use for cereal production decreased from 80 to 30 % (Erisman, *et al.,* 2008). High levels of reactive nitrogen (NH_4, NO_3) in soils may contribute to the emission of nitrous oxides and are main drivers of agricultural emissions. The excess fertilizers (not taken up by the plants) are often emitted into the water bodies and the atmosphere. The emission of GHG in CO_2 equivalents from the production and application of nitrogen fertilizers from fossil fuel amounted to 750 to 1080 mt (1 to 2 % of total global GHG emissions) in 2007. In 1960, 47 years earlier, it was less than 100 mt. In summary, each year, agriculture emits 10 to 12 % of the total estimated GHG emissions. Smith *et al.,* (2007) documented that fertilizers alone contributes for 38 % of GHG emissions (Nitrous oxide) from agriculture sector (Fig 1).

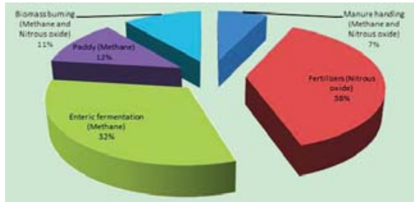

Fig. 1. GHG emissions of the agriculture sector (Source: Smith et al., 2007)

23.6 POTENTIAL OF ORGANIC AGRICULTURE FOR CLIMATE CHANGE MITIGATION

Potential of organic agriculture for climate change mitigation is based on its capacity of carbon sequestration, reduction in the energy use and lowering the greenhouse gases emission.

23.6.1 Enhancing carbon sequestration

Soils are the major sink for atmospheric CO_2. Organic farming increases organic carbon through organic manures, crop cover and crop rotation and restores it for the longer duration. It is reported that soil carbon sequestration rates on arable land can range from 200kg to 2000kg of carbon per hectare per year above ‘business as usual’ conventional agriculture depending on the organic agriculture soil management practice (IFOAM, 2009). Global adoption of organic agriculture has the potential to sequester up to the equivalent of 32% of all current man-made GHG emissions (Jorden *et al.,* 2009).

23.6.2 Reduction in energy use in agriculture

Organic agriculture reduces the direct and indirect use of energy in agriculture. It is reported that organic farming systems use 20 to 50% less energy compared to the conventional farming system (Pimentel *et al.,* 2005; Schader *et al.,* 2011 and Muller *et al.,* 2012). In the USA, high-input industrialized systems consumed 22-120% more energy than sustainable and organic systems and achieved similar yields (Pretty and Ball, 2001). Lampkin (2007) reported that the lower energy use on organic farms is largely because industrial fertilizers and pesticides are not used, thus avoiding the energy inputs for their production. Pimentel *et al*. (2005)

reported that organic no-till practice saved 61% of fuel/ha compared to conventional no-till corn production practice and organic tillage farming practice saved 47% fuel per hectare as compared to the conventional tillage practice. Pretty and Ball (2001) compared sustainable and low-input systems of production with the high-input conventional systems for both developed and developing countries and reported that low-input or organic rice in Bangladesh, China, and Latin America was 15-25 times more energy efficient than irrigated rice produced in the USA. They further reported that for each tonne of cereal or vegetable production from the modernized high-input systems consumed 3000-10,000 MJ of energy compared to the 500-1000 MJ for sustainable farming.

23.6.3 Lower greenhouse gas emissions

Olesen *et al.* (2006) reported that organic agriculture emits lower N2O from nitrogen application, due to lower overall nitrogen input per ha than in conventional agriculture. Greenhouse gas emissions were calculated to be 48-66 percent lower per hectare in organic farming systems in Europe and were attributed to no input of chemical N fertilizers. The FAO also reported that organic agriculture is likely to emit less nitrous oxide (N_2O). According to the IOFOAM report the global adoption of organic agriculture would deliver additional emissions reductions of approximately. 0.6 to 0.7 Gt CO_2 eq through the avoidance of biomass burning (CH_4 and N_2O emissions) and the avoidance of 0.41 Gt CO_2 eq/year emitted from the use of fossil energy consumption for chemical N fertilizer production.

In the context of global warming and climate change, organic agriculture can be a potential strategy to mitigate consequences of climate change either by reducing GHG emissions or by sequestering CO2 from the atmosphere in the soil. Although the yield potential is little less in the initial period of conversion from conventional agriculture to organic agriculture but this can be managed by the reduction potential of the greenhouse gases emissions. Organic agriculture is potentially capable to serve the twin role of countries' food security and the environment protection. Even though the increasing trend in the organic agricultural area in the country, there is still need for further improvement, especially in the areas of research, extension and awareness among personnel directly or indirectly involved in the organic farming.

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Chapter 24

GENDER ROLE IN ORGANIC FARMING

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24.1 INTRODUCTION

Access to desirable, sufficient, safe and nutritious food is a basic component of development and health of a society. Thus, when developing country goals and priorities, food security is of utmost importance (Lashgarara *et. al.,* 2009). Food insecurity is one of the most pressing challenges, particularly in developing countries (WHO 2013). There is a general movement in the agricultural sector aimed at developing sustainable agriculture as a means of improving peoples' livelihoods. Many NGOs, and the government promoted an approach to agriculture which would allow for the safeguarding of food security, help to provide income, maintain soil fertility and control pests. Hunger, poverty and environmental degradation persist even as concerns about global human security issues continue to increase. Moreover, the last decades provide uncompromising evidence of diminishing returns on grains despite the rapid increases of chemical pesticide and fertilizer applications, resulting in lower confidence that these high input technologies will provide for equitable household and national food security in the next decades. Overall, global cereal output is declining, mainly among the major producing and exporting countries (Morshedi 2015).

Organic agriculture as a holistic production management system that avoids use of synthetic fertilizers, pesticides, genetically modified organisms, growth regulators; livestock feed additives and other harmful or potentially harmful substances, minimizes pollution of air, soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people. It includes the use of technologies such as crop rotations, mechanical cultivation and biological pest control; and such materials as legumes, crop residues, animal manures, green manures, compost, other organic wastes and mineral bearing rocks. Organic agriculture is a production system that sustains the health of soils, ecosystems and people.

It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Organic farming seems to be a viable option to improve food security of smallholding farms by increasing income/decreasing input cost; producing more for home consumption, and adopting ecologically sustainable practices with locally available resources. Finally, "organic agriculture" is not just about production. It includes the entire food supply chain, from production and handling, through quality control and certification, to marketing and trade (Scialabba 2007, NASSA 1998).

Organic agriculture is rapidly growing all across the world, with India too experiencing significant growth. India is bestowed with lot of potential to produce all varieties of organic products due to its various agro climatic regions. In several parts of the country, the inherited tradition of organic farming is an added advantage. This holds promise for the organic producers to tap the market which is growing steadily in the domestic market related to the export market.

Women are generally invisible workers as far as agricultural activities in developing countries like India are concerned. Thus, one of the Millennium Development Goals (MDGs) of the member states of the United Nations adopted in 2000 is to promote gender equality and empower women. The ancient African proverb "without women we all go hungry reveal the importance of women in agriculture. They supply much of the labour for agricultural production and perform many activities key to the household economy. In fact, women produce more than half of the food in Latin America and South Asia and 80 per cent in Africa. Although women work as long as men do, there is a real and apparent gender bias with only a few policies oriented to correct the situation (IFOAM 2007).

