PACKAGE OF PRACTICES

FOR

ORGANIC PRODUCTION OF IMPORTANT CROPS IN NEH REGION

Network Project on Organic Farming
DIVISION OF NATURAL RESOURCE MANAGEMENT
ICAR RESEARCH COMPLEX FOR NEH REGION
UMIAM –793 103, MEGHALAYA

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PREFACE

Indian agriculture achieved self-sufficiency in food grain production through "Green Revolution" technologies but at the same time, the country cropped up with multiple problems of decline in agricultural productivity, loss in soil quality, decline soil organic carbon, micronutrient deficiency in soil, build-up of pesticide residues in soil and water, ecological imbalance, etc. Fall in factor productivity followed by soil and health hazards are the burning problems of Indian agriculture today. It is now gradually felt that in addition to the chemical intensive conventional agriculture in the green revolution areas which are mostly confined to irrigated plains, adoption of organic form of agriculture especially in the disadvantaged areas viz., rainfed, dry land and no chemical intensive agriculture zone like the north eastern region of India would be very much useful to sustain the productivity through maintenance of good soil health. These non-green revolution areas could be utilized for promotion and intensification of organic farming to improve economy and prosperity of the farmers of those disadvantaged areas. Organic farming is not merely avoiding fertilizers, pesticides and other agro-chemicals, but also a holistic approach to increase the soil fertility and productivity as the central point for sustainable yields without causing the environmental harm.

The Northeastern Region of India is organic by wisdom and farmers of the region are practicing organic farming from centuries with indigenous knowledge systems. However, with the increase in population pressure there is need for technological backstopping for sustainable organic food production in the region. The research on organic farming conducted by ICAR Research Complex for NEH region, over last one decade has generated very good information on nutrient, water, weed and insect pest management for organic food production. There is constant demand from Extension and Development Agencies, line Departments and farmers for package of practices for organic production of important crops in the region. Organic farming is a continuous and holistic process and hence, there is no single solution to multiples issues under organic farming. The knowledge on organic production systems is based on the innovations and deeper understanding of the system and evolved over the years. Considering the need of the extension agencies and farming community a humble effort is being made for bringing out a publication on "**Package of practices for organic production of important crops in NEH region**". The authors hope that the publication will be helpful for all those who are involved in promoting organic farming in the Region.

The contributions of the Scientists, Technical & Field staff and research associates in generating the information included in this book are gracefully acknowledged. The authors are deeply thankful to the Project Directorate of Farming System Research, Modipuram for sponsoring the Network Project on Organic farming (NPOF) to the ICAR Research Complex for NEH Region, Umiam, Meghalaya. The financial support of ICAR for NPOF is also sincerely acknowledged. ,

Umaim, 2013 Authors

Organic farming - Principles and practices

Organic agriculture is holistic food production system which promotes and enhances agro-ecosystem health including quality and healthy food. This system of agriculture avoids the use of synthetically produced fertilizers, pesticides, growth regulators and livestock feed additives and rely on biological process such as crop rotation, organic manure, green manuring, bio-pesticides etc. The principle elements for success of organic agriculture are-

1. Maintaining a living soil
2. Making available all the essential elements in required quantity
3. Diversified farming with focus on integrated farming system
4. Attaining sustainable optimum yield

Farm designing and Layout

Farm designing is an important aspect for optimizing the utilization of resources within the farm. Topography of the land and varieties of crops to be cultivated are the two basic factors in farm design. Border trees, bund, cattle shed, compost pits, storehouse, etc. should be suitably incorporated (Fig.1).

- The cattle shed, compost yard, storehouse and office could be at a comparatively higher elevation than the cropped area to prevent water logging. This will also help to utilize cattle shed washings to lower ridge cropped area, fishery, etc.
- Multipurpose border trees like neem, pongamia, erythrina, alder or any other local trees of importance may be planted (8–10 m apart) on fences or higher ridges of the farm. These border trees may serve different purposes like wind brakes, green leaf manuring and composting, managing pests and diseases, etc.
- Shrubs like *Glyricidia sp,* Subabul, *Erythrina,* Dhaincha, fodder plants and any other legumes can also be planted between the border trees.
- Leguminous hedge row species such as *Tephrosia candida, Crotalaria sp, Flemingia* sp.etc. should be planted on the boundaries and fences for isolating organic plots, to serve as biological fencing and above all to produce nutrient rich green leaf manure for organic crop production.
- Farm diversification by maintaining subsidiary activities like apiculture, dairy farming, etc. needs to be incorporated.
- Fodder, grasses etc. should be planted on the field bunds to get an additional income to the farmers and also to prevent bunds from breaching.

For sustainable organic farming, the farm should be designed in such a way that all the components or resources of the farm are complementary to each other. A good farm design should incorporate rain water harvesting, soil & water conservation measure, *in-situ* residue management for soil health, hedge row on fences, fodder crops, multiple tree, fruits vegetables and food crops at appropriate location, livestock, fisheries, vermicomposting etc should be integrated for enhancing income and effectively recycling of on farm residues.

Field preparation

The field is ploughed to get a good tilth. At the time of field preparation well decomposed FYM @ 10 – 15 t/ha or vermicompost @ 5-7.5 t/ha should be uniformly incorporated into the soil depending upon their nutrient content. Neem cake @ 150 kg/ha and rock phosphate @ 150kg/ha should be applied during last ploughing.

Choice of crops and varieties

- As per demand of the people of the region as well as market, particular crops should be selected. Joha rice, medicinal rice, vegetable, baby corn, pineapple, passion fruit, ginger, large cardamom, medicinal plants, etc. are in demand for organic production in the region.
- Location specific varieties need to be selected for organic production. The seeds and planting materials should be used which is certified as organic.
- Chemically untreated conventional seed and plant material can be used if certified organic materials are not available. Chemically treated seed and plant materials may be used with the approval of Certification Agency (CA) where no other alternatives are available.
- Crops/varieties should be naturally resistant to pests and diseases.
- Crop rotation including legumes and other green manuring to be practiced. Cover crops, catch crops and mulching should be done for conserving soil fertility and reduce soil loss in hills.
- Seeds which are healthy clean and having high germination percentage from authentic source should be selected.
- Seed treatment should be done by using Cowdung, Neem seed powder coating, Bio-fertilizers (*Azospirillium, Azotobacter*, Phosphorus Solubilising Bacteria) etc.
- Genetically engineered seeds, pollen, transgenic plants or planting materials should not be used.
- Efficient rice and maize based cropping system should identified including vegetable, legume, oilseeds etc., for organic production system in North Eastern Region of India.

Diversity in crop production

Rotation of crops with any leguminous crops to be practiced. Sufficient diversification should be obtained to take care of the pest and disease pressure and to improve soil fertility, microbial activity and general soil health. This also reduces farmers risks and provides some insurance against failure or poor performance of one or other component in the farm.

Nutrient management

- Maintenance of soil fertility may be achieved through organic matter recycling, enrichment of compost, vermi-composting, animal manures, urine, farm yard manure, litter composting, use of botanicals, green manuring, etc.
- Use of bio-fertilizers like *Azolla, Azospirillium, Azotobacter, Rhizobium* culture, *PSB*, etc. to be used.

- Saw dust from untreated wood, calcified seaweed, limestone, gypsum, chalk, magnesium rock and rock phosphate can be used.
- Various sprays like vermiwash and liquid manures etc. can be used in crops for nourishing the soil and plant.

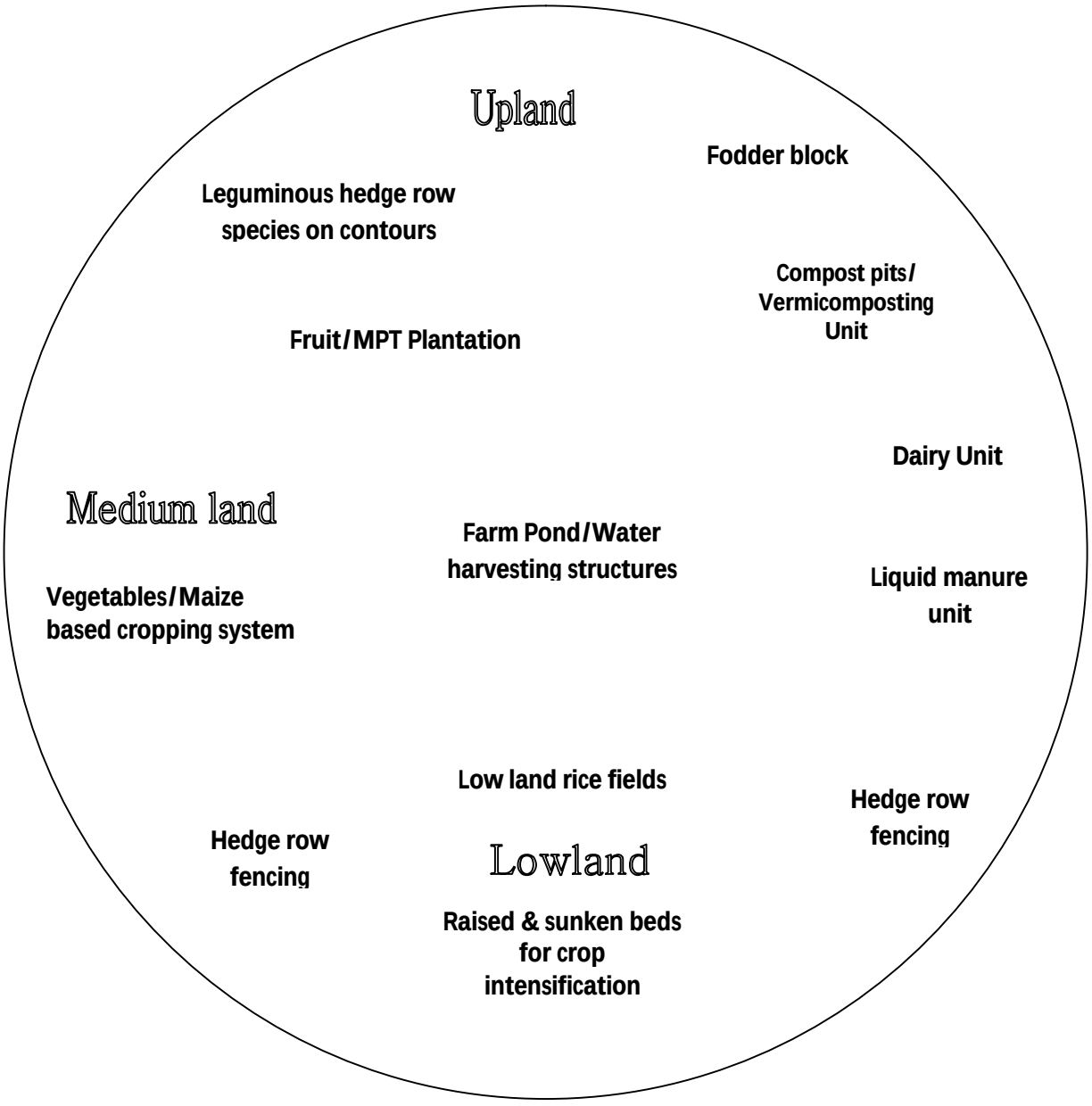

Fig 1. Schematic diagram of farm design for Organic Production in hill agriculture

Weed management

- Hand weeding is to be practiced. Rotary weeder is found efficient in controlling weeds.
- Practice of intercropping, crop rotation, mulching and growing of cover crops are advocated.
- Use of all kinds of herbicides is prohibited.
- Biological weed control may be adopted if feasible.

Contamination control

- All relevant measures should be taken to minimize contamination from outside and within the farm.
- Accumulation of heavy metals (lead, cadmium, nickel, chromium, etc.) and other pollutants should be kept minimum.

Pest and disease management

- Use resistant varieties suitable for the region
- Cultural practices like use of healthy seed, timely sowing, crop rotation, summer ploughing, removal of infested and overcrowded leaves and plants, intercropping, proper use of manure etc. Reduces pest and disease problems.
- Collect the adult and larvae of insect and kill manually
- Biopesticides (Neem cakes 250 kg/ha, Neem oil 2 %, Karanjin, *Beauveria basiana* (2 g/lt), botanicals (Extracts of Eupatorium, Lantana, Turmeric etc) and biological control (Soil application of *Trichoderma harzianium* @ 5 kg/ha) may be used.

Soil and water conservation

Soil and water resources should be handled in a suitable manner. Relevant/appropriate measures should be taken to ameliorate acid soil.

- Excessive exploitation and depletion of water resources is not permitted.
- Pollution of surface and ground water is not allowed.
- Clearing of primary forest not permitted and burning of organic matters to clear land to the minimum level.
- Landscape and biodiversity improvement shall be taken up.
- Across the slope cultivation should be practiced.