Gender relationships are fundamental worldwide to the way farm work is organised, the way assets such as land, labour, seeds and machinery are managed, and to farm decision-making. The lack of adequate attention to gender issues within the organic and sustainable farming movements is worrying. The revolutionary potential of sustainable approaches to far-ming to reshape our food systems, and the way humans interact with those systems, will not be realized unless there is a concerted effort by committed sustainable farmers and consumers to work towards gender equality. Indeed, the question addressed by this paper can be turned on its head: How does the participation of women broaden and deepen the multiple goals of organic and sustainable farming?

Organic and sustainable farming has the potential to create new structures that actively work towards achieving women's empowerment and protecting the use of indigenous knowledge. This is a challenge for the organic movement, particularly certified organic, which is predomina-tely driven and supported by political, cultural, economic and social structures that are located within western ideologies and practices. Part of the challenge is to identify behaviour that is impeding women's empowerment in organic agriculture. Efforts to include indigenous peoples in sustainable agriculture have rarely been gender sensitive (Badri and Badri 1994). "Half or more of indigenous ecologi-cal science has been obscured by the prevailing invisibility of women, their work, their in-terests and especially their knowledge" (Rocheleau 1991). The marginalisation of indigenous women's skills, needs and knowledge in agriculture is directly related to the unequal power relations inherent within the ideologies of colonisation, capitalism and globalisation. As a con-sequence sustainable agriculture loses out (Awa 1989, Badri and Badri 1994, Rocheleau, 1991). Indigenous women over the world have traditionally played a key role in biodiversity manage-ment and sustainable agriculture (Jiggins 1994, Shiva and Dankelman, 1992). Some indige-nous women hold important roles in the preservation of biodiversity and specific forms of knowledge pertaining to biodiversity and sustainable agricultural practices. Typically, women hold specific knowledge about seeds and their selection, and vegetative propagation. On the other hand, in conventional farming communities, business transactions and knowledge about farming are conducted and exchanged within the public spaces peculiar to the agricultural community, such as equipment dealerships, farm shows, grain elevators, cattle markets etc. These spaces are ge-nerally male-dominated. Farm women often feel ignored, overlooked, not taken seriously and even cheated in these spaces. They are seen as 'farmwives' rather than true farmers, and as such not capable of producing and sharing valuable knowledge about farming. The strategies farm women adopt to achieve their goals in these male-dominated spaces include getting a trusted male friend to accompany them, or to negotiate a price on their behalf.

Organic agriculture has the potential to create situation of more gender balanced agriculture development, since principles of fairness and enforcement of social justice laws minimise the discrimination in agricultural production under organic systems. Organic and sustainable farming has the potential to create new structures that actively work towards achieving women's empowerment and protecting the use of indigenous knowledge.

24.2 CURRENT STATUS (SECTOR SPECIFIC REGIONAL, NATIONAL AND GLOBAL STATUS)

All over the world, women are playing a crucial role in the organic food chain. On the farm, women are very important for saving seeds, maintaining biodiversity, production of traditional crops and livestock, which in turn provides healthy and safe food, and saves the culinary culture, they take leading roles in ecotourism and didactic farm activities. In the cities, but also in rural areas, women decide what to buy for their families and they are leading the increasing consumer demand for organic products. Gender is a factor in the decision to convert to organic farming, although the role of women in organic agriculture in general and in the decision making in particular has not been studied in detail.

24.2.1 National Status

According to the Agricultural and Processed Food Product Export Development Authority (APEDA), the organic land in India is 5.71 million hectares (ranks 15th in the world) includes 26 % cultivable area with 1.49 million hectare and rest 74% (4.22 million hectare) forest and wild area for collection of minor forest produces. India exported 86 organic products worth US$ 100.40 Million during 2007-08 with 30 per cent growth over previous years (APEDA 2009). The export figures further rose to US$122 Million in 2009-10. Recent export figures rose up to US$ 298 Million in 2015-16 (APEDA 2016). India's National Standards of Organic Production (NSOP) and accreditation have been recognised by European Commission, Switzerland and also these are considered by the United State Department of Agriculture (USDA) as having equivalence for its National Organic Programme (NOP), indicating significant progress India has made regarding organic farming (Wai 2007, Willer and Kilcher 2009).

Certifying these farms remains a challenge, however, as many of these farms are small holdings (nearly 60% of all farms in India are less than one ha). Smallholders and resource-poor farmers may not be able to afford the cost of certification, they are illiterate and unable to maintain necessary records, or may be using indigenous cultivation systems not recognized in organic certification systems. These farms mainly produce for home consumption, and supply to the local markets in case of irregular surpluses. Such barriers pose difficulties for farms to reap potential benefits of organic certification. The states of Uttarakhand and Sikkim have declared their states as organic states. In Maharashtra, since 2003, about 5 lakh ha area has been under organic farming (of the 1.8 crore ha of cultivable land in the state). In Gujarat, organic production of chickoo, banana and coconut is being encouraged both from profit as well as yield point of view. In Karnataka, the area under non certified organic farming (4750 hectares) was substantially high as comparison to ha land was under certified organic farming (1513 hectares). The reasons behind this transition of shifting towards organic farming are sustained soil fertility, reduced cost of cultivation, higher quality of produce, sustained yields, easy availability of farm inputs and reduced attacks of pest and diseases (Reddy 2010).

Apart from this, the government of Karnataka had released a state organic farming policy in 2004 for encouraging organic farming. Infact, most of the north eastern states are also encouraging organic farming. In Nagaland, 3000 ha area is under organic farming. Also States like Rajasthan, Tamil Nadu, Kerala, Madhya Pradesh, Himachal Pradesh and Gujarat are promoting organic farming vigorously. Various farmers' organizations have been established in different states for the marketing of organic products. For example, the establishment of the Chetana in three states: Andhra Pradesh (Asifabad and Karimnagar), Maharashtra (Vidarbha, Akola and Yavatmal) and Tamil Nadu (Dindigul and Tuticorn). However, there are indeed some constraints being faced by the farmers for transforming their conventional farming system into organic farming system. Lanting (2007) has identified some of the problems as follows: Non-payment of premium price for these products because they are in the transition stage, lack of storage facility, with cash paid (preferably 70% of the crop value) for the stored products. Here the urgency for the assistance from the government as a helping hand is of utmost importance for overcoming the barriers faced due to the transition from conventional farming to organic farming.

Rural Indian women are extensively involved in agricultural activities and the extent of their involvement differs with the variations in agro-production systems. In all farm production, women's average contribution is estimated at 55 per cent to 66 per cent of the total labour with percentages, much higher in certain regions especially in the hills. Women are the major stakeholders in organic agriculture, precisely because they are the worst victims of chemical farming. Over decades, the socio-economic and health status of women in farming communities has been adversely affected by green revolution/industrial farming technologies and policies leading them into debt, disease and destitution. The organisational structures supporting smallholder organic agriculture in India fall into four forms: farmers organised by a company, (2) farmers operating under NGO initiatives, (3) farmers organised or facilitated by government, and (4) farmers forming their own organisations (cooperatives, associations, self-help groups, etc.). However, in many instances, these basic organisational forms coexist with one another, giving rise to more complex structures (Das 2007).

Gender relations with respect to faming activities are more or less same worldwide in terms of the way farm work is organised, the way assets such as land, livestock, labour, seeds and machinery are managed and farm decision-making is done. Therefore, in view of the women's significant role in livestock production, role of gender was studied among organic farmers, who were in the process of conversion to livestock farming in the North Indian state- Uttarakhand. A study has been conducted to know the traditional knowledge and indigenous practices being followed by farmers in agriculture and animal husbandry to assess the possibility of integrating with organic farming in Uttarakhand which is the first state in India promoted organic farming in a systematic way. The farmers of Uttarakhand specially women possessed a vast pool of indigenous knowledge with regards to livestock management, treat animals through eco-friendly ways, little or no cost means, reduced dependence on externally purchased inputs as required under organic farming systems and the farmers were in practice of utilizing renewable farm resources. The Uttarakhand Organic Commodity Board (UOCB) had taken initiatives like compiling farmers age old knowledge sayings and practices relating to natural resource management in the form of booklets to protect it from gradual extinction and integrating it successfully with organic production methods. Such knowledge and practices of farmers is worth validating (Subrahmanyeswari and Chander 2013).

In an another study done in Uttarakhand state, a total of 4,459 organic farmers were registered with UOCB, out of which a sample of 180 farmers were selected randomly from a total of 18 villages, nine blocks from Dehradun, Nainital and Tehri Garhwal districts. Interestingly women farmers represented 38% (69) of the total sample studied. Care has been taken such that the sample represents diverse geographical areas of the state i.e. 110 farmers representing hill area and 70 representing plain area. Over 75% of the respondents were having 3-6 years of experience in organic farming, followed by 15 percent of farmers having 6-8 years of experience in organic farming (Subrahmanyeswari and Chander 2011).

Out of the total 180 households studied, land ownership was with male members (80.56%), while only 19.74 per cent of female respondent shad land ownerships in their names. Ownership of livestock in majority of cases was with both men and women (48.82%), as against with women in 33.33 per cent households. Management of income from agriculture as well as livestock was jointly by both men and women (40.00 and 47.22%) followed by 30 and 30.6 per cent respectively of women members of respective households (Tables 24.1).

Marketing of livestock products was attended mostly by women (48 %) in hill area, whereas in case of plain area farmers, its by men mostly (49 %). In general, men look after the crop management (62%) and marketing of agriculture produce (65%), whereas compost application was attended mostly by both (56%) men and women together in plain area. However, processing was also done by both (42%) in hill area amongst the respective households (Table 24.2).

Organic farming based on millets has been introduced in rural areas of Tamil Nadu as a consequence of the efforts made by the Tamil Nadu Women's Collective (TNWC), a non-governmental organization that is active in some specific districts in Tamil Nadu an effective manner considering the availability of natural resources (Pande and Jha 2016). Organic farming has enhanced the growth of an agricultural economy by introducing new, innovative techniques and practices of farming which are least dependent on the natural rainfall conditions. Besides, it has also supplemented the financial-social sovereignty of the rural women by giving the entire process of this farming in their own hands, thus enhancing an educative communion among them by sharing their individual experiences of organic farming and the returns or benefits that they have achieved in their individual cases based on millets leading to the creation of an inherent and integral food sovereignty *vis-a-vis* the increasing usurpation of agricultural land through the nexus of the state government and private companies. Organic farming enhanced awareness about farming and its significance for women, the utility and long-term effectiveness of farming as a dynamic practice rather than a stagnant one, imparting informal education on farming techniques and functioning of machinery and equipments, addressing environmental concerns by invoking a sense of belongingness, invoking a sense and a spirit of social, ethical and moral responsibility among the youth by taking into consideration their views and perspectives in participatory decision-making. Hence, collective and organic farming bear the notion of not only changing the course or nature of agricultural economy and practices in this part of rural India, but also introducing a variety to the existing paradigms of women's socio-economic upliftment, especially in relation to women belonging to the lower castes in rural Tamil Nadu.

In Andhra Pradesh, Permaculture Association of India popularized the concept of 'Permaculture' (permanent agriculture). Permaculture is the

Table 24.1. Ownership pattern among the farmers

Area	Number (%) of organic farmers								
	Hill area (100)			Plain area (70)			Total (180)		
	M	F	Both	M	F	Both	M	F	Both
Land	90(81.8)	20(18.2)	-	54 (77.1)	16 (22.9)	-	145 (80.6)	35 (19.4)	-
Livestock	23 (20.9)	35 (31.8)	52 (47.3)	09 (12.9)	25 (35.7)	36 (51.4)	32 (17.8)	60 (33.3)	88 (48.9)
Control over income from crops	33 (30.0)	36 (32.7)	41 (37.3)	21 (30.0)	18 (25.7)	31 (44.3)	54 (30.0)	54 (30.0)	72 (40.0)
Control over income from livestock	11 (10.0)	38 (34.6)	61 (55.5)	29 (41.4)	17 (24.3)	24 (34.3)	40 (22.2)	55 (30.6)	85 (47.2)

M= Men; W = Women

Table 24.2. Division of labour among organic farmers in livestock farming activities

	Number (%) of organic farmers				Number (%) of organic farmers			
Area	**Hill area (n=110)**				**Plain area (n=70)**			
Activity	**M**	**W**	**MW**	**WF**	**M**	**W**	**MW**	**WF**
Livestock								
Management	31 (28.2)	40 (36.4)	34 (30.9)	5 (4.6)	17 (24.3)	23 (32.9)	16 (22.9)	14 (20.0)
Feeding	5 (4.6)	77**(70.0)	17 (15.5)	11 (10.0)	11* (15.7)	34 (48.6)	8 (11.4)	17** (24.3)
Breeding	61 (55.5)	05 (4.6)	13 (11.8)	18 (16.4)	42 (60.0)	10* (14.3)	04 (5.7)	10 (14.3)
Health care	19 (17.3)	67** (60.9)	24 (21.8)		22* (31.4)	21 (30.0)	16 (22.9)	03* (4.3)
Marketing	23 (20.9)	53** (48.2)	25* (22.7)	09 (8.2)	34** (48.6)	19 (27.1)	07 (10.0)	10 (14.3)
Grazing	11 (10.0)	09 (08.2)	11 (10.0)	17 (15.5)	07 (10.0)	06 (0.8.6)	11 (15.7)	12 (17.1)
Crop								
Compost making	40 (36.4)	23 (20.9)	35 (31.8)	12 (10.9)	16 (22.9)	11 (15.7)	39** (55.7)	06 (08.6)
Crop management	69 (62.7)	11 (10.0)	30 (27.3)	—	43 (61.4)	11 (15.7)	19 (27.1)	—
Manure/compost application	31 (28.2)	24 (21.8)	45** (40.9)	10 (9.1)	29 (41.4)	09 (12.9)	11 (15.7)	05 (7.1)
Crop produce processing	20 (18.2)	35* (31.8)	46 (41.8)	09* (8.2)	40** (57.1)	11 (15.7)	19 (27.1)	—
Marketing of produce	68 (61.8)	11 (10.0)	16 (14.6)	15 (13.6)	49 (70.0)	05 (7.1)	11 (15.7)	05 (7.1)

*=significant at 0.01 level of probability, **significant at 0.05 level of probability, M=men, W = women, MW=men and women, WF = whole family

conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems (Mollison 1990). The Deccan Development Society (DDS) — an internationally well-known NGO working with *dalit* women groups, has developed a farm on the principles of Permaculture in Zaheerabad region of deccan area. The DDS encourages sustainable agricultural practices in a big way and has been a pioneer in the country. More than 5000 women farmers in an area of more than 20,000 acres have adopted sustainable agricultural practices, which are environment friendly and are based on the traditional knowledge. Similarly, the Centre for Sustainable Agriculture (CSA) based at Hyderabad, through several NGOs in the state, has promoted non-pesticidal management of pests in the state, wherein the use of pesticides and chemical fertilizers is discouraged, while the use of local resources is encouraged. The Community Managed Sustainable Agriculture program is being implemented by the Society for Elimination of Rural Poverty (SERP), the Government of Andhra Pradesh and the Sustainable Agriculture Network of NGOs, with technical support from the Centre for Sustainable Agriculture. In 2009, there were 50 villages which had become pesticide free and 7 villages which have become completely organic. The Timbaktu Collective is another organization which has been promoting organic farming practices since a long time in the Ananthapur district.