The major challenge in Organic Agriculture is the availability of huge quantities of organic inputs for satisfying the farm demand. Use of animal excreta based manure alone is not sufficient for meeting the nutrient needs of the crops. It is therefore, necessary to utilize all the resources available on and off the farm effectively. The resource components available for nutrient management in organic farming are listed below:

- Farmyard manure
- Crop residues
- Weed biomass
- Green manures
- Biofertilizers
- Composts / phospho-compost
- Vermicomposting
- Oil cakes
- Mulching / Cover crops
- Liquid manures
- Biodynamic preparations
- Botanicals
- Legumes in cropping sequence
- Crop rotation / intercropping / sequential cropping
- Hedge row / Alley cropping
- Indigenous Nutrient solutions
- Conservation tillage
- By products from Integrated Farming Systems
- Industrial / agricultural / household waste
- Certified commercial products

Table 1. **Nutrient contents (%) of various livestock excreta based organic manures**

Sources	N	P	K
Farmyard manure	0.93	0.36	0.92
Pig manure	1.19	0.38	0.98
Poultry manure	1.82	0.51	2.10

Table 2. Micronutrient content in FYM and other manures (ppm)

	Micronutrients					
	Fe	**Cu**	**Zn**	**Mn**	***B***	**Mo**
FYM	2600	2.5	57	250	2.1	0.13
Compost	-	450	9.4	12.4	5.8	0.10
Pig manure	1200	8.9	50	70	-	-
Poultry manure	1400	7.1	90	210	5.0	-
Goat / Sheep manure	-	61	2570	150	4600	-

Green Manure

Green manuring can be defined as a practice of ploughing or turning down tender and fresh green biomass into the soil, for the purpose of improving fertility and physical condition of the soil. An ideal green manure crop should be adaptable to growing condition with faster growth, tolerant to adverse

climatic condition, should be effective nitrogen fixer with adequate *Rhizobium* nodulation potential, easy to incorporate and quickly decomposable. Green manuring of different fast growing leguminous crops is suitable for soil fertility maintenance in organic farming. The nutrient content of some green manure crops are given in Table 3. The green manure crop should be allowed to grow up to 45-60 days and should be incorporated into the soil around flowering time. Green manure should not be ploughed deep into the soil. It must be incorporated in few inches of the soil. Usually in light textured soils with optimum moisture conditions sowing can be done after 2 - 7 days of incorporation.

Table 3. Nutrient content of some green manures (% Dry Weight)

	N	P	K
Green manure			
Crotolaria juncea	3.50	0.33	2.38
Tephrosia purpurea	3.11	0.23	1.24

Crop residues and weed biomass

Residues which are left out after the harvest of the crop are either used as cattle feed, removed from the field as stubbles or in many cases burnt in the field. But the residues have good manurial value since it contains appreciable quantity of plant nutrients. The crop residues can be recycled through direct incorporation, compost making and mulch material.

Table 4. Nutrient contents (%) of weeds

Weed biomass	N	P	K
Eupatorium odoratum	2.38	0.07	2.84
Ambrossia artimisifolia	3.19	0.22	4.38

Biodynamic farming

The approach is based on principles of harnessing the energy between cosmos, mother earth, cow and plants. By understanding the gesture and effect of each rhythm, agricultural activities like soil preparation, sowing, intercultural operations and harvesting are programmed to harness cosmic forces. Biodynamic products are applied in small doses as per calendar for improvement in physical, chemical and biological properties of the soil. The ‘cow horn technology’ using cow dung from a lactating cow (BD - 500 and BD - 501) composted in a hollow of cow horn buried in the soil at a moment to link planetary rhythms and constellation is claimed to possess efficacy to increase the soil nitrogen and crop yield. The ascendance (full moon) or descendance of moon may affect the plant growth in the way that the above ground parts develop with the former and the root development, with the latter.

Use of byproduct of livestock based integrated farming system in organic farming

In integrated farming system approach, livestock is an integral part, wherein various enterprises like crop production, horticulture, dairying, agroforestry, fishery etc. are scientifically integrated for efficient utilization of resources and higher productivity and farm income. Here, the waste from one enterprise serve as input for other enterprise e.g. the livestock excreta can be used as manure for crop, as well as feed for fish. Crop residue is again used as feed for the cattle. Cattle, pig, duck etc are very often used as component of such integrated farming system. Likewise there can be a very effective recycling of nutrients, which is desired in any successful organic production system. Bhatt and Bujarbaruah (2006) also indicated that intensive integrated farming system (IIFS) is a viable option for organic farming in North Eastern condition.

Botanicals

Botanicals are the aqueous or alcohol extracts of the different plant species viz., herbs, shrubs or tree that has the properties to stimulate plant growth and productivity by supplying required nutrients and acting as biopesticides. Extracts of some of the plant species were found very effective in improving yield of cereals, oilseeds and pulses. To mention a few are Neem, Karanj, *Eupatorium*, Marigold etc. Botanicals are also available commercially. But only those botanicals that are certified by the accredited certifying agencies are to be used.

Hedge row /alley cropping

Growing leguminous hedge row species in the bound aries will not only protect the field from outside contaminations but also a very good source of plant nutrients and feed for cattle. Some important leguminous species suitable for hedge row are *Cajanus cajan, Crotolaria tetragona, Desmodium rensonii, Flemingia macrophylla, Indigofera tinctoria* and *Tephrosia candida, C. tetragona* can add as high as 50 q fresh leaves / ha /year. On average, the pruning of N fixing hedgerow species can add 20 - 80; 3 – 14 and 8 - 38 kg N, P and K / ha / year, respectively. Addition of leaf biomass from hedge row species improves the fertility status of the soil and lower the soil acidity remarkably from its initial level. C *tetragonoloba* green biomass contains 3.38 % N, 0.46 % P and 1.51 % potassium.The pruning of these species can also be used for mulching, which will help in conserving moisture and on decomposition supply nutrients to the plants.

In alley cropping arable crops are grown in alleys formed by the trees or shrubs mostly leguminous, to hasten the soil fertility. This ensures use of green leaf manures for the intensity crops during the pruning of the trees. Perennial pigeonpea, *Leucaena leucocephala* are commonly used species in alley cropping. The height of the tree is maintained by pruning to avoid excessive shedding. This type of cropping is also practiced in agroforestry systems and plantation crops for maintaining soil fertility.

Vermicomposting

Vermicomposting is a method of preparing enriched compost with the use of earthworms. It is one of the easiest methods to recycle agricultural wastes to produce quality compost. Earthworms modify soil physical and chemical and biological properties and it is believed that they enhance nutrient cycling by ingestion of soil and humus by production of casts. The concentrations of exchangeable Ca, Na, Mg, K and available P, Mo are higher in earthworm casts than in surrounding soil. On an average, vermicompost contains higher level of N, P and K compared to farmyard manure and other sources of manures**.** The vermicompost is not only a source of humus but also contains substances like hormones, auxins, vitamin and other growth promoting compounds.

The worm cast or excretions of worms form the needed organic fertilizer. One worm weighs about 0.5 to 0.6 g and consumes wastes of the same weight as their body weight in a day. If one million worms exist in one acre, the cast they produce in that area is about 500 kg / day / acre i.e., about 200 tonnes per year. The worm cast contains all the nutrients in available form and in addition, a great deal of organic matter is provided to the soil. Therefore, the activity of earthworms is recognized as beneficial for the improvement of soil physical conditions and plant growth. On the other hand, the burrowing activities of earthworms improve air and water penetration into soil. Vermicasts being granular with enhanced porosity and water absorption capacity absorb moisture particularly during night and hold it effectively for releasing it to micro-roots of the vegetation.

Organic matter when subjected to decomposition with the help of earthworms, the resultant product is called vermicompost and the process is known as vermicasting. The product is the result of organic waste consumed by earthworm, digested and excreted in the form of granules. The vermicompost, chiefly the fecal matter of earthworm is rich in plant nutrients, plant growth promoters and beneficial microflora. They grow plants extremely well and they can also be used as structural additives for poorer soils to provide nutrients and minimize erosion.

Plate: 4 vermicompost production organic farming, ICAR-RC-NEH, Umiam

Earthworms enhance the decomposition of organic matter and also contribute 20 - 100 kg nitrogen per ha per year, besides other mineralized nutrients and plant growth factors. Earthworms help the growth of beneficial bacteria and actinomycetes by providing several enzymes, which split complex polymers in waste into simple molecules, which are further utilized by the soil micro-organisms. They also control parasitic nematodes and enhance the crop yields. Although they are present in the soil,

deliberate attempts to enhance their population in the soil through application of vermicompost will be beneficial.

The most commonly used species of earth worms are African night crawler (*Eudrillus euginae*) and red compost worm (*Eisenia foetida*). The optimal conditions for breeding *E. foetida* are summarized, whose values do not differ much from those suitable for other species (Table 5).

Table 5. Optimal conditions for breeding *E. foetida* in animal and vegetable wastes

Condition	Requirements
Temperature	15 - 20 ^{0}C (limits 4 – 30 ^{0}C)
Moisture content	80 - 90 % (limits 60 – 90 %)
Oxygen requirements	Aerobicity
Ammonia content of waste	Low: < 0.5 mg/g
Salt content of waste	Low: < 0.5 %
pH	> 5 and < 9

Source: Azad Thakur, (2006).

Methods of vermicomposting

Vermicomposting of wastes in field pits and ground heaps

Pit method: The optimum pits size for vermicomposting is 2 x 1 x 0.75 meter (L x W x D). Length can be adjusted as per convenience. Series of such beds are to be prepared at one place. This system is good for less rainfall areas. **Bed method:** Instead of opening pits, vermicomposting can be done on the pucca/kachcha floor by making bed (6 x 2 x 1 ft) of organic mixture. For large scale preparations, vermicomposting is also taken up in large structures such as series of rectangular brick columns, cement tanks, stone blocks etc which are filled with organic wastes and composting is taken up.

Methodology

1. Site selection: The site should be cool, moist and shady. Site should be free from termite and red ant activity; pH should be between 6 and 8.
2. Collection of refuge biomass: The waste available in the farm should be sorted in to degradable and non-degradable and may be chopped into small pieces of 5 cm size.
3. Pre-treatment of waste:
   a. Lignin rich residues: The residues like pine needles may be chopped and treated with lignin degrading fungi and later placed to vermi-beds.
   b. Crop stalks sandwiched with garden soil followed by watering for 10 days to make the material soft and acceptable to worms.
   c. Agro-industrial wastes: Mixing with animal dung in 3:1 proportion and kept for partial decomposition and subsequently allowed for end product.
4. Filling of vermicompost pits: A layer of 15 - 20 cm of chopped dried leaves / grasses are kept as bedding material at the bottom of the pit. The processed wastes are then to be filled layer wise (10 - 15 cm layer) and each layer should be made wet while filling and continuously watered for next 10 days.
5. Release of worms in to beds: The optimum number of worms to be introduced is 1000 nos. / m length of bed.
6. Bed moisture: Maintain optimum moisture (30 - 40 %) level by watering at regular intervals to maintain sufficient moisture. Avoid excess watering.

7. Temperature: Thatching the bed during summer months will maintain the required temperature in the pit.

8. Monitoring for activity of enemies (ants etc.) of earthworms and management of enemies with botanicals like neem leaf dust, *Acorus calamus* rhizome dust, neem cake etc. A thin water channel may be provided around the pit to prevent ant problems.

9. Harvesting and storage of vermicompost: When the materials become granular, blackish in colour just like used tea leaves, it indicates that the compost is ready for harvest. At this time, watering should be avoided for 7 days so that worms settle at the bottom layer. It may be mentioned here that earth worm starts feeding from upper surface and move slowly downwards. Collect the compost, dry it in shade for 12 hours, sieve and bag it for storage. It takes about 60 - 75 days for complete process depending upon the weather conditions.

10. Harvesting of worm biomass: The worms are to be collected and used for subsequent vermicomposting.

Liquid manures

Vermi-wash

Vermi-wash is a liquid manure obtained from earthworm used in vermicomposting and is used as foliar spray. It contains plant growth hormones like auxin and cytokinin apart from nitrogen, phosphorus, potash and micronutrients. A container (Concrete/plastic) with small hole at the base can be used for the purpose. A based layer of gravel/broken pieces of bricks are placed in the bottom of the container to the height of 10 - 15 cm above which another layer of coarse sand is placed (10 cm). Normal process of vermicomposting can be practiced in the container using earthworms. For continuous supply of vermi-wash, a pot with some holes in the bottom can be used so that the water trickles down continuously to the vermi-wash container. About 4 to5 litre water everyday may be used in the pot. After about 10 days vermi-wash starts forming in the container. Vermi -wash can be diluted with water and sprayed in the evening hours.

Natural growth promoters /Indigenous nutrient solutions

Various indigenous and natural growth promoting substances have been identified, developed and used for crop production by the farmers. These natural preparations will be of much help in conversion from chemical farming to organic farming. Such alternative natural preparations are Panchkavya, Amritpani, themore solution, Extended EM solution and treated cow urine etc. The growth promoters should be applied two days before full moon, on full moon and /or four to five days after new moon for good results (Sundararaman, 2004). Biochemical properties of Panchagavya (Table 6) were evaluated by Somasundaram and Singaram (2006).

Table 6. Biochemical properties of Panchagavya

Properties	Content	Properties	Content
Total N (mg/kg)	302	Total organic carbon (%)	0.80
Total P (mg/kg)	218	Zn (mg/kg)	0.26
Total K (mg/kg)	355	Fe (mg/kg)	0.83
Sodium (mg/kg)	96	Mn (mg/kg)	0.23
Calcium (mg/kg)	27	Cu (mg/kg)	0.20
PH	5.62	EC (Ds/m)	10.30

Mulching and cover crops

Mulching not only help to improve the soil temperature and moisture regime but on decomposition also enrich the nutrient pool of the soil. Leguminous mulching materials viz., prunings of leguminous hedge row species, stovers of different pulses etc. specially improve the N status of the soil beside other nutrients and organic matter content. Cover crops are grown mainly to conserve soil and moisture beside improving fertility of the soil. In North East, leguminous crops like ricebean, lablab bean, cowpea, groundnut etc. are grown as cover crops. These crops are also very often grown as pulse crop and vegetable crop due to their high nutrient content and demand. These are also used as fodder crop for cattle. Paddy straw, crop residues and grasses are also widely used as mulching and covering materials. Locally available weeds like *Eupatorium, Ambrosia* etc. were found very effective mulching materials. These materials also improved soil fertility on decomposition. In groundnut, grass mulching and *Ambrosia* weed mulching recorded a pod yield of 19.9 and 16.4 q/ha compared to 12.3 q/ha under no mulch.

Specific fertilizer

Mineral grade fertilizers such as rock phosphate (14 – 20 % P), lime, gypsum etc. can be used if required for soil amelioration. Rockphosphate applied to legume is very useful for subsequent cereal or other non-leguminous crops.

Forest litter/tank silts

In North East, there is a huge area (about 60 %) under forest, which offers a lot of litters rich in nutrients. If managed properly, this can be a potent source of nutrients supply in organic crop production. Another important source is the sediment from pond, tank, beels etc. This is not only a good source of nutrients but also a good amendment for improving soil physico-chemical properties.

Oil cakes

Oil cakes can also be used for nutrient addition in soils. Different oil cakes contain different concentration of N, P and K (Table 7). Besides having a high amount of plant nutrients, most of them contain alkaloids, which inhibits the nitrification process of nitrogen in soils. Neem, mahua etc. are potent nitrification inhibitors, equal in efficiency to N-serve in increasing the yield, N uptake and protein content of rice grain. Since the oil cakes form an important component of animal feed, their availability for use in the field is limited. Moreover, oilcakes are not available in bulk and costly in NE region. Only mustard/rapeseed oilcake is available and can be used as source of nutrition to crops.

Table 7. Nutrient composition (%) of oil cakes

Oil Cake	N	P	K
Rape seed cake	4.8	2.0	1.3
Neem cake	5.2	1.1	1.5

Source: Sharma (2002).

Panchagavya

Constituents

Particulars	Quantity	Particulars	Quantity
Cow dung	: 5 kg	Ghee	: 2 litres
Cow's urine	: 5 litres	Jaggary	: 1 Kg
Sour curd	: 2 litres	Tender coconut	: 5 - 6 nos.
Milk	: 2 litres	Banana	: 10 - 12 nos.
Water	: 5 litres		

Method of preparation

Fresh cow dung and cow ghee may be mixed together and kept in a plastic bucket for four days. This may be mixed daily once after four days, with 5 L of cow urine, 2 L of sour curd, 2 L of milk, 1 kg of palm sugar, 1 L of coconut water from immature fruits, 12 ripe bananas and 5 L of water are added to it. The container with the mixture was covered with wire mesh and kept under shade for fermentation and stirred thoroughly twice a day up to 15 days. The more it is stirred, more aeration is provided and therefore more micro-organisms are multiplied in the solution. This material can be kept for six months for use, by stirring it daily. If the solutions become very thick, add sufficient water and keep it loose enough. The number of days the panchagavya is stirred, the more potent it becomes. This contains all nutrients, microorganisms and plant growth nutrients in large quantity. This acts 75 per cent as manure and 25 per cent as pest controller.

How to apply

Dilute 1litre of mother solution in 10 litres of water (10 % strength) and use as a foliar spray or 5 - 10 litres per acre in irrigation water.

Biochemical properties of Panchagavya (Table 8) was evaluated by Somasundaram and Singaram (2006).

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Farming system: the key to success of organic farming

Adoption of farming system approach is the key to success of any organic farming system. The resources are to efficiency recycled within the farm and dependants on external resources have to be minimum. Crop rotation, vermicomposting, green leaf manuring, dairying, livestock components, residue recycling etc should be done in an efficient manner. There should not be any waste in the system. All the wastes are to be converted to valuable biomanure for organic food production. The component of farming system should be selected depending upon the local demand, soil and agro-climatic conditions. Soil and water conservation measures should be the integral part of farming system for natural resource conservation and sustainable organic farming.

Certification

Organically produced food are to be certified by a registered certifying agency e.g. INDOCERT, SKAL, SGS, etc. Certification is a process in which entire process of production are monitored by the accredited certifying agency. Without this certificate, even the organically produced commodities can not be sold outside or exported with organic tag.

RICE

Rice (*Oryza sativa* L.) is the staple food for the people of North Esat India. There is very good potential for organic rice production in the region. Most of the farmers in the region are small and marginal and generally do not use any chemical input to rice. The average nutrient consumption is only about 12 kg/ha except Manipur and Tripura. Even in Manipur and Tripura also the use of fertilizer and other agro-chemicals are meager in hilly areas. Therefore, organic rice cultivation using proper technology would not reduce the producti vity, rather there is scope for enhancing yield. The aromatic and sticky rice of the region has got very good export potential. To mention a few are Joha rice (Assam), purple and sticky rice (Manipur) and Jasulaya (Meghalaya) and aromatic rice such as Harinarayan and Kalakhasa (Tripura). Thus farmers of the region can grow aromatic and slender grain rice to take advantage of the growing international market. The entire jhum rice area is organic by default and the region is still having an area of about 0.88 m ha under jhum.

Organic rice production involves recycling of crop residues, crop rotation, inclusion of legumes in system both in sequence or as intercrop, green manuring, off -farm waste recycling, use of mineral rocks like rock phosphate, mechanical cultivation, biological pest control and avoid use of synthetic agrochemicals with the overall objective of sustainable production, maintaining resources and environmental quality. Weed control, soil fertility and management of pest and diseases are the principal challenges associated with organic rice production.

Climatic requirements

In India rice is grown under widely varying conditions of altitude and climate. Rice crop needs a hot and humid climate. The average temperature required throughout the life period of the crop ranges from 21-37 ^{0}C. At the time of tillering the crop requires a higher temperature than growth. Temperature requirement for blooming is in the range of 26.5-29.5 ^{0}C and ripening time temperature should be between 20-25 ^{0}C.

Soil

In India rice is grown so diverse soil conditions and any type of soil reaction varying from acidic to alkaline. Soil having good water retention capacity with good amount of clay and organic matter are ideal for rice cultivation. Well-drained, loamy and light alluvial soils with pH 5.0 to 6.5 are ideal for proper growth and development of Rice.

Varieties

Low latitude

IR 64, Naveen, Gomati Dhan, Ranjit, RC-Maniphou-4, RC-Maniphou-5, RC-Maniphou-7, RC Maniphou 10, TRC Borodhan-1, DR 92, Shahsarang 1, Lampnah etc.
Aromatic and fine grain rice: Joha, Kalikhasa, Harinarayan

Mid altitude

Upland: Bhalum-1, Bhalum-2, Bhalum-3, Bhalum-4, Iuron and IET 20204

Lowland: Shahsarang-1, IR-64, Lampnah, VD-82, Krishma Hamsa, Mendri, Manipuri

Aromatic and fine grain rice : Megha AR-1, Megha AR-2, Kekeki Joha

High altitude
Megha rice1, Megha rice 2, Megha rice 3

Crop Duration

120 – 160 days depending upon varieties and sowing time

Seed rate:

a. **Transplanting:** For medium to fine type rice variety a seed rate of 35-40 kg/ha and for bold type 40-50 kg/ha will be sufficient for transplanting one hectare of land.
b. **Direct seeding**: For direct seeding in upland condition, a seed rate of 60-80 kg/ha is required to get good plant stand.
c. **System of Rice Intensification**: 5 kg/ha
d. **Integrated Crop Management**: 10 kg/ha

Land preparation:

a. **For transplanting**: Prepare the land thoroughly and keep well leveled with peripheral bunding. Puddling should be done 3-4 times to make it weed free and water retentive. Apply FYM 15 t/ha or FYM 7.5 t/ha + V.C 2.5 t/ha with 150 Kg/ha Rock phosphate 20 days before last ploughing. All the phosphorus and potash and 50 % of nitrogen should be incorporated thoroughly into the soil at the final puddling. Recycled all the residues into the soil.
b. **For direct seeding:** Two cross ploughing (4 ploughing) is necessary to get good tilth of soil and weed free land. Application of lime @ 2 t/ha at the first or second ploughing is necessary to obtain good yield. Lime should be applied at least 1-2 weeks before sowing. Liming should be repeated every 3-4 years. All the phosphorus and potash should be placed in furrow before sowing. Cultivate lugume in rice field after 2-3 years to building up the soil fertility.

Methods of nursery

a. Wet method

The wet method can be adopted in areas where water is available. Prepare raised beds of 5-10 cm height, 1-1.5 m width and of convenient length with drainage channels between the beds. The total seedbed area should be 1000 m^2 for each ha of the field to be transplanted. Apply vermicompost @ 500g / m^2 and rice husk ash @ 100 g / m^2 of the nursery bed and mix well with the soil at the time of preparation of the field. Application of vermicompost reduces the incidence of thrips. If vermicompost is not available, apply compost or cattle manure @ 1 kg / m^2 and 100 g of rice husk ash / m2 of the nursery bed and mix well with the soil at the time of preparation of the field. Biofertilizers can also mixed well in nursery @ 2kg/1000 m^2 before the sowing of seed.

b. Dry method

This method is practiced in areas where sufficient water is not available and the time of planting is uncertain. Prepare raised beds of 1-1.5 m width 15 cm height and of convenient length. Apply vermicompost @ 500 g/ m^2 and rice husk ash @ 100 g / m^2 of the nursery bed. If vermicompost is not available, apply compost or cattle manure @ 1 kg / m^2 and 100 g of rice husk ash / m2 of the nursery bed

and mix well with the soil at the time of preparation of the field. Sow the seeds treated as described under dry seed treatment method, evenly over the bed and cover with fine sand / soil.

Time of transplanting/sowing:

Transplanting: The optimum time of transplanting is first fortnight of July for low and mid altitude. Time of transplanting should be adjusted to avoid low temperature during flowering especially in higher altitudes (above 1300 m). Therefore, under high altitude, transplanting should be completed within 15th June, preferably by first week of June. For mid and low altitude valley land, transplanting can be done as late as 3rd week of July with closer spacing (15 x 10 cm) and aged seedling (40-45 days old). Seedling age of 20 -25 days with 20 x 15cm spacing and 2-3 seedlings/hill is considered best for timely transplanted crop. For SRI, 10-12 days and for ICM 15-20 days old seedlings are transplanted. For SRI and ICM methods of rice cultivation the number seedlings / hill required are only 1 and 2 seedlings/hill, respectively with a spacing of 25 x 25 cm for SRI and 20 x 20 cm for ICM.

Direct sown:

In upland direct sown crops, sowing should be completed within first fortnight of June in mid altitude condition. Timely sowing is necessary to have enough time for the succeeding *rabi* crops, which are normally sown in the second fortnight of October. Direct seeded crop is sown in line of 25-30 cm apart maintaining a seed rate of 60-80 kg/ha.

Age of seedlings and spacing

Methods	Spacing	Age of seedling	Seedling/hill
Conventional Rice culture (CRC)	20 x15 cm	30 days	3 seedlings
Integrated Crop Management (ICM)	20 x 20 cm	20 days	2 seedlings
System of Rice Intensification (SRI)	25 x 25 cm	12 days	1 seedlings
Late transplanting	20 x10 cm	30-35 days	3-4 seedlings

Liming

Lime application ameliorates soil acidity and enhances crop nutrient uptake. In general, addition of lime is absolutely necessary when the pH is lower than 5.0 and it is not advisable especially for rice when pH varies between 5.5 and 6.5. For direct seeded crops, apply lime @ 2000 kg/ha in about one month before sowing and if lime was applied in the furrow then doses should be 500 kg/ha during at the time of sowing. For transplanted crop, apply lime @ 2000 kg/ha about one month before transplanting once in every three yaers.

Nutrient Management for Main Field:

(a) Direct sown:

In upland direct seeded crop, 12-15 tonnes well rotten Farm Yard Manure (FYM) along with 150 kg rock phosphate is sufficient for sowing of one hectare area. Alternatively, 5-7.5 tonnes vermicompost along with 150 kg rock phosphate may be used. Integrated application of FYM @ 10 t/ha and vermicompost 2.5 t/ha along with 150 kg rock phosphate is the best option for higher productivity and sustainability of rice production. Application of neem cake 150 kg/ha provides protection against soil borne diseases and improves nutrition of rice crops.