24.2.2 Global Status

Organic agriculture is developing rapidly, and statistical information is now available from 172 countries of the world. Its share of agricultural land and farms continues to grow in many countries 43.7 million hectares of agricultural land are managed organically. The regions with the largest areas of organically managed agricultural land are Oceania (12.1 million hectares), Europe (8.2 million hectares) and Latin America (8.1 million hectares). The countries with the most organic agricultural land are Australia, Argentina and China. The highest shares of organically managed agricultural land are in the Falkland Islands (36.9 percent), Liechtenstein (29.8 percent) and Austria (15.9 percent). The countries with the highest numbers of producers are India (340’000 producers), Uganda (180’000) and Mexico (130’000). More than one third of organic producers are in Africa. On a global level, the organic agricultural land area increased in all regions, in total by almost three million hectares, or nine percent, compared to the data from 2007. Twenty-six percent (or 1.65 million hectares) more land under organic management was reported for Latin America, mainly due to strong growth in Argentina. In Europe the organic land increased by more than half a million hectares, in Asia by 0.4 million.

About one-third of the world's organically managed agricultural land – 12 million hectares is located in developing countries. Most of this land is in Latin America, with Asia and Africa in second and third place. The countries with the largest area under organic management are Argentina, China and Brazil. 31 million hectares are organic wild collection areas and land for bee keeping. The majority of this land is in developing countries – in stark contrast to agricultural land, of which two-thirds is in developed countries. Further organic areas include aquaculture areas (0.43 million hectares), forest (0.01 million hectares) and grazed non-agricultural land (0.32 million hectares). Almost two-thirds of the agricultural land under organic management is grassland (22 million hectares). The cropped area (arable land and permanent crops) constitutes 8.2 million hectares, (up to 10.4 per-cent from 2007), which represents a quarter of the organic agricultural land.

As far as gender is concerned it was found that organic farming is practiced by around 27% women of EU farm holders in the year 2007, and they occupied 17% of the EU area devoted to organic farming. In general, farm holders with organic farming have larger farms: 10.5 hectares more than the average farm for women (i.e., 15.9 instead of 5.4 hectares) and 17 hectares more than the average farm for men (i.e., 28.6 instead of 11.6 hectares).Austria has highest female farm holders with organic farming (10.6%) followed by Denmark (7%) and Finland (6.9%). However, maximum female organic farmers were found in Finland (64.48%) followed by Denmark (59.32%) and Germany (42.70%) amongst 27 European Union countries (Table 24.3).

In 2010, the share of male and female farm managers in the EU-27 shows no difference between the organic and non-organic farms. The majority of farm managers are men, be they active in organic (74%) or non-organic farms (72%). The share of female managers, both in organic and non-organic farms, is higher in the EU-N12 (above 30%).

On several of the100 organic farms whose motives to go organic were studied in a qualitative social study in Switzerland, the initial 'organic' ideas came from the woman (Fischer 1982). Organic methods were tried at first in the vegetable garden, which is traditionally the woman's domain, before they were introduced on the whole farm (Dettmer1986, Fischer 1982).

Thailand is one of the leading countries in Southeast Asia in the production of organic food and its domestic market for organic produce has recently bypassed the organic export market. The Government of Thailand implemented an extensive organic agriculture promotion programme

Table 24.3. Women in organic agriculture in the European Union 27

S.No.		Female farm holders as % of total farm holders (2007)	% of female farm holders with organic farming (2007)	Percentage of female organic farmers
1	Belgium	14.7	1.1	7.48
2	Bulgaria	19.9	0.0	0.0
3	Czech Republic	17.8	1.5	8.42
4	Denmark	11.8	7.0	59.32
5	Germany	9.6	4.1	42.70
6	Estonia	41.5	3.2	7.7
7	Ireland	10.4	0.8	7.69
8	Greece	30.3	3.7	12.2
9	Spain	28.8	1.2	4.16
10	France	23.1	1.4	6.06
11	Italy	32.2	2.2	6.83
12	Cyprus	25.5	0.3	1.17
13	Latvia	47.0	2.5	5.31
14	Lithuania	46.4	0.4	0.86
15	Luxembourg	21.2	2.1	9.90
16	Hungary	23.3	0.0	0.0
17	Malta	11.7	0.0	0.0
18	Netherlands	5.4	1.8	33.33
19	Austria	32.1	10.6	33.02
20	Poland	33.0	0.2	0.60
21	Portugal	26.5	0.3	1.13
22	Romania	30.0	0.0	0.0
23	Slovenia	26.3	1.8	4.95
24	Slovakia	18.6	0.1	0.53
25	Finland	10.7	6.9	64.48
26	Sweden	15.1	3.3	21.85
27	United Kingdom	18.8	1.0	5.31
28	EU-27	28.7	1.0	3.48

Table 24.4. Share of farm managers per gender in organic and non-organic farms

	Organic		Conventional	
	Male (%)	Female (%)	Male (%)	Female (%)
EU-15	75.7	24.3	75.7	24.3
EU-N12	67.0	33.0	68.9	31.1
EU-27	74.4	25.6	71.8	28.2

Source: Eurostat data Farm Structure Survey (2010)

in 2005, including several organic vegetable production pilot projects. This organic vegetable production follows organic standards but is not certified organic, rather being aimed mainly at household consumption or local markets.

Gender was the most important factor explaining the adoption of organic agriculture in a case study in Northeast Thailand. Households in which women had a central role were more likely to adopt organic vegetable production, as women were concerned about the health impacts of pesticide use under conventional farming as well as food quality.

The adoption of organic practices was also dependent on extension services, including training in organic management as well as education about the environmental and health problems of conventional farming. But the diffusion of organic agriculture was also mediated through fellow farmers. Another factor influencing the adoption of organic vegetable production was the availability of organic fertilizers – the area under organic agriculture on a farm expanded with increasing availability of organic fertilizers like manure and bio-fertilizers, made from crop residues and molasses (Scott *et al*. 2009, Thapa and Rattanasuteerakul, 2011).

In Pakistan, the Sindh Rural Women's Uplift Group has an Organic Fruit Production programme based at the Panwhar Farm. The Group owns a 43-hectare fruit orchard that is managed organically and produces high yields of citrus and mango. According to Farzana Panhwar, Managing Director of the group, the high quality of produce has enhanced its price, and more income has resulted in a two to threefold increase in community food security. Innovations in fruit varieties and post-harvest handling are expected to further increase the value of the farm's crops. Training and employment of women have also increased (Scialabba and Hattam 2002, Panhwar, 1998).

24.2.2.1 Methodology

The Socio-economic and Gender Analysis (SEAGA) is an approach elaborated by the Food and Agriculture Organization (FAO) in partnership with the International Labour Organization (ILO), the World Bank and the United Nations Development Programme (UNDP) to develop the capacity of development specialists and humanitarian officers to incorporate socio-economic and gender analysis into development initiatives and rehabilitation interventions.

Participatory gender analysis can describe what a sub-population does, and can explain why the sub-population does what they do; statistical approaches to gender analysis can describe what the whole population does and correlate associated behaviours in the whole population.' gender-focused research is the degree to which the worlds of men and women can be considered analytically distinct. It is absolutely fundamental to gender analysis to recognise that the relations between men and women are undergoing constant change, in response to interaction with emergent opportunities and threats in the wider environment, such as climate change, incidence of disease, or new market opportunities, as in the case of organic farming. But it is also important to recognise that identities themselves mutate constantly. Gender-focused research seeks to pin down for a moment the shifting, relational nature of gender, and the active role of men and women in constructing their identities, in 'doing gender'. It involves pinning down what it means to be a man or woman in a specific place and time (Grown and Sebstad 1989). Gender analysis builds the knowledge, can provide the basis for policies that specifically aim to redress the balance of power, to 'empower' those who have little control over their lives. One way of thinking about power is in terms of the ability to make choices: to be disempowered implies to be denied choice (Kabeer 2000). Empowerment thus implies a process of discovering new ways of exercising choice, or new domains in which choice might be exercised. Choices need to be 'meaningful': having the right to education means nothing if one does not have enough time to go to school, or cannot pay for it.

For quantifying human energy expenditure, three main mechanisms exist for quantifying human energy expenditure (HEE): the nutritional, physiological and ergonomic models. A measurement that embraces all the well-being outcomes of work tasks can be obtained by combining elements of each model.

24.2.2.2 Nutritional model

The WHO/FAO/UNU (1985) nutritional model considers a balance between energy consumption and expenditure as a prerequisite for bodily wellbeing, this balance is expressed by weight for height in adults, and height in proportion to age in children. It is recognised that enduring weight loss or gain is not sustainable and so seeks indicators of nutritional status. Calorific intake alone does not indicate nutritional status, as needs are determined by a combination of an individual's weight, sex, age and activity level. The nutritional model relates all energy expenditure to an individual's basal metabolic rate (BMR) that is, the energy requirement for body maintenance. The calculation of BMR is therefore the first step in the processes of making direct connections between work intensity and well being. For practical purposes the most useful index of BMR is body weight, which can be fed into an equation along with age and gender to provide a fairly accurate BMR. Body mass index (BMI) calculated as weight in kilograms divided by height in metres squared, is generally found to be the best model for indicating nutritional status, as it adjusts for differences in height between individuals. A healthy BMI is between 18.5 and 25, individuals that fall outside these BMI's are more at risk from functional risks (James and Shetty, 1984). BMI tells us much about the health of an individual but tells us little about their energy expenditure, for which the factorial method must be examined.

The factorial method calculates the energy cost of physical activity through multiples of BMR. Each physical activity is allocated a physical activity ratio (PAR), which is based on either direct or indirect measurements of populations in self-paced activity. Every physical activity, including sleep, is allocated a PAR, based on either direct or indirect measurements of populations in self-paced activity.

The energy cost of this activity can then be calculated by weighting the time spent on each activity by its PAR which gives the physical activity level (PAL). PALs may be classified as light, moderate or heavy. Total energy expenditure (TEE) over a 24 h period may then be calculated by multiplying BMR by PAL. The nutritional model and factorial methods described above are very useful tools, as they allow both the nutritional requirements of populations and of the calories needed by individuals and populations to be estimated. However they fail to take account of the physical work capacity (PWC), which will affect the physical stress level of individual. This study requires calculations of PWC (the time for which an intensity of work can be sustained) which forms the basis of the physiological model.

24.2.2.3 Physiological model

The physiological model is based around the theory that the work capacity of an individual is denoted by the maximum level of oxygen (VO_2

max) that can be consumed during activity. Direct measurements of VO---$_2$ max are usually avoided. It can be estimated from O_2 consumption at a specified% of maximum heart rate. VO---$_2$ max can only be sustained for short periods of time because the laws of thermodynamics constrain humans to a slow energy conversion rate (Pimentel 1979). It is argued that over a full working day, just 35–40% of an individual's VO-$_2$ max can be sustained. However, there is evidence to suggest that physical stress and burden may not be related to VO_2 max. The experience of stress of an activity sustaining 35–40% VO_2max throughout a working day for an individual with a low BMI may be quite different to an individual with a high BMI. The BMI of an individual depends on active tissue mass; a nutritionally impaired subject is likely to have less active tissue than a well-nourished subject. Thirty-five per-cent of VO_2 max for the nutritionally impaired subject may correspond to very low levels of energy expenditure compared to higher levels for well-nourished subject. Secondly, actual tasks performed may require bursts of energy expenditure in excess of VO-$_2$ max, such as lifting bags of fertiliser, which require one sudden burst of energy. To enhance understanding of how energy expenditure generates fatigue, burden and stress attention must be turned to the ergonomics.

24.2.2.4 Ergonomic Model

Ergonomics is concerned with actual work tasks, observing well-being outcomes separate from nutrition, such as musculo-skeletal disorders and fatigue. Ergonomic observations have shown that even working at 35% VO_2 max, humans rarely work continuously, but in bursts coupled with periods of rest (Kilbom, 1995). The health impacts of working in bursts are yet to be proved, but it is thought that short rest periods interspersed with work reduces fatigue. It is also argued that frequent rest pauses can maintain and enhance productivity more than if one long rest was taken for the equivalent amount of time (Kilbom 1995). Ergonomic arguments also identify intense bursts of work as increasing risks of musculo-skeletal injury and fatigue. All human beings are familiar with the experience of fatigue but it proves difficult to measure quantitatively. Working at high levels of energy expenditure is likely to impair physical performance through localised, whole body or emotional fatigue. The onset of fatigue reduces the ability of an individual to exert force and impairs muscular and mental performance in complex ways, spurring the need for rest. Characteristics associated with fatigue include reduced attention, thinking and motivation, all of which limit an individual's productivity. Rest, increasing calories consumed, pacing the speed of an activity, training and reducing excessive strain and working in bursts may reduce fatigue (Jones and Jackson 1997).

It is therefore apparent that rest and leisure are necessary to recover from fatigue and are a requisite for preserving an individual's productivity. Fatigue may be considered a stock, which builds up with activity above certain thresholds and in relation to the intensity of work. Excessive energy expenditure resulting in high levels of fatigue and both short and long term negative health affects. In the short term musco-skeletal damage/ impairment is common, resulting in immunological suppression whilst in the long run, health and nutrition interactions lead to phenomena such as premature ageing.

24.3 GENDER ISSUES IN ORGANIC FARMING

In almost all countries of the world, women are in a worse situation than men when considering poverty and its effects, access to land, clean water and health services. Therefore, sustainable agriculture should consider sustainability between men and women. However, for an effective change to take place not just women need to be targeted, but men should also be involved. As, we are all human beings, with the same basic needs and wantsand we are either a man or a woman, and with that come our specific needs. Both men and women need to be drawn in to developing projects so that they both understand and grasp each other's problems. If failing to do so, the techniques introduced might not be well implemented and therefore, the result will be unsatisfactory. Gender is a socially formed phenomenon, referring to the learned behavioural differences between women and men. The roles are subject to change and they differ from culture to culture. The different roles of men and women and issues in relation to organic farming addressed to crop management, access to and control over land and economic resources including organic certification, resource and energy saving, food security, health safety, markets, women empowerment needs to be studied.