(b) Transplanted:

All the weed biomass and crop residues of previous crop should be incorporated within the field, which improve the fertility of soil and reduces the requirement for organic manure application. Apply 10-12 tonnes of FYM before 20 days transplanting and 250-300 kg neem cakes during transplanting of rice crop or apply 5-6 tonnes of vermicompost before 20 days transplanting and 250-300 kg neem cakes during transplanting of rice crop. Application of 5 tonnes FYM + 2 tonnes vermicompost + 3 tonnes green manures / weed biomass (*Eupatorium/Ambrosia*) before 20 days transplanting and 250-300 kg neem cakes during transplanting of rice crop is the best nutrient management options. Rockphosphate @ 150 kg/ha may be applied for better phosphorus nutrition.

Methods of green manuring

Leguminous green manures used in rice based cropping system include *Sesbania aculeata, Sesbania rostrata, Sesbania speciosa* and *Crotalaria juncea*. These are grown during the pre rice season between April and June and the biomass is incorporated into the soil before rice is transplanted. Wherever limited irrigation facilities are available, grain legumes such as green gram, black gram and cowpea can be grown in summer season.

In-situ green manuring

Farmers can choose the green manure crop according to their local availability and agroclimatic conditions. Dhaincha (*Sesbania aculeata*) is the commonly used and ideal green manure crop for rice fields. Usually after the harvest of *rabi* crop, daincha is sown with the receipt of summer showers and it is ploughed and incorporated 8-10 weeks after sowing. Among the green manure crops, *Sesbania aculeata* is the one, which can supply highest amount of biomass and nitrogen. It is fairly drought tolerant and resistant to water logging. It is suitable for loamy and clayey soils. One crop of dhaincha can add 10-20 tonnes of biomass per ha. For sowing one ha area, 20-25 kg of seed is required. It can fix about 75-80 kg N per ha depending on the environmental conditions.

Methods of application of biofertilsers

Azospirillum

Seed treatment:

Mix the carrier based inoculum 200 g in 200 ml of rice gruel to make a slurry which is sufficient to treat 10 kg of seed. The seeds are mixed in the slurry so as to have a uniform coating of the inoculum over the seeds and then shade dried for 30 minutes. The shade dried seeds should be sown within 24 hours. Biorganic RF 79 developed at ICAR Complex, Umiam @ 40 ml/L for seed treatment has been found to increase rice productivity by about 15 %.

Main field application:

Two kilogram *Azospirillum* is mixed with 50 kg of dried powdered farm yard manure and then broadcast in one ha of main field just before transplanting.

Phosphorus Solubilising Bacteria (PSB)
Carrier based phosphobacteria can be applied as seed treatment and field application as in the case of *Azospirillum.*

Azolla
Azolla can be applied as green manure for rice before transplanting. For this, Azolla is grown 15-20 days before transplanting of rice by applying 1-2 t fresh inoculum per ha in a well prepared field. Rock phosphate is applied @ 62.5 kg/ha in three equal splits at an interval of seven days. After the formation of thick mat, water is drained out and the field is ploughed for incorporating Azolla.

***Dual culture*:**
Growing of Azolla along with rice is more easy and feasible. Azolla technology is very efficient in terms of nitrogen fixation and biomass accumulation during *rabi* season due to better environmental conditions for its vegetative multiplication. It can also be used for late *kharif* season. Fresh biomass of Azolla is applied in the main field 7-10 days after transplanting rice. Inoculation of fresh biomass of Azolla @ 200 kg / ha could multiply faster and cover the rice field as a green mat in 2-3 weeks period with 15-20 tonnes biomass accumulation. Azolla is incorporated at the time of first weeding. It can be done with a weeder or leave it for self decomposition. Azolla decompose in the flooded rice field in 2-3 weeks period. During the incorporation of Azolla, the left over fronds float on water surface which multiply and cover the rice field. Again 2-3 incorporation is possible. The cultivation of Azolla not only supplies biomass and N, but also contributes K, P, Ca, S, Zn, and Fe. The suppression of weed growth is another added advantage of Azolla cultivation along with rice.

The nutrient content of some tree leaves such as *Gliricidia maculcata* grown abundantly in humid tropical areas of NE region contains 2.9% N, 0.5% P and 2.8% K on dry wet basis can be a local source of leaf manure producing 12 – 15 kg dry matter / tree. About 400 plants can be grown on the peripheral yielding 5-6 t green manure/ha. Other tree species like *Crotalaria juncea* and *Tephrosia purpurea* are observed to have 2.4 – 2.7 % N, 0.3 – 0.6 % P and 0.8 – 2.0 % K.

Table 1. Biomass production and N accumulation in some common green manures

Common name	Botanical name	Growing season	Output in 40-60 days	
			Green matter (t/ha)	N accumulation (kg/ha)
Sunhemp	Crotolaria juncea	Wet	21.2	91
Dhaincha	*Sesbania aculeate*	Wet	20.2	86
Pillipesara	*Phaseolus trilobus*	Wet	18.3	201
Cowpea	*Vigna sinensis*	Wet	15.0	74
Guar	*Cyamopsis tetragonoloba*	Wet	20.0	68
Khesari	*Lathyrus sativus*	Dry	12.3	66

Table:2 Rice grain yield (t/ha) as influenced by organic, inorganic and integrated practices

Treatments	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
Natural	2.22	2.23	2.20	2.08	1.56	2.04	2.05
Organic	3.23	3.24	3.47	3.49	3.36	4.05	3.47
Inorganic	3.16	3.19	3.35	3.53	3.56	3.89	3.45
Integrated	2.93	3.14	3.50	3.34	3.61	4.26	3.46
CD *(P=0.05)*	**0.19**	**0.21**	**0.12**	**0.120**	**0.18**	**0.34**	**-**

Table:3 Varieties and organic nutrient management sources on productivity on lowland rice

	Yield (t/ha)					
Varieties	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**Mean**
IR-64	4.32	4.12	4.36	4.20	4.03	4.21
Shahsarang-1	4.51	4.23	4.58	4.33	4.16	4.36
Lampnah	4.20	4.19	4.06	4.24	4.13	4.16
K.Hamsa	4.00	3.96	3.86	3.76	3.94	3.90
SEm (±)	**0.026**	**0.02**	**0.011**	**0.011**	**0.038**	**0.023**
CD(P=0.05)	**0.08**	**0.06**	**0.04**	**0.04**	**0.11**	**0.07**
FYM	4.45	4.25	4.56	4.28	4.33	4.37
Vermicompost	4.11	4.02	4.25	4.13	4.17	4.14
Pigmanure	4.62	4.36	4.64	4.48	4.40	4.50
Paddy straw	4.20	3.96	3.96	4.19	4.24	4.11
Control	3.52	3.41	3.35	3.61	3.19	3.42
SEm (±)	**0.027**	**0.03**	**0.05**	**0.02**	**0.04**	**0.032**
CD(P=0.05)	**0.080**	**0.09**	**0.15**	**0.06**	**0.14**	**0.10**

Water Management:

(a) Transplanted rice:

Continuous sub-mergence of 2-5 cm during crop growth (transplanting to maturity) gave higher yield. This practice help to suppress weed growth right from the beginning. Water is drained out during fertilizer application. The depth of water should not exceed 5 cm in the field particularly at the tillering stage of the crop. Higher depth of water during tillering reduces the number of tillers/hill causing reduction in yield. After the completion of tillering, the field should be drained out for a week and reflooded again. This will result in higher number of effective tillers/hill. In any case, there should not be any water stress during panicle initiation to grain filling stage. Irrigation should be stopped 3-4 weeks before harvesting the crop. Under SRI practice no flooding is needed and field is kept saturated. No standing water to be maintained during tillering up to panicle initiation. Intermittent wetting and drying until panicle initiation stage is desirable. The period of drying and wetting can range from 2-7 days.

(b) Direct seeded rice:

Cultivation of crops in topo-sequence helps in better utilization of water in hill slopes and terraces. While rice is cultivated in terraces or slopes, it should be grown in the lower portion of the hill slope where runoff concentrates. Water harvesting in-*situ* in flat or terrace land can be done by providing peripheral bunding to increase crop yield. Saturation and submergence are equally effective for direct sown rice.

Weed management

Weed control practices includes hand weeding, crop rotation, land leveling, stale seed bed preparation, flooding and use of rotary weeder etc. Longer crop rotation breaks the cycle of weed growth, while proper land preparation, leveling and flooding to uniform depth suppress weeds directly. In upland rice intercropping with legumes like soybean, groundnut etc. (4:2 row ratio) was found to reduce weed problem besides adding to soil fertility.

Weed management through cono-weeder at lowland field

Application of fresh makrishal (*Schima walchii*) leaves and twigs @ 10 t/ha was found to improve rice yield besides keeping the weeds at minimal level. Regular incorporation of weeds into the soil during fallow period not only reduces the weed problem but also adds to soil nutrient reserve. The longer rotation allows additional time to break weed life cycles and reduce the number of weed seeds in the soil. Other weed-control options center on the use of field flooding to suppress weeds directly and to give the crop a competitive advantage. Flooding will be more effective if fields are precision leveled. Levelling makes the water depth uniform and facilitates rapid flow onto and from the field. Dual cropping of rice with *Azolla* also reduces weed problems and improves productivity through addition of macro and micronutrients. Releasing about 20 ducklings/ha also keeps the weeds at minimal level and increases rice yield.

Pest and disease management

The incidence of pest and diseases in properly managed organic fields are generally low. This is because of resistant varieties, cultural practices like crop rotations, time of planting, balanced nutrition, proper water management, clean field bunds, removal of infested leaves and plants. Selection of healthy and

clean seed materials will keep the problem of disease pest at minimal level. The pest and diseases are also kept at minimum level, by use of botanicals such as neem based formulations as repellant, growth retardants, release of natural enemies such as *Trichogramma* against stem borer and leaf folder, while decomposing organic manures suppress the nematode population. Soil application of neem cake @150 kg/ha or spraying of and derisom, neem oil @ 2.5 ml/lt water prevent insect pest and disease attacks and enhance plant growth and yield through reduction in nitrogen loss from the system. Spraying 2 % solution of turmeric powder is effective against rice blast. Stored grain pests are managed by keeping the produce with neem, lantana leaves, *Eupatorium* leaves etc.

Spraying *verticilium lecanii* @ $1x10^9$ spore/ml reduces the problem of white backed plant hopper (WBPH) in rice. Release of *Trichogramma* egg parasitoids @ 50,000/ha reduces stem borer and leaf folder population to a great extent. Entomophthora fungal infection is severe on white leaf hoppers in North East. The pathogen infects leaf hoppers during booting stage of rice and control the pest population to the tune of 60 %. Spraying of *Beauveria bassiana* @ 3 g/lt for the control of rice hispa was found. Application of neem cake or neem oil with organic manures prevent insect pest and disease attacks and enhance plant growth and yield through reduction in nitrogen loss from the system. Karanjin/derisome spray @ 2ml/lt is useful to check sucking pests, thrips, BPH etc. Timely planting, variety selection, and cultural practices to suppress weeds and encourage dense stands of rice will help control stinkbugs and water weevils. Rice blast and sheath blight diseases are often controlled by appropriate variety selection. Excessive nitrogen levels, rarely a problem in organic production, can encourage sheath blight, kernel smut, and other diseases. Spraying 2 % solution of turmeric powder was found effective against rice blast. Stored grain pests are managed by keeping the produce with neem, lantana, leaves, Eupatorium leaves, bamboo bean, paddy straw bins etc. good aeration. In tripura farmers uses fresh branches of eupatorium locally called *Pisach* (*Eupatorium adhenophorum*) to control sucking pests in rice. Detopping of rice at vegetative stage also reduces the problem of some pests in rice. Spraying of aqueous extract of plant species *Gnidia glauca* and *Labelia nicotianifolium* reported to significantly reduce the incidence of orange headed leaf hopper (OHLH), *Thaia subrufa* in the hill zone of Karnataka along the western zone. It was also reported that the management of OHLH using botanical extract is not only economical but also ecologically safe. Indigenous pheromone traps (100 traps/ha) at flowering are very effective against insects like gundhibug. Light trap is effective against those pests of rice that are attracted towards light. Proper storage of seeds in **s**toring in bamboo bin, paddy straw bins etc. provides good aeration and reduces the problem of storage pests.

Cropping systems

Since successful *rabi* cropping is very difficult under rainfed upland in NEH region, cropping intensity and total productivity can be increased by intercropping of soybean, arhar and groundnut with rice in upland. It has been found that rice + soybean (4:2 row ratio) and rice + groundnut (4:2 row ratio) are promising in NEH regions. Wherever possible rice should be rotated with leguminous crops for improving soil health and sustaining rice productivity.

Under high altitude conditions monoculture of rice is prevalent but cropping sequence of potato-rice is recommended. Under mid and low altitude, rice-mustard, rice-pea/lentil is recommended. In irrigated condition of Manipur and Tripura, rice-rice-pea/lentil/toria as rainfed is in practice. Rice + tomato, rice - tomato, rice + chillies, rice-chillies, rice-mustard, rice-

Frenchbean, rice- carrot etc are recommended on raised and sunken bed systems under wet and marshy valley land of Meghalaya or elsewhere in NEH Region.

Under raised and sunken bed system of cultivation in lowlands and valley lands, rice-rice or rice-pulses on sunken beds and rice-vegetables on raised beds are having very good potential for higher productivity and income.

Rice under raised & sunken bed systems

Vegetables crop under raised bed after rice crop

Harvesting:
Rice attains maturity at around 30 days for early and 40 days for medium to late maturing varieties after 50 % heading in low and mid altitude areas. In high altitude areas, it may take some more time to attain maturity. Harvesting is done at the yellow ripening stage to avoid shattering loss in field. SRI was mature 12-15 days than conventional and 7-10 days than ICM.

Yield

A well managed direct seeded crop yields about 2.5-3.0 t/ha and transplanted crop gives about 4.5 -5.0 t/ha under organic production.

MAIZE

Maize (*Zea mays* L.) of one of the most important cereal crop in the world used as food for humans and feed for animals. It has very high yield potential, there is no cereal on the earth which has so immense potentiality and that's why it is called 'queen of cereals'. Maize is grown in almost all the states of India. It is next to rice, wheat and sorghum with regards to area and production in India.

Maize crop is utilized in many ways like grain crops.Over 85 % maize produced in the country is consumed as human food. Several food dishes including 'chapaties' are prepared out of maize floor and grains. Green cobs are roasted and eaten by people with great interest. It is good food for poultry, piggery and other animals. Maize grain contains about 10 percent protein,4 per cent oil, 70 percent carbohydtates, 2.3 per cent crude fibre,10.40 per centalbuminoides, 10.4 per cent ash. Maize protein 'Zein' is deficient in tryptophane and lysine, the two essential amino acid. Maize grain has vitamin A, nicotinic acid, riboflavin and vitamin E. Maize is low in calcium,fairly high in phosphorus.

Soil and Climate

Maize is best suited in well drained sandy loam to silty loam soils. Water stagnation is harmful to the crop, therefore, proper drainage is a must for the success of the crop especially during *kharif* season. The pH ranges between 5.5 -7.5.The alluvial soils are very suitable for growing maize crop.

Maize is warm weather plant. It grows from sea level to 3000 m altitude. It can be grown under diverse conditions. It is grown in many part of the country. *Kharif* season is main growing season in northern India. In the south, however maize is sown any time from April to October. The most suitable temperature for germination is 21^{O}C and for growth 32 ^{O} C. Extremely high temperature and low humidity during flowering damage the foliage, desiccates the pollen and interferes with pollen germination.

Varieties

RCM1-1, RCM 1-2, RCM 1-3, DA 61-A, RCM 75, RCM 76,Vijay Composite, HQPM-1, HQPM-2, Ganga-11, Ganga-2

Baby corn:HM-4, VL-42, Prakash

Land Preparation

Land should be plough 2-3 times to a depth of 20-25 cm. Planking should be done after each ploughing. A properly leveled and uniformly graded field is required for good water management. Good drainage should be provided in maize field, because stagnation of water in the field is harmful to the crop.

Seed rate and Spacing

Optimum plant population about 60-66 thousand per hectare would be needed to attain optimum yield. Maize seed should be planted at 60 cm row to row and 20-25 cm plant to plant spacing. Seed rate 20-25 kg/ha is sufficient for sowing of one hectare land. Maize seed should be sown at a depth of 5-7 cm. For baby corn spacing between plant to plant can be reduced to 10 cm for accommodating more number of plants with increased seed rate of 30 kg/ha.

Time of planting

Date of planting will differ from place to place. *Kharif* season maize should be sown two weeks before the onset of monsoon, where irrigation facilities are available. In rainfed, condition, the sowing of maize is generally done with the onset on rains. The optimum time of sowing for *kharif* maize in different agro climatic regions is as follows

Agroclimatic region	**Sowing Time**
North-western hills	April to early May
North-eastern hills	April-May
Peninsular region	May-June
Indi-gangetic plains	June –July

Manures and Fertilizers

Manures and fertilizers both play important role in the maize cultivation. Maize seed should be inoculated with N fixing microorganisms like *Azospirillum*, *Azotobacter*, etc. and phosphorus solubilizing bacteria (PSB) at 20 g/kg seed. Well decomposed FYM at 15 t/ha should be applied 20 days before sowing of crop with150 kg rockphosphate. Crop residue of maize plant after harvesting should be incorporated in the field. FYM doses can be reduced up to 10 t/ha if vermicompost is applied @ 2-3 t/ha along with rockphosphate @150 kg/ha. Neem cake can also be added @150 kg/ha to the field for effective control of soil borne insect pests. Maize plant should be intercropped with legume crops or legumes should be incorporated in the cropping systems. Green manuring (dhaincha) and green leaf manuring (*Tephrosia*) are also very good source of plant nutrients to be incorporated into the soil.

Earthing up

One earthing up may be given along with first weeding at 30-35 days after sowing to protect the plant from lodging.

Water Management

Maize is very sensitive both to excess water and moisture stress. Never allow water to stand in a maize field during its life cycle. Water stagnation even for 6-7 hours continuously can damage the crop. Maize can tolerate heavy rains provided water does not stand in the field for long periods. Therefore, drain out excess water by making drains of adequate capacity at the lower end of the field. A good crop of maize require about 500-600 mm of water during its life cycle. Tasseling and silking is most critical stage for irrigation. At critical growth stage water shortage even for 2 days can reduce maize yields by about 20 per cent.

Weed Management

In *kharif* season weed problem is more due to abundant rainfall. Weeds emerge with the germination of maize seeds and grow along with plants till the early growth period. This causes severe crop-weed competition. Failure of timely weed control gives heavy loss to crop yield. Mechanical weeding should be done 15-20 days after sowing of maize, which provide aeration to soil and also manage the weeds. Second weeding (Hand weeding) was done after 30-35 DAS and third after 50-55 days sowing. Mulching in between two rows of maize with weed biomass also control the weeds.

Cropping System

Intercropping

It is better to grow a legume as intercrop in maize. In high altitude, Maize + soybean (one row of soybean in between two rows of maize) is very good intercropping practice for the region. In maize + soybean inter cropping, soybean detopping is necessary in high rain fall area, which adds 8-10 kg N/ha and also improve the productivity of soybean. In mid and low altitude area Maize + arhar (1:1 ratio) or Maize + groundnut/soybean and maize + rice bean is highly promising intercropping system. Paired row planting (2:2 row ratio) should be done for intercropping by adjusting spacing of the maize crop.

Cropping sequence

High altitude	-	Maize + soybean
Mid & low altitude	-	Maize-French bean, maize- mustard and maize-vegetables
		Maize-pea (for vegetable purpose, 70 days duration)
		Maize (fodder)-Rice (early variety sown at the end of June)
		Maize + Soybean (2:2)- mustard

Plantprotection

Insect pests

Maize cob borer, stem borer, cut worms are the major insect pest of maize. Use of resistant varieties (RCM 1-1 and local yellow are tolerant to cob borer) and timely sowing reduces the problem of disease and pests. Summer ploughing exposes the larvae of insect pest to natural predators like birds. Eggs of insect (Grasshoppers, crickets, etc) also gets exposed to sunlight and get killed. Burn the stubbles of infested crop to reduce the problem.

Trichogramma @ 50000 nos. per ha is suitable for most of the insect pest. Spraying Derisome (product of *Derisindica*) or neem oil @ 2.5 ml/litre of water at 20- 25 days after germination checks stem borer, cut worms and army worms. Spraying of lantana extract 10%and panchgavya 3 % control in insect pest. Application of Neem cake @150 kg/ha to the field for effective control of soil borne insect pests like cut worm.

Diseases

Leaf blight, brown spot and rust are the major diseases of maize. These can be managed by using resistant varieties like MCU-9, COM-1, Vaimindum (local var. of Mizoram), Local yellow, Local white, Vijay, MCU-204, MCU-314. Spraying the crop for 3 or 4 times at 15 days interval with neem oil/ derisome @ 2.5 g/lit or panchgavya 3 % is effective for controlling of many

diseases and also supply some nutrients to the plants. Preventive measures like collection and destruction of all infested plant materials after harvest and practice crop rotations with non-cereal crops preferably legumes should be followed to manage diseases effectively.

Harvesting

Crop should be harvested by removing the mature cobs from the plants and keep the standing stalks in the field itself for putting mulch in succeeding crop. In baby corn, harvesting of cobs should be done immediately after emergence of the silk. Five to six harvesting can be done at two days interval in baby corn.

Shelling

Use maize sheller developed by the ICAR Research Complex for NEH Region, Umiam, Meghalaya for shelling the dry cobs to save money, time and increase efficiency of labourers. After shelling seed should be sundried to keep the grain moisture at 20-12 %.

Yield

A good crop of maize produces a grain yield of about 4.0 to 5.0t/ha under organic production system.

POTATO

Potato (*Solanum tuberosum L*) is one of the major world food crops. The contribution of potato in world food basket is only after rice, wheat and maize. The potato is a crop which has always been the 'poor man's friend'. Potato gives an exceptionally high yield and also produces more edible energy and protein per unit area and time than many other crops. Potato is an economical food and it provides a source of low cost energy to the human diet. It is the rich source of starch, vitamin C and B and minerals. It contains 20.6 % carbohydrates, 2.1% protein, 0.3 % fat, 1.1 % crude fibre and 0.9 % ash. It also contains good amount of essential amino acids like leucine, tryptophane and isolucine. The important potato growing countries are Russian Federation, Polland, USA, China, India, Germany and Spain. In India, potato is cultivated in about 1.34 million hectares with a total production of about 24.7 million tones. It is cultivated on a large scale in Uttar Pradesh, West Bengal, Bihar and Punjab. North Eastern hill region of India covers 9 % area of the country with 4 % of its population. In this region potato productivity is very low (8.64 t ha-1) except Tripura (17. t ha-1) due to use of unscientific production technology. Organic manures particularly farm yard manure (FYM) and poultry manures (PM) have traditionally been used by potato farmers of this region. Higher food production needs higher amount of plant nutrients. Use of inorganic fertilizers has increased considerably to meet the higher nutrient requirements of the present day improved varieties. Potatoes are used for several industrial purposes such as for the production of starch and alcohol. Potato starch (farina) is used in laundries and for sizing yarn in textile mills. Potatoes are also used for the production of dextrin and glucose. As a food product itself, potatoes are converted into dried products such as 'potato chips', 'sliced' or 'shredded potatoes'.

Soil and Climate

Potatoes can be produced on a wide range of soils, ranging from sandy loam, silt loam, loam and clay soil. Soils for potato should be friable, well aerated, fairly deep and well supplied with organic matter. Well drained sandy loam and medium loam sols, rich in humus are most suitable for potato. Soil structure and texture has a marked effect on the quality of the tuber. Light soils are preferred because they tend to promote more uniform soil temperatures and make harvesting of the crop easier. Alkaline or saline soils are not suitable for potato cultivation. They are well suited to acidic soils (pH 5.0 to 6.5) as acidic conditions tend to limit scab disease.

Potato is a cool season crop. It thrives best in cool regions where there is sufficient moisture and fertile soil. Satisfactory tuber growth occurs if soil temperatures are between 17 and 19°C.Higher soil temperatures adversely affect the tuber development. Tuber development

virtually stops if temperatures rise above 30°C.At higher temperatures, the respiration rate increases, and the carbohydrates produced by photosynthesis are consumed rather than stored in the tuber. High temperatures at any part of the growing period affect the size of the leaflets, thereby reducing the tuber formation. It grows best under long day conditions. Sunshine along with cooler nights is essential for reducing the spread of diseases.

Variety:

Tuber purpose: Kufri Jyoti, Kufri Megha, Kufri Giriraj, Kufri Kanchan (red tuber), Kufri Himalini, Kufri Girdhari

Chips purpose : Kufri chipsona -1, Kufri chipsona -2 and Kufri chipsona -3

Field preparation

Soil should be prepared by 2-3 deep ploughing with plough or spade followed by harrowing. If necessary, planking may also be done to make the soil cloudless. Enough moisture is essential at the time of sowing.

Seed Size, Seed Rate and Spacing:

Tubers having 30 to 50 g weight are the most economical and give the highest yield. Whole tubers should be planted for early crop. This will avoid rotting of tubers. Due to high temperature and moisture in soil, there is always more rotting of cut tubers in early plantings. Large seeds can be effectively used by increasing plant to plant spacing and smaller tubers by decreasing it. Storing seed tuber with dry leaves of lantana reduces problems of insect pets in potato. Distance between rows should be 55 and 60 cm and between plants 20 and 25 cm. About 20-25 quintals of seed is sufficient for planting one hectare area.

For main crop, cut tubers can be planted. While cutting the tubers, care should be taken that each piece has two to three eyes and weighs at least 25 g. If any diseased tuber is observed, it should be discarded. For planting one hectare about 15-20 quintals of seed potatoes are required. A row to row distance of 45 to 60 cm and plant to plant 15 to 20 cm should be maintained in the main crop.

Methods of Planting: There are three methods of planting in India:

1. **Planting potatoes on ridges:** After preparation of field, ridges are made at a distance of 45-60 cm with the help of spade. Planting of potato is done on the ridges with the help of *khurpi*.
2. **Flat method:** Planting of potato is done on the flat surface in shallow furrows. Ridges are made after germination when plants attain 10-12 cm height. This method is suitable for light soils. Later on two to three earthings are done to make the ridges thick.
3. **Planting potatoes on flat surface followed by ridges:** In this method field is prepared and then shallow furrows are opened on the flat surface. Potatoes are planted in furrows

and immediately after planting tubers, small ridges are made. Later on these ridges are made thick by earthing up of the side soil.