24.3.1 Gendered crop management

Female farmers on vegetable farms and mixed livestock/cash crop farms are more likely to be involved in farm production and management than women on field crop farms, where mechanization and capital intensive production is much higher. The links to ideological orientations and motivations are examined, suggesting that farmers with more conventional orientations to organic farming are also less likely to support gender equality (Hall and Mogyorody 2007).

In Benin, West Africa more than half of organic cotton producers found were are females, against only 8% of women in the conventional cotton. The gender analysis of producers growing organic cotton within each category of households according to the welfare status also shows the dominance of females. Indeed, in 60 per cent of the surveyed households, organic cotton is produced only by females. Intra-household analysis shows that in the class of poor households, organic cotton is produced solely by females in 70 per cent of cases, while in 20 per cent of cases organic cotton is practiced by both male and female (Figure 1). Females are also the majority among producers of organic cotton in the class of rich and medium households. In wealthy households, females and males are almost equally represented in the production of organic cotton. Overall, the predominance of females among adopters of organic cotton is interesting given that they are often the most marginalized stratum of society, with less access to land (Sodjinou *et. al.,* 2015).

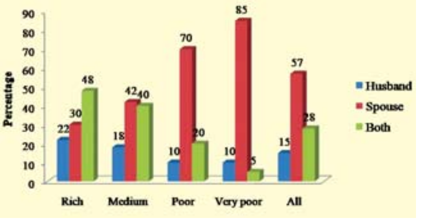

Fig. 1. Gender of the member producing organic cotton in the household of Organic cotton farms

Gender significantly influences the adoption of organic cotton that is more attractive to women compared to conventional farming. Infact, organic cotton farming enables women to hold a separate cotton farm and thus increase their economic independence, whereas with the conventional system they depend mainly on the farm of the (male) head of the household (Glin *et al.*2012andTovignan2005).The use of inputs locally available is also key factor that foster women decision to practice organic farming (Assogba*etal*.,2014). In most cases, female salso perform more effectively inorganic farming than males because their farms are smaller in size and often closer to the compounds. This eases the mobilization of organic inputs as well as the provision of the necessary cares and the overall management of the organic farm. Male-headed farms tend to be large with a strong commercial focus, while women-headed farms tend to be smaller in size, with lower output volume and higher contribution of off-farmin come to total farmin come Bjorkhaug (2006). Moreover, women are particularly concerned with the health effects of the highly toxic pyrethroid insecticides used in conventional cotton farms (Bassett 2010). There is a belief that toxic chemical products affect woman fertility and fetal developmentin case of pregnancy. All this in addition to the high input cost and discrimination in conventional (cotton) farming system makes organic the best and preferred option for women.

24.3.2 Access to control over land and economic resources including organic certification

Women's participation in organic farming led to an increase in agency and decision making capacity for women. Changes have also been documented in women's access to, and control over resources as a consequence of shifting from a subsistence-based farming system to market oriented organic farming. The impact of organic agriculture on women's perceptions of their role is demonstrated by the fact that in Uruguay they describe themselves as "collaborators" in conventional farming whereas they call themselves "farmers" in organics. In order to meet the high quality standards for organic products, organic production demands more labour, which is often supplied by women. However, a research in Uganda shows that women involved in organic farming have to work longer hours and reduce the time spent in other income-generating activities, which in turn is found to reduce their income.

Participation of women in organic farming is defined by certification under one or another 'sustainability standard', such as Organic, Fairtrade, UTZ or Rainforest Alliance. None of these standards are specifically targeted at women, although Fairtrade does require that special attention is given to the participation of female members in Fairtrade-registered cooperatives. It is the evaluations, not the interventions, which have a specific gender focus. The evaluations presented here measure gender-differentiated impacts at the levels of the household (both in relation to decision making and workload), and in relation to access to services (including training), producer organizations and markets.

The CAFEFEMININO brand is an initiative which aims to empower women organic coffee growers in different Latin American countries. The experience of CAFEFEMININO in the Dominican Republic is notable, as the programme promotes women's property rights over land by convincing the man of the household to transfer a portion of the land to the woman. In this way women can exercise control over the coffee they produce and market it directly without the intermediation of men, who are traditionally responsible for marketing activities. The programme also facilitates access to credit and technical support, through which women learn how to acquire the organic/CAFEFEMININO certification and manage the productive process. As a result of this initiative, women have acquired greater self-esteem and increased their income. Moreover, the active presence of women in the directive board of coffee producers' organizations has sharply increased (IFAD 2009).

Case studies of Fairtrade and organic certified cotton producers in West Africa shows that women are typically excluded from conventional cotton growing because of discrimination by extension agents and men, and by high production costs. Fairtrade cotton can increase women's incomes and autonomy and promote greater gender equality. This is mainly due to the fact that Fairtrade cooperatives are perceived to be more transparent and democratic than non-Fairtrade and hence women experience less discrimination. Men are attracted by the greater returns of the Fairtrade or organic crop and may use their wives' names to apply for certification. Limited access to land also limits women's participation (Basset 2009).

Through improved access to organizations like Fairtrade (although mostly at lower hierarchical levels) women have greater access to network benefits. Secondly, legal requirements of organic certification lead to increased registration of land to women. Thirdly enjoy increased access to cash. The combination of higher Fairtrade–organic coffee prices and receipt audits provides women with direct access to higher union coffee prices.

Change from conventional to Fairtrade–organic production methods has altered the gender balance in coffee work. On the one hand, significantly hig her quality requirements tend to increase women's labour burdens since women typically perform key quality-producing steps such as washing, drying, and selection. On the other hand, Fair trade– organic cooperatives may gain access to technical support and credit support, allowing them to purchase mechanized wet mill equipment that can dramatically reduce women's labour.

24.3.3 Resource and energy Saving

For back-to-the-landers in Italy, the forms of empowerment associated with farming are generally expressed as economic independence, control of food supplies and mastery over one's time. A gendered interpretation of empowerment and ethics among back-to-the-landers might rely too heavily on an essentialist reading of 'feminine' and 'masculine' principles. Bjorkhaug (2005), whose quantitative work on organic farmers in Norway aims to assess whether there is a 'feminine principle' in organic farming, bases this principle on gender studies that understand women to 'hold holistic attitudes to the use of natural resources, encompassing the principle of conservation. Men on the other hand are more focused on economic issues such as output rather than on ecological systems. Shiva(1989) mounts an interesting project in appropriating and subverting a long-standing justification for gender discrimination, one that sees women as more 'natural' then men, and consequently less rational, having not transcended an assumed nature/culture boundary so completely. For such eco-feminists, reclaiming a 'feminine perspective' or ethic permits ideas of care and nurture to be mobilised toward radical ends, recalling the claim of (Kneafsey *et al.* 2008).