Planting Time:

To secure high yields, it is essential to plant the potatoes at the optimum time. The best time of planting is when the maximum and minimum temperatures are from 30°C to 32°C and 18°C to 20°C, respectively. In north eastern India, the following time schedule should be followed for obtaining good yields.

a) Plains- 10th October to 25th October
c) Hills- February for Valleys and March-April at higher altitudes.

Nutrient Management

Potato requires high manuring and special care should be taken for supplying potassium in adequate quantity. Application of FYM @ 10 t /ha along with vermicompost 5 t, neem cake 150 kg and rockphosphate and 150 kg/ha is recommended for good yield of potato. Liming @ 500 kg/ha in furrow reduces the problem of diseases in potato under acid soil of north east India.

Water Management

Potato crop is very much responsive to good water management. Drainage of excess water is essential. In no case water should reach more than two-thirds height of the ridges. Length of the ridges should depend upon the soil type, slope and source of water. It may vary from 10 to 200 meters. The objective is to supply uniform water throughout the plot. As a rule soil must be kept always moist but hardening or too wet conditions of soil should not be allowed. Irrigation may be moderate to heavy but over-flooding of water on ridges should be avoided. The frequency of irrigation also varies depending upon water table and soil type. In medium to heavy soils three to four irrigations shall be sufficient. On the other hand, in sandy soils having low table, even 8-12 irrigations may be necessary. In Northeast India, potato is mostly grown as rainfed crop during pre-*kharif* season. The pre-*kharif* rains received during the season is used by the crop. Incase of dry condition, one life saving irrigation at vegetative stage and another at tuber formation stage is recommended for better growth

Earthing

Proper development of tubers depends upon, aeration, moisture availability and proper soil temperature. Therefore, proper earthing up is necessary. Earthing should be done when the plants are 15-22 centimeters high. Generally earthing is done at the time of topdressing of nitrogenous fertilizers. The ridges should be broad, loose and high enough to cover up tubers. If necessary, a second earthing may be done after two weeks of the first one. A mould board plough or ridge may be used for earthing up in large area.

Weed management:

Weeding should be done as soon as the weeds appears, The final earthing up should be done when the plants are 10-15 cm height (30-35 DAP)

Pest and disease management:

Potato tuber moth (PTM) damages the potato both in the field and store. Therefore pest management pest management as under

A. Field

- Use healthy seed materials
- Deep planting (10 cm) with proper earthing up and timely irrigation.
- Installation of PTM sex pheromones traps @20 traps/ha for mass trapping of male moths.
- Spraying crop with microbial agents like *Bacillus thuringiensis* (Bt) WG 300 gm/ha, *Granulosis virus* (GV) @ 2 larval equivalent (LE)/litre of water.
- If possible, inoculative release of potential parasitoid i.e. *Copidosoma koehleri* or *Chelonus blackburni*, in potato field during pest build up stage.
- Proper sanitation viz. removal of left over tubers, volunteer plants and alternate host plants from and vicinity of the crop.

B. Stores

- Provide 2-3 cm thick layer of chopped leaves of *Lantana* sp./*Eucalyptus* sp. below and above the stored potatoes.
- Install PTM sex pheromone traps @ 4 trap/100 m^3 store area.

  Soil pests viz. white grub Brahmina (Lachnosterna) coriacea and *H. longipennis*., cutworm (*Agrotis segetum*) and *A. ipsilon* and red ants (*Dorylus orientalis*) cause moderate to heavy damage to potato tubers. These pest are manageable by adopting following schedule in the potato fields.
- Timely planting and harvesting of potato crop.
- Removal of alternate /collateral hosts of beetle (white grub) host from the vicinity and within potato crop.
- 2-3 ploughing before planting and after harvesting to expose the immature stage of white grubs should be done for natural mortality and for predation.
- Conservation of natural enemies (predatory birds, parasites and predators)
- Fixing the light traps for mass trapping of beetles/moths.

(C) Control of fungal and bacterial diseases

In the northern hill region, fungal diseases such as late blight, phoma and early blight damage the potato crop severely. In North Eastern hills the environmental conditions remain congenial for late blight development throughout the crop season. The following management practices should be adopted:

- Grow only late blight resistant varieties recommended for the region namely Kufri Jyoti, Kufri Megha, Kufri Giriraj, Kufri Kanchan (red tuber), Kufri Himalini and Kufri Girdhari.
- Seed potato should be checked thoroughly before storage. All blight affected tubers must be removed and buried deep in the soil. Sort out the tubers showing disease symptoms once again before planting to reduce the further chance s of disease spread. As far as possible, Seed should be taken from disease free field.
- Ridges should be made high enough to cover daughter tubers and reduce chance of their infection upon exposure.
- Late blight appears with the congenial weather conditions of 1- 20 ^{0}C temperature, RH $\geq$ 80 %. No organic pesticides are available as of now for managing late blight. Some organic pesticides such as neem oil or derisom should be sprayed @ 2.5 ml per lit. of water for controlling of late blight up to some extent.
- When 75 % crop foliage is killed by late blight, the haulms should be cut and removed from the field and buried deep in the soil.
- Harvest the crop 15-20 days after haulm cutting or when the skin has become firm, sort out the late blight infected tubers and store the seed.

Besides the above mentioned diseases, some other soil and tuber borne diseases also common in potato, though these are of minor significance for the north eastern region. They can be successfully managed by adopting the following management practices:

- Use disease free seed, preferably from disease free area/field.
- Do not grow potato every year in the same field. Rotate it with crops like cereals, maize, millets and non-solanaceous crops.
- Follow hot weather cultivation in plains and plateau and cold weather cultivation in the hills.
- Avoid injuries to the tubers during harvest, handling and transportation.
- Allow the potato tubers to cure for 8-10 days immediately after harvest in shade preferably at 10-15 ^{0}C.
- Store potatoes in well ventilated cool stores.
- If field remains fallow, plough regularly to minimize weeds which harbour the pathogens. Alternately, grow green manure crops (any legume).

Harvesting

Harvest the crop when the skin of the tubers has become firm. Harvesting should be done on bright sunny days. Heap the produce in shade for curing of skin and the heap left undisturbed for 15- 20 days. Sorted out the infected tubers and grade them according to their sizes, preferably into four grade-small, medium, large and extra large depending upon their weight and diameter and packed in gunny bags and kept in cool place till it is marketed.

Yield

Under rainfed condition the average yield of 20 – 25 t/ha potato tubers can be obtained under organic production system.

GROUNDNUT

Groundnut (*Arachis hypogaea* L.), is an important oil seed crop grown in India. The NEH region is a non- traditional area for groundnut production. The crop has been newly introduced for cultivation in NEH region and found successful as rainfed crop during *kharif* season. It has got very high yield potential. The crop gaining popularity among farmers of NEH region due to its multiple benefit as food, feed, cover crop and for restoring soil fertility. By far the groundnut is found as most potential field crop for organic production in the North-eastern region due to its high yield potential, ability to grow in marginal soils with minimum input and management and less problem of pests and diseases. However, the yield of groundnut in farmers field is low, mainly due to lack of improved technology available with them. The adoption of appropriate package of practices can increase the productivity of groundnut substantially in the NEH region.

Climate and soil

Groundnut is grown throughout the tropics and its cultivated upto an altitude of 1000 metres. The crop can be grown successfully in places receiving a minimum rainfall of 1,250 mm. The rainfall should be well distributed well during the flowering and pegging of the crop. The groundnut crop, however, cannot stand frost, long and severe draught or water stagnation.

Groundnut is grown on wide variety of soil types. However, the crop does best on sandy loam and loamy soils and in the black soils with good drainage. Heavy and stiff clays are unsuitable for groundnut cultivation as the pod development is hampered in these soils.

Land preparation

With the onset of rains in April-May, the field is given two ploughings to make the land weed free and the soil is pulverised well to obtain a good tilth. The third ploughing may be given just before sowing. In terraces and flat lands, raised beds of 10-15cm height should be prepared to avoid water logging problems.

Varieties

Cultivars suitable for cultivation in NEH regions are ICGS 76, ICGS 44, ICGV 86590, TKG 19A, OG52l and ICGS 11.

Seed selection and treatment

Healthy and well developed pods should be hand shelled or shelled with a suitable groundnut sheller about fortnight before sowing. Remove small, shrivelled, damaged and broken kernels

and retain only bold seeds. Application of a culture of *Rhizobium* as seed treatment is beneficial in increasing nodulation and nitrogen fixation. Seed treatment with bioorganic RCHE 641 @ 30 ml/l is found effective for enhancing maize yield.

Seed rate and spacing

Use of optimum seed rate for the maintenance of optimum plant population is the key to success in groundnut cultivation. The seed rate and spacing depends upon the varieties. For the bunch type the spacing should be 30x10cm and for semi-spreading type 30x15cm. The quantity of well developed seeds required per hectare with the above spacing's will be about 95-100 kg for semi-spreading varieties and 100-120 kg for the bunch varieties.

Liming

Application of lime @ 2 tonne/ha is necessary to achieve higher yield of groundnut. Lime should be incorporated into the soil at least 1-2 weeks before sowing of the crop as it takes sometime to complete the soil reaction, which starts immediately after the application of lime into the soil. The lime requirement can be reduced to 500 kg/ha if applied in furrows. Application of lime reduces the harmful effect of Al-toxicity and increases pod yield of groundnut.

Sowing time

Groundnut is grown mostly as a rainfed *kharif* crop. The optimum time for sowing is from May to June with the onset of monsoon. In some areas, where the monsoon is delayed, it is sown as late in August or early September.

Sowing method

Sowing should be done in furrows at a row spacing of 30cm and plant to plant 10-15cm depending upon the variety.

Manures

Apply 10-15t/ha of well decomposed farmyard manure (FYM) about 15-20 days before sowing along with 150 kg neem cake and 150 kg rock-phosphate is found optimum for attaining good yield of groundnut. Integrated application of FYM 10t + vermicompost 5 t + Rockphosphate 150 kg and neem cake 150 kg/ha is recommended for better soil health and higher productivity. Seed treatment with biorganic MF92/MF 29 @60 ml/l has been found very effective in increasing maize productivity.

Weed control

Weeds cause considerable reduction in yield. A reduction of 20 to 45% in yield due to weeds has been recorded. For controlling weeds, and also to keep the soil in a friable condition, the crop should generally receive one or two hand hoeing. First operation should be done 15-20 days after sowing and the second operation at 30-35 days after sowing. Intercultural should not be done at peg initiation stage. Earthing up can be done in the case of bunch and semi-spreading types to facilitate the maximum penetration of the pegs into the soil. Weeding can also be done quickly and efficiently with a wheel hand-hoe, if the soil is light. It should be run before weeds make excessive growth.

Crop rotation

Cropping sequences being followed in NEH region are as follows:

Groundnut – toria
Maize + Groundnut (2:2) – toria
Maize + Groundnut (2:2) – carrot
Upland rice + Groundnut (4:2) – toria
Upland rice + Groundnut (4:2) – Radish

Diseases and their management

Pest and diseases problems in groundnut as very minimum. Selection of good quality seed materials can control most of the diseases. Diseases like Tikka leaf-spot (*Cercospora arachidicola* and *C. personata*) and Collar- rot (*Aspergillus niger* and *A. pulverulentum*) are commonly observed. Liming and crop rotation reduces the problem of diseases to a great extent.

Harvesting and Storage

Harvesting should be done at the right time for obtaining higher yield of pods and oil. The bunch type varieties mature in about 110-115 days and the semi spreading varieties in 120-125 days. The prominent symptoms of maturity are the yellowing of leaves, the shedding of older leaves, the development of pink color of the testa and the dark tint inside the shell. The bunch and semi-spreading varieties are usually harvested by hand pulling when there is adequate moisture in a soil. The spreading types, on the other hand, are harvested by digging with a spade or local plough or with the help of a blade harrow. The pulled out plants are stacked for a few days for drying and detached the pods afterwards. Delay of harvest after maturity will result in stem rot and weakening of pegs, thus pods may be left in the soil.

The pods are cleaned and dried to a safe moisture content of not more than 5%. Damp nuts, if stored, will ferment and allow the development of poisonous moulds, e.g. aspergillus flavus in the Kernels, leading to contamination with aflatoxin--a health hazard both for human beings and livestock. It is desirable to store groundnut in gunny bags are stacked in a storeroom in tires comprising not more ten in each in such a way that the air keeps circulating planks to avoid damage from dampness, rats, etc. The store rooms should be periodically inspected to ensure that there is no storage pest.

Yield

Under rainfed conditions, the average yield of semi-spreading and spreading varieties is 1500-2000 kg of unshelled pods per hectare and that of bunch types is 1200-1500 kg.

RAPESEED AND MUSTARD

Rapeseed (*Brassica campestries*) and Mustard (*Brassica juncea*) are the major *rabi* oilseed crops of India. India is one of the largest producers in the world. The production of rapeseed and mustard in India accounts for about 18% of the total oilseed production of the country. Sarson and *toria* (lahi) are generally termed as rapeseed, rai or raya or laha is termed as mustard. The seed and oil are used as condiment in the preparation of pickles and for flavouring curries and vegetables. The oil is utilized for human consumption throughout northern India in cooking and frying purposes. The oil cake is used as a cattle feed and manure. Green stems and leaves are a good source of green fodder for cattle. The leaves of young plants are used as green vegetables as they supply enough sulphur and minerals in the diet.

The oil content of the rapeseed and mustard ranges from 30 to 48 percent. The crop is grown both in subtropical and tropical countries. Among the *rabi* oilseeds, rapeseed and mustard can play an important role in the north eastern hill region to boost oilseed production. In the region, rapeseed-mustard can be successfully grown as *rabi* crop up to mid altitude (<1300 m msl) and yield level of 8-12 q/ha can be achieved by adopting improved production technology**.**

In NEH region, rapeseed - mustard is cultivated in an area of 0.46 lakh ha and the average yield is 888 kg/ha, which is much lower compared to the national average (941 kg /ha). The low productivity is primarily due to untimely sowing, poor crop stand, inadequate nutrition, moisture stress and almost no plant protection measures. The problems get further aggravated when the crop is cultivated on marginal land under rainfed conditions

Climate

Rapeseed and mustard are crops of tropical as well as temperate zones and require somewhat cool and dry weather for satisfactory growth. They require a fair supply of moisture during the growing period and a dry clear weather at the time of maturity. Cool temperature, clear dry weather with plentiful of bright sun shine accompanied with adequate soil moisture increases the oil yield. In India they are grown in Rabi season from September-October to February-March. *Toria* is more liable to suffer from frost and cold and is, therefore, usually sown earlier and harvested before the onset of frost. Rape seed and mustard are long day in periodic response. These crops are not drought tolerant. They require an annual precipitation of 35-45 centimetres.

Soil

Rape seed and mustard are capable of growing under a wide range of soil conditions varying from sandy loam to clay loam soils but they thrive best on light loam soils. They neither tolerate

water logging conditions nor do well on heavy soils. Plants can tolerate moderate salinity reasonably well but a soil having neutral pH is ideal for their proper growth and development.

Variety

ICAR Research Complex for NEH Region has developed four yellow sarson lines viz. TRS –Y-01-5-1-1 (1.6 1 t/ha), TRS –Y-01-2-2-1 (1.3 t/ha), SCRT 1-2-1 and SCRT 1-2-3 (1.64 t/ha).

Table 1. State-wise major varieties of mustard & rapeseed

State	Varieties	State	Varieties
Meghalaya	M-27,TS-36,TS-46	Nagaland	TCN-42,M-27,TS-38
Manipur	M-27,TS-36	Sikkim	Sikkim Sarson,M-27,Kranti
Mizoram	Kranti, TS-36,TS-46	Tripura	TM-6, Kranti, M-27, TS-38

Cropping systems

Generally in the NEH region, the rainfall ceases in the last week of September and moisture stress starts after November, which is not suitable for taking *rabi* crop. If short duration varieties of rapeseed and mustards, which mature in 90-100 days, are sown after harvest of upland rice and maize, not only the cropping intensity would be increased but the production of oilseeds also will be increased. Under high moisture condition in low, wet and marshy lands where *rabi* crop is not possible due to excessive moisture, the permanent or temporary raised and sunken beds opens up new vistas for growing any crop including oilseeds during *rabi* Season. The inclusion of rapeseed and mustard in cropping systems on raised beds increase the production and productivity of oilseeds. The adoption of intercropping system on raised bed although decreased the productivity of individual crop but overall system productivity increased markedly. The following cropping systems have been identified for the NEH region -

Mid and low altitude

(a) Dry upland terraces

Maize-mustard, Maize + French bean-mustard
Rice – mustard, French bean - mustard
Groundnut – mustard

(b) Marshy/lowland/wetland conditions (raised beds)

Maize-mustard, Rice-mustard
Rice-mustard-tomato, Rice-mustard-potato
Groundnut- mustard

Intercropping on raised beds

Cabbage + mustard, Broccoli + mustard
Coriander + mustard

Field Preparation

A clean and well pulverised seedbed of good tilth is needed for better germination. The land should be well prepared first by ploughing deep with soil turning plough, followed by two cross harrowing. Each ploughing should be followed by planking so that the soil is well pulverised and

levelled. Care should be taken to see that weeds and stubbles are well removed from the field and the soil contains adequate moisture to ensure good germination. Zero tillage cultivation of toria after rice and maize is a viable proposition which saves time, energy and reduces cost of cultivation. Immediately after rice harvest, a narrow furrow should be opened in between two rice rows with the help of furrow opener and the manure should be applied and the sowing of seeds should be undertaken followed by covering of the seeds.

Seed and Sowing

a. Time of sowing

Planting time is the single most important variable affecting the seed yield of rape seed and mustard to a great extent. Since the rate of development of oil in seed is greatly influenced by the variation in atmospheric temperature, humidity, and other biotic factors, sowing either too early or too late have been reported to be harmful. Delay in planting reduces the yield on account of its depressing effect on the plant growth, flowering duration, seed formation and seed size. Therefore, for getting good yields of rape and mustard timely sowing is a must. *Toria* should be sown from the mid to the last week of September. If sowing of *toria* is delayed, there is great danger of attack of aphids on this crop. Sowing of sarson and rai must be completed in the first fortnight of October.

b. Seed Rate and Spacing

Spacing has no absolute value in the cultivation of rape and mustard as it fluctuates a great deal with the growth habit of variety, date of sowing, manuring and irrigation practices. Generally *toria* is planted in rows 30 cm apart while sarson and rai are sown in rows 45 cm apart. Thinning is done three weeks after sowing to maintain a plant to plant distance of 10 to 15 cm. In case of mixed cropping they are generally sown in rows 1.8 to 2.4 metres apart in the main crop, 5 to 6 kg seed should be sown in rows at a depth of 2.5-3.0 cm in case of a pure crop. When sown mixed with some other crop, 1.5 to 2 kg seed per hectare is sufficient. Sowing could be done either behind the local plough or through seed drill. Before sowing, seed should be treated with Thiram or Captan at the rate of 2.5g per kg of seed.

Manures and Fertilizers

Apply 10 tonnes of farm yard manure or vermicompost @5t/ha during last field preparation along with 150 kg rock phosphate.

Water management

Normally, no irrigation is required in the rapeseed-mustard as it is sown on residual soil moisture and it receives one or two showers during October and November months. However, in case of moisture stress, one irrigation at flowering is required to obtain good yield. Irrigation increases yield of rapeseed and mustard significantly. In agro-climatic conditions of Meghalaya, irrigation at 0.3 IW/CPE ratio produced significantly higher seed yield followed by 0.6 IW/CPE ratios. Flowering and siliqua formation stages are critical stages for irrigation in rapeseed and mustard. Two irrigations at pre-bloom and pod filling stages are beneficial.

Weed management

Weeds in rape and mustard crop cause approximately 20-30 percent reduction in yield. Care should be taken to remove all weeds in the early stages of crop growth to avoid competition on

the reserve of moisture. One intercultural operation with hand hoe is very beneficial. This, besides creating soil mulch and thus reducing moisture losses through evaporation helps in better growth and development of crop plants. Thinning operation helps in better growth and development of crop plants. Thinning operation should be accompanied by with interculture to provide the plants proper space within the rows. Major weeds observed in rapeseed and mustard field are *Bidens pilosa*, *Ageratum conyzoides*, *Chenopodium album*, *Euphorbia hirta* etc. Hand weeding at 30 and 60 DAS recorded maximum seed yield.

Mulching

Under Meghalaya condition, mulching with rice straw resulted increase in mustard seed yield significantly. Mulching helps in conserving soil moisture, reduces weed problems and maintains soil temperature. Mulching with thin black polythene film gave highest seed yield compared to other mulch at Umiam, Meghalaya.

Plant protection

White rust and Alternaria blight are two important diseases of rapeseed and mustard in the region. Spraying of Derisom or neem oil @ 2.5 g/lit of water at 10 days intervals found to be effective in controlling the diseases and Panchagavya 3 % also control the diseases and increasing the yield. The most serious insect-pest of mustard is aphids. To control aphids, the spraying of Derisom or neem oil @ 2.5 g/lit of water two to three times are required. As the cold and cloudy weather favours the pest multiplication, sowing the crop earlier than the normal sowing escape the pest attack.

Harvesting and Threshing

As soon as the pods turn yellowish-brown, harvest the crop. Normally, the crop is ready for harvest after 90 - 105 days of sowing. Preferably, harvesting should be done in the morning hours to avoid shattering loss. The crop is liable to shattering, hence it should be harvested just before the pods open in order to avoid losses. Sarson is less liable to shattering as compared to toria and mustard. Crop is harvested with the help of sickles. The harvested crop should be stacked in threshing floor for five to six days before threshing. Threshing is very easy with the help of sticks. The pods easily shatter and give away seeds. Threshing could be done with bullocks or tractor. The threshed grain is separated from the husk with the help of slow moving natural air current. Cleaned seed must be dried in the sun for four to five days or till the moisture content comes down to 8 percent.

Yield

With the use of improved varieties, agronomical and plant protection techniques, the farmers may expect to harvest per hectare A well managed crop gives a seed yield of about 10-15 q/ha.

SOYBEAN

Soybean (*Glycine Max* L.) is a very high nutritious crop. It contains about 20 per cent oil and 40 per cent high quality protein (as against 7.0 % in rice, 12 % in wheat, 10 % in maize and 20-25 % in othe pulses. Soybean rich in amino acid (Lycine 5 %), in which most of the cereals are deficient. Soybean oil is used for manufacturing vanaspati ghee and several other industrial products. Soybean used for making high protein food for children. Soybean builds up the soil fertility by fixing a large amount of atmospheric nitrogen through the root nodules, and also through leaf fall on the ground at maturity. It can be used as fodder, forage can be made into hey, silage etc. Soybean being the richest, cheapest and easiest source of best quality proteins and fats and having a vast multiplicity of uses as food and industrial products is called a wonder crop.

Soybean is one of the most important crop in the world and cultivated over an area of 71.87 million hectare

Soil and Climate

Well drained and fertile loamy soils are suitable for cultivation of soybean. The pH ranges from 5.2- 7.5. In acid soils liming to be done to raise the pH. Water logging is injurious to the crop. Soybean grows well in warm and moist climate. Temperature of 26-30 OC to be the optimum for cultivation of soybean.

Variety

The recommended varieties are JS-80-21,JS 335, JS-75-46, Bragg, JS (SH) 89 - 2 and PK - 472. Among different cultivars, maximum yield was recorded with JS-80-21 under mid altitude. For high altitudes (1300-1900 msl), PK-71-21, DS 74-42 and PK-73-213 were found promising. The institute has developed three promising breeding lines H 1, H 9 and H 10 which are resistant to frog eye leaf spot, a serious disease of soybean in the region.

Sowing

Generally sowing is done during May/June at mid and low altitudes at the onset of monsoon. Seeds are sown at a depth of 3-5 cm at a spacing of 30-35 x 10-15 cm. A seed rate of 25 – 30 kg/ha would be sufficient for pure stand. For flat lands, is recommended. Spacing may be reduced in upper terraces where water retention is very low.

Fertilizer management

Soybean, being leguminous crop does not require high dose of nitrogen. Apply 5-7 t/ha of well decomposed farmyard manure (FYM) about 15-20 days before sowing along with with 150 kg rock phosphate. It is also advisible to apply 3-4 t vermicompost/ha alongwith @ 150 kg/ha rockphosphate. Green manuring crop like taprosia, crotolaria and sesbania should be applied @ 10 t/ha before 15-20 days sowing the crop.

Maximum soybean seed yield was recorded in FYM treatment which was at par with integrated nutrient supply in the year 2006-07 under cropping system Rice +soybean – *toria* and Rice + soybean –tomato. Whereas highest seed yield was recorded in integrated nutrient supply in the year 2007-08 and 2008-09 under above two cropping systems. The average yield of soybean was recorded 12.51 and 11.86 q/ha in Maize +soybean –groundnut and Maize + soybean –frenchbean, respectively.