It has been suggested that organic agriculture can provide a more energy efficient approach due to its focus on sustainable production methods. Compared to conventional agriculture, organic agriculture is reported to be more efficient and effective in reducing water and soil pollution, greenhouse gases (GHGs) emission and risk of human health. In additional, field management under organic condition can be useful for increasing energy efficiency. This is due to the exclusion of N fertiliser, the largest energy input in conventional cropping systems. Energy use per unit yield expresses system efficiency, but the term is insufficient to evaluate the energy characteristics of agricultural systems. Calculation of the most important energy component, net energy production per unit area, showed that conventional systems produced far more energy per hectare than organic systems. Organic versus conventional energy/agriculture debate from a human energy perspective, focusing not only on calorific balance but also on the well-being costs associated with high levels of energy and effort expenditure(Bertilsson *et al.* 2008,Mansoori*et al.* 2012and Smith *et al* 2015).

Through profiling and comparing the effort and energy expenditures of farmers, it sought to bring attention to the importance of the human energy component in farming systems. The main findings of the experiment indicated that both systems require high levels of human energy expenditure but there is a marked difference in the annual and daily energy expenditure levels between the farmers, the organic farmer expended more energy and worked at higher effort intensity than the conventional. The analysis and comparison of annual energy expenditure patterns supported this argument, revealing that over a typical year, the organic farmer experiences a greater level of physical and physiological stress. Due to a lack of useful literature, study has been unable to prove whether organic farming has negative affects for farmers, but has certainly placed a question over the healthfulness of this method of production. It has revealed an unfavourable ratio of human energy to total energy in the organic system. Such a finding draws attention to the need to include human energy efficiencies and calculate human energy both as an input and a physical experience in energy budgets. Increasing levels of environmental destruction and falling energy returns in conventional systems are raising important questions about the energy sources and efficiency of systems. Indeed, more energy accounting studies are now being commissioned and it is felt that important lessons for these studies can be drawn from this experiment. (Loake 2001) illustrated the importance of including human energy inputs in energy accounts and treating them as a physical experience as well as an abstract category as organic agriculture expands in the UK. If analysts fail to calculate human inputs then there is a danger of existing problems in UK agriculture being replaced by concerns over farmer well-being and diminishing returns to human energy. The energy budgets illustrate a clear difference in energy efficiency between the farms, the conventional farm has an energy efficiency of 0.43, the organic farm is approximately eight times more energy efficient than the conventional farm with an energy ratio of 3.4. Also, the time budget study of organic farm in Switzerland shows that the farm women on organic farms work strongly significant longer (191 min a day) in total on specialized produce farms likewise the farmer (247 min a day). (Reissig *et al* 2015).Despite being more efficient in terms of overall energy, the organic farm is less efficient in terms of human energy, and the net energetic returns combined with effort intensity bring into question the health implications of organic livelihoods both in the short and long term.

Table 24.5. Overall energy efficiency ratios

Conventional farm	Energy in GJ	Organic farm	Energy in GJ
Inputs			
Human labour	5.8	Human labour	6.2
Fertilizer	16,380	Fertilizer	180
Electricity	1.2	Electricity	2.1
Fossil fuels	478	-	-
Chemical inputs	350	-	-
Animal feed	85.5	-	-
Total inputs	17,301	Total inputs	188
Outputs			
Yield	7391	Yield	663
Total outputs	7391	Total outputs	663
Balance	-9910	Balance	+445
Efficiency ratio	0.43	Efficiency ratio	3.4

24.3.4 Health safety

Organic cotton production is gaining importance despite its labour intensity, and though yields are around 0.5 ton compared to 1 ton in the conventional sector. In addition, it became attractive for women. Access to modern inputs (synthetic pesticides and fertilisers) and particularly the manipulation of pesticides are among the major constraints for women in cotton production, as they can be the victims of abortion or contaminate easily family food. With the introduction of organic farming, more women start getting their separate cotton field, because they can perform safely all the farming activities themselves. Therefore, the number of women producing organic cotton on a separate plot is increasing. For example in Benin, the percentage of organic female farmers increased from 0 to 25% between 1996 and 2001. This trend was not only observed in Benin but also in Senegal where the percentage of women, producing organic, increased from 5 to 38% between 1995 and 2000.

In order to avoid the contamination of organic cotton, one of the regulatory measures is that the whole household should convert to organic farming. The increasing number of households and particularly the number of women coming to organic cotton lead to the assumption that gender is playing somehow a role in the adoption process of organic cotton. Main reasons for adoption are based on desire for stable income, lack of transparency in the conventional sector and health. Very few (1%) adopt because of environmental reasons. On the side of non-adopter, low yields and a lack of information are the main reasons. Only 4.8% of respondents do not adopt because of labour intensity. Specific gender has been computed as index developed by (Tovignan and Nuppenau, 2004).

Mathematical expression: GI is the gender index of the i^{th} household can be mathematically expressed as follows:

Where, LW and LM be respectively the total labour the women and her husband of thei^{th} household use on the common form for cash crop and food crop. Similarly, IW and IM be respectively the total income the women and her husband get from farm and off farm activities. The gender index *GI* is comprised in the interval [0; 1]. This means that, if GI takes the value zero, the woman contributes neither to the labour nor to the income; a situation which is not common. The other extreme is when the GI takes the value one, a situation that can occur only in a woman headed household. This situation cannot be found in the scope of this study because only households constituting with husband and wife have been taken into account during the field study. The variables such as: the predicted gender index, education level of the head, the topographic status of the land, the farmer's experience about pesticides accidents, access to credit and the number of extension visits farmers receive per month age of the farmer, the amount of his off-farm income and the number of active household members determine positively the adoption of organic cotton. Gender index itself is determined by the education level of women and their membership in women's associations. Women use the opportunity to be educated and belonging to local associations to increase their information level about economic and technical possibilities around them. By taking advantage of those possibilities, they increase their income and contribution to the household needs. Thereby, they may convince their husband to adopt organic cotton in the household, as the whole household has to be converted into organic cotton (and knowing that women are highly constrained in producing conventional cotton).

In-spite of getting almost similar market prices for both the pesticide without pesticide use, the non-pesticide farmers confirmed that they still choose to produce the vegetables without pesticide because they believe they save money from the medical payment due to agrichemical poisoning, which generate higher income over all. Farmers of Thailand reported that they sometimes had headache, dizziness, fatigue, skin itching, burning sensation in nose, runny nose, cough, dry throat and difficulty of breathing. They also experienced in eye itching or burning pain during spraying and skin itching during mixing and spraying pesticides but they believed that these symptoms were common occupational illness and could be occurred even among healthy person (61.8%). The majority (61.1%) thought a pesticide poisoning was not a serious illness. It could not be the cause of abortion or affect nervous system. From their experiences, pesticides poisoning could be the cause of death (16.6%) only in case of suicide. (Chalermphol *et al.*, 2014).

A gendered impact assessment of organic certified pineapple and coffee producers in Uganda found more biased against women in the case of coffee than pineapple regarding additional costs and benefits associated with organic conversion. Gender relations were generally more equal among pineapple farmers, this greater equality giving women better access to pineapple incomes and men less control over their labour for the purpose of pineapple growing. This was in contrast to the situation in the coffee farming community, where the role of women in cash crop production resembled that of hired labourers. Secondly, the sexual division of labour appeared less strict in pineapple than in coffee farming, possibly because pineapple was a crop that was new to the area. Thirdly, pineapple farmers earned very high incomes, which allowed them to hire more labour, as a result of which the demand for women's household labour was reduced. Organic conversion has significantly increased women's labour effort in coffee production that performed most of the extra farming and processing tasks needed for meeting the organic standards and the exporter's additional demands in respect of quality and farm management. As a result, women had an increased workload in farming since organic conversion, which increased their total work burden and reduced the time available for earning individual incomes. However, they still found that organic farming was well worth the extra effort because of the income benefits for the household as a whole, and this despite the fact that in most cases they had no or little control over the use of the income (Bolwig and Odeke, 2007).