Table 3.Yield (t/ha) of soybean as influenced by cropping system and nutrient sources

Cropping system	**CS1:Rice +Soybean -*Toria***				**CS2:Rice+Soybean –Tomato**			
Treatments	**2006-07**	**2007-08**	**2008-09**	**Mean**	**2006-07**	**2007-08**	**2008-09**	**Mean**
FYM	1.21	1.3.2	1.16	1.23	1.20	1.55	1.45	1.40
V. Compost	0.99	1.1.4	1.04	1.06	0.97	1.55	1.40	1.31
L. Compost	0.75	1.1.3	1.03	0.97	0.89	1.48	1.32	1.23
Integrated	1.19	1.4.1	1.34	1.322	1.12	1.61	1.49	1.40
Control	0.531	0.5.5	0.51	0.53	0.48	0.47	0.51	0.48
SEm(±)	**0.50**	**0.12**			**0.08**	**0.05**		
CD*(P=0.05)*	**1.64**	**NS**	**NS**		**NS**	**0.21**	**NS**	

Table 4. Grain yield (t/ha) of soybean as influenced by cropping system and nutrient sources

Cropping system	**CS3:Maize +soybean -groundnut**				**CS4:Maize+soybean –frenchbean**			
Treatments	**2006-07**	**2007-08**	**2008-09**	**Mean**	**2006-07**	**2007-08**	**2008-09**	**Mean**
FYM	1.02	1.52	1.21	1.25	1.0.88	1.28	1.19	1.19
V. Compost	0.92	1.27	1.13	1.10	0.9.57	1.12	1.03	1.04
L. Compost	0.76	1.17	1.11	1.01	0.8.23	0.93	0.99	0.91
Integrated	0.96	1.28	1.19	1.14	1.0.67	1.11	1.04	1.07
Control	0.44	0.45	0.49	0.46	0.5.03	0.49	0.42	0.47
SEm(±)	**0.03**	**0.11**		**-**	**0.05**	**0.05**		**-**
CD*(P=0.05)*	**0.11**	**NS**		**-**	**0.16**	**0.15**		**-**

Long-term experiment on soybean (Maize + soybean) was conducted at Umiam, Meghalaya. In intercropping system, result (7 years) showed that the maximum soybean yield was recorded with 50 % FYM + 50 % vermicompost treatment followed by FYM and vermicompost.

Table 24. Soybean yield (t/ha) as influenced by cropping system and nutrient management practices

Nutrient sources	Maize+ soybean –frenchbean -carrot						
	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	Mean
FYM	1.56	1.39	1.54	0.97	0.68	0.96	1.18
Vermicompost	1.53	1.60	1.49	0.79	0.65	0.91	1.16
FYM+VC	1.54	1.74	1.64	0.86	0.77	0.95	1.25
Control	1.47	1.05	0.93	0.51	0.50	0.47	0.82
CD*(P=0.05)*	**NS**	**NS**	**0.32**	**0.21**	**NS**		

Weed management

The crop should be kept weed free up to 60 DAS. One mechanical (20 DAS) weeding and two hand weeding (30 and 50 DAS) are sufficient for higher seed yield. Mulching is also done with weed biomass such as eupatorium and Ambrosia @ 10 t/ha, which reduced the weed population and also add nutrient to the soil, ultimately improved the crop productivity.

Irrigation

Soybean is grown during *kharif* season and due to high rainfall no irrigation is needed. However, water stress should be avoided during flowering and pod formation stage of the crop.

Disease and pest management

Leaf blight, leaf spot, seedling rot frog eye leaf and rust are the major diseases of soybean. Seed treatment with *trichoderma*@5g/kg was found effective. Application of Derisom @ 3 ml/lit of water or neem oil @ 3 ml/llit of water is recommended for effective control of insect, pest and diseases.

Cropping system

Intercropping of soybean with maize (2:2) and rice (4:2) has been found promising. Experiments on cropping system conducted at ICAR farm of NEH region indicated that there is tremendous potential and scope for growing soybean in the region particularly during spring, pre-*rabi* and *rabi* season by adopting resource conservation technologies. The most suitable cropping systems found were maize + soybean 2:2 (*kharif*) - mustard (*rabi*) and maize + groundnut 1:2 (*kharif*) – mustard (*rabi*). It has also been noticed that resource conservation technologies, such as straw mulching play an important role by conserving moisture in *rabi* oilseed production under upland.

Harvesting

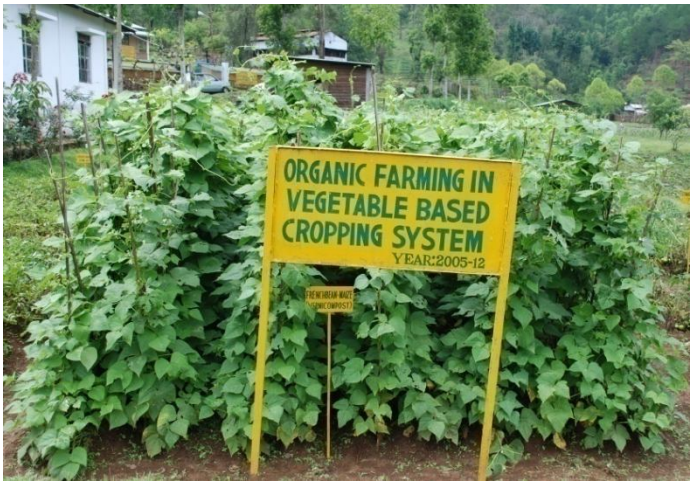
Harvesting is done when the crop is fully matured. Seed are sundried and stored in a cool and dry place.

Yield

Soybean seed yield ranges from 2.0 -2.5 t/ha under organic farming.

FRENCHBEAN

Frenchbean (*Phaseolus vulgaris* L.) being a traditional vegetable crop of North Eastern region, its cultivation under organic farming would be a profitable enterprise. Among different vegetables, frenchbean responds well to organic management practices and most potential crop for organic production in the NEH hills. It is an added advantage that this crop is relatively less prone to pest and disease problems. Appropriate technological backstopping for production of frenchbean will encourage the farmers to go for organic cultivation. Frenchbean being a self-pollinated crop, its seed production and maintenance of its purity is much easier than other vegetable crops. Its dry seeds contain 22% proteins, 1.7 % fat, 70% carbohydrates, 381 mg calcium, 425 mg phosphorus, and 12.4 mg iron per 100 gram of edible portions. The green pods are rich sources of vitamins. Increased production and consumption will help in supplementing the major portion of the protein requirements of vegetarian population of the country.



Frenchbean is highly profitable vegetable crop of north-eastern hill region of India. Generally, it is cultivated mostly for vegetable purpose round the year except winter months (October - January). It is grown in foothills, mid and high altitude in all the north- eastern states including Sikkim. Tender pods are used as vegetable and mature seeds are consumed as dal. However, at present its average green pod yield is low in farmers field (4-5 t/ha) as compared to its potential yield (10-12 t/ha). The increase in productivity of frenchbean will meet the increasing demand of green vegetables of the region.

Climatic requirements

Most of the frenchbean varieties are day neutral and sensitive to high temperature and frost. The frenchbean seeds do not germinate in cold weather. In order to obtain a good pod/ seed set, the mean day temperature should not exceed 30^0C

Soil

Well-drained, loamy and light alluvial soils with pH 6.0 to 7.0 are ideal for proper growth and development of frenchbean.

Land preparation

For preparation of field, 2-3 ploughing followed by planking to make the land weed free and getting good tilth of soil.

Varieties

Frenchbean varieties are classified in two groups Viz., bush or dwarf type and pole or climbing type. Some varieties suitable for the region are listed below-

Bush type –Arka Komal, Contender
Pole Type- Meghlaya Local Selection, Naga Local & Manipuri

Duration
75 – 90 days depending upon varieties and sowing time

Seed rate
Seed rate depends mainly on methods of sowing, size of seed and nature of the crop growth. However, the general seed rates of frenchbean are as follows:

Bush type: 50 - 60 kg/ha
Pole type: 25 - 30 kg/ha

Sowing time
Green pod (vegetable) purpose

Low land: February- March
Upland: August- 1st week of September

Highest green pod yield was recorded in the crop sown in last week of July (123.4 q/ha), which was followed by crop sown in the 1st week of August (110.9 q/ha). Further delay in sowing significantly reduced green pod yield irrespective of the variety.

Seed purpose
Middle of August to middle of September (upland) found to be optimum period for sowing of frenchbean for seed purpose in upland condition.

No significant reduction in seed yield was noticed when crop was sown up to second week of August but thereafter a significant reduction in seed yield was recorded when sowing was delayed beyond the last week of August. Although, seed yield was found higher in early sown crops, but seed quality was poor when sowing was done in the first week of August or prior to this due to heavy rain at maturity.

Sowing Method
(a) Flat bed sowing
Seed should be sown at a row spacing of 30-40 cm keeping 15-20 cm distance from plant to plant.

(b) Bun sowing (Raised bed)
Seed should be sown on bun (raised bed) having 60-80 cm width and 20-30 cm height at a row spacing of 30-40 cm keeping 15-20 cm distance from plant to plant.

Thinning
Thinning should be done at 3-4 leaf stage i.e. 12-15 days after sowing to maintain optimum plant population (2.22 lakh /ha).

Earthing up
Earthing up of the crop is done immediately after thinning to avoid water logging.

Staking of pole type frenchbean

Plant should be supported by bamboo/wooden sticks (1.5- 2.0 m height) 15-20 days after sowing. Staking increases pod yield as well as seed quality. The same staking materials may be used for two to three times.

Weed management

Management of weed through cultural practices is safe and involves low inputs. When weeds are controlled by hoeing and hand weeding in the first half of the season, the increased canopy cover suppress the weeds.

Nutrient management

Application of lime @ 500 kg/ha in furrow/pits 2 weeks before sowing every year improves the growth and yield of frenchbean in the acid soils of north east India. Supply crop with well decomposed FYM @ 15 t/ha + Rock phosphate 150 kg/ha or FYM @ 10 t/ha + vermicompost 2.5 t/ha + Rock phosphate 150 kg/ha + neem cake 150 kg/ha. Full dose of organic manure and Rock Phosphate should be placed in furrows/pits below the seed at sowing. The entire crop residue and weed biomass should be incorporated in the field, which improves the fertility of soil.

Yield attributes and seed yield of frenchbean in upland terraces under rainfed conditions.

Cultivars	Pods/ plant	Pod length /plant (cm)	Seeds /pod	100 seed wt. (g)	Seed yield/ plant (g)	Biomass/plant (g)	H. I. (%)	Yield (t/ha)
Local Purple Pod	5.3	18.0	8.2	28.4	11.4	20.4	0.562	0.64
Meghalaya Local	10.0	12.6	6.4	26.2	14.2	22.4	0.623	1.31
Naga Local	9.0	14.5	6.6	27.4	18.3	28.7	0.637	1.26
Manipuri	8.2	15.1	6.4	31.7	15.0	25.7	0.580	1.11
Meghalaya Local Selection	9.2	14.6	7.4	30.1	17.6	27.1	0.653	1.54
C. D. (P=0.05)	1.0	0.9	0.6	1.2	3.2	4.7	0.024	0.18

Green pod yield (t/ha) of frenchbean as influenced by different organic sources of nutrient supply

Nutrient sources	2006-07	2007-08	2008-09	2009-10	2010-11	Mean
FYM	13.5	13.2	24.6	17.65	21.0	18.0
Vermicompost	11.5	117	23.9	16.99	20.6	16.9
FYM+VC	11.6	13.0	26.0	18.53	22.1	18.2
Control	7.07	7.16	21.50	3.39	17.2	11.2
CD*(P=0.05)*	**0.78**	**0.34**	**0.70**	**0.99**	**0.46**	**-**

Water management

In NEH Region, frenchbean is generally grown as rainfed crop during pre-rabi season (August-September) in upland conditions. However, under longer dry spell one irrigation may be given at flowering stage to get higher yield. In Pre-*kharif* season (Feb- March), frenchbeanis grown in lowland or medium upland requires assured irrigation because of very low rainfall during this period. 2-3 irrigations are sufficient to get higher yield. First irrigation may be given at 2-3 leaf stage and 2nd and 3rd irrigation may be given at branching and flowering stages, respectively.

Cropping systems

Under upland conditions, frenchbean is grown after maize. After maize harvest, the maize stalks should be used for mulching purpose in between the two rows of the frenchbean. In lowland, cropping sequence of rice-frenchbean is recommended. Frenchbean helps in increasing cropping intensity because of its shorter growth duration.

Crop rotation

Paddy – Frenchbean (Low land)
Maize –Frenchbean (Upland)
Maize - Carrot – Frenchbean (Upland)
Maize - Frenchbean-Tomato (Upland)
Maize - Frenchbean-Toria (Upland)
Frenchbean-bhindi-blackgram (raised beds)
Frenchbean-bhindi-frenchbean (raised beds)

Diseases and their management

Anthracnose

Symptoms

Brownish to black lesions on leaves and pods.

Management

(a) Use healthy seeds
(b) Field sanitation
(c) Crop rotation

Rhizoctonia blight

Symptoms

Red brown shrunken spots on the stem just near the ground.

Management

Rhizoctonia blight can be controlled by the following measures:
(a) Use healthy seeds
(b) Removal of infected leaves
(c) Soil application of bio-control agent *Trichoderma harzianum* @ 5 kg/hectare

Powdery mildew

Symptoms

White powdery spots develop on both sides of leaves and other aerial parts of the plant

Management

Powdery mildew can be controlled by the following measures:

(d) Use healthy seeds

(e) Removal of infected leaves

Insect pests and their management

Blister beetle

Damage

Feed voraciously on flowers, young pods and affect pod formation.

Management

a) Sowing of frenchbean after second week of August helps in avoiding infestation of blister beetle.

b) Manual collection and killing of blister beetle from the flowers during forenoon and collection of beetle aggregates from the grasses grown on bunds where they rest. It is most effective and economical.

Mites

Symptoms

Plant become etiolated and starts dying due to sucking of sap from tender parts.

Management

Spray Neem oil (0.2%) or Karanjin (a plant product from Pongamia glaubra) or Derisome- 0.2% after germination at 10 days interval.

Aphid