24.4 FOOD AND NUTRITION SECURITY

Gender differences in food preferences suggest that females and males assign different meanings and values to different types of foods, which translate into gendered preferences towards certain food types or food attributes (Beardsworth *et al*., 2002).Cultural perceptions of appropriate feminine and masculine identities have also been linked to the types of foods preferred and ascribed to each gender in different societies. Studies conducted in relatively food secure conditions relying on dietary data, have shown that females and males do eat differently. In comparison to males, females tend to eat healthier, have higher nutrition knowledge, higher engagement in food-related activities, and show higher preference towards food items that are commonly included in dietary guidelines. Gender based differences in preferences for organic, GM or local food attributes have been explored to varying degree. Among these three attributes, most attention has been devoted to the organic characteristic of food.

Preference for organics is highest among middle aged wealthy and highly educated females, in families with children, and with persons who claim health, environmentalist, and animal welfare. With regard to GM food, research indicates that females generally do not favour GM products and they are more willing than are men to pay a premium for GM-free foods. Women's influence is also likely to be important where reasons of family health are cited, as traditionally it is the women's role to look after nutrition and health of the family. On several of the 100 organic farms whose motives to go organic were studied in a qualitative social study in Switzerland, the initial 'organic' ideas came from the woman Organic methods were tried at first in the vegetable garden, which is traditionally the woman's domain, before they were introduced on the whole farm. Women's influence is also likely to be important where reasons of family health are cited, as traditionally it is the women's role to look after nutrition and health of the family.

24.4.1 Markets and women empowerment

Women have a lower presence in the formal sector and in more urbanized and developed markets. Their ability to participate in markets will not improve unless women gain land ownership, access to formal financial and technical assistance, and a higher level of education and training (IFAD 2002). Yet there are opportunities for women farmers. If they use traditional production systems, they may find it relatively simple to meet some certification requirements, such as those for organic production. Many high-value crops require labor-intensive production techniques, such as pruning and trellising, which cannot be mechanized and in which women often specialize. There is increasing demand for high-value products such as vegetables and local crops in urban markets. High-value niche markets, such as markets for certified organic or fair trade products, are expanding. The challenge is to ensure that women retain control over their production, processing, and marketing; product quality and reliability must be enhanced. Women farmers to access niche export markets for high-value and brand-marketed products such as fair trade and certified organic products is a way forward. Several market niches are based on these local, traditional, and organic crops that could be developed as specialization areas for women farmers and entrepreneurs. The equity agenda helps in organizing women into cooperatives, providing them with good training, and providing quality technology—good plant genetic material could be the key to commercial success. Several social enterprise initiatives where a collaboration can be formed between producer groups, a private marketing (and/or processing) firm, and a development organization—with the development organization supporting the unsustainable costs of initial capacity building of smallholders.

24.5 LIMITATIONS

Gender plays a role in organic farming practices, despite the fact that women participate more than men in agriculture in developing world, they remain more malnourished and less economically empowered because of the past, generally development assistance failed to reach women in rural areas. There is some indication that gender is a factor in the decision to convert to organic farming, although the role of women in organic agriculture in general and in the decision making in particular has not been studied in detail. High energy and time expenditure in organic farming is a major constraint in organic farming. However, it leads women to participate more but from the view of time and labour intensive it is a shortcoming. Less control and access of women to land, trainings, extension agents, certification, etc. are some other constraints. Women's lack of mobility, lack of access to assets and markets, and lack of linkages to organic value chain actors are major gender-based constraints. Forging women-focused vertical and horizontal linkages for upgrading are particularly effective strategies for addressing such constraints.

24.6 LESSONS LEARNT SO FAR AND ITS POSSIBLE IMPACT ON AGRICULTURE

Organic Agriculture supports gender equality because it creates meaningful work - Due to diverse working tasks, specialized skills, and specific knowledge, women in organic farming often have a more diversified role in the household economy and access to education which increases self-esteem and decision making power.

Offers economic opportunities- Low start-up and production costs and stabilized yields makes organic farming less risky, more affordable and accessible to women, while high-value end products increase their income earning potential.

Supports health. Due to the prohibition of synthetic chemicals, the health of agricultural workers, and thus their ability to participate in income-generating activities and in the community, is not compromised.

Encourages biodiversity and traditional knowledge- Women often held empowering roles as keepers of seeds and traditional knowledge. Control over these resources is strengthened in organic agriculture due to its encouragement of biodiversity and traditional knowledge.

Ensures equitable work standards - Organic standards require that employees have equal opportunity and wages, and access to education and health services. The higher level of social awareness associated with organic agriculture also reduces exploitation of women.

24.7 FUTURE THRUST

Organic agriculture industry should consider the significance of individuals situated, gendered locations in shaping their experiences, participation and knowledge related to organics. This is particularly pertinent in order to understand the ways in which processes of institutionalisation are gendered, and the impacts of this for women and men organic producers, and organic agriculture more generally. The contributions of eco-feminism to better understand these relationships could also be explored further. Gender issues in organic agriculture needs to be studied in detail including participation, access and control over the land and other farm/ economic resources, women's drudgery, health and nutrition etc. Understanding gendered preferences and attitudes towards organic, conventional, GM-free, and other food attributes in the context of competing public health and nutrition, agricultural practice, and marketing demand are the important factors.

Human energy consumption in organic agriculture needs to be studied with respect to gender as very important aspect. Researches related to enhancement of working and time efficiency of women farmers is very essential for organic agriculture. Incorporation of development organisations *viz.* social enterprises, NGOs research institutions in organic value chain where collaboration is required between women producer groups, a private marketing (and/or processing) firm. Such research will benefit from the incorporation of feminist research methods. Indeed, future sociological research into organic agriculture, and rural sociological inquiry in general, might produce more thoughtful (and accurate) findings, by repositioning itself in these ways. Such approaches would provide a framework to re-position the relationships between gendered bodies and the biophysical environment in studies of agriculture and food. This theoretical shift might, in tum, facilitate the reconnection between producers, consumers and the environment – which will surely be the necessary basis of any shift towards a more socially and environmentally responsible system of agriculture and food provision.

In almost all countries of the world, including India women are in a worse situation than men when considering poverty and its effects, access to land, clean water and health services, they remain more malnourished and less economically empowered. Therefore, sustainable agriculture should consider sustainability between men and women. Women's participation in organic farming led to an increase in decision making capacity for women. Many studies revealed that comparatively women are working more in organic farms all over the world including India. Main reasons for adoption are based on desire for stable income, lack of transparency in the conventional sector and health. Traditionally, it is the women's role to look after nutrition and health of the family. In a country like India, where women are working manually in fields for long working hours whereas men are doing mechanized farming, organic agriculture is a viable option. However, possible solutions regarding women's drudgery in organic agriculture is new researchable issue due high levels energy expenditures. Inclusion of women in organic value chains comprising processing and high value organically certified market access is an imperative aspect.

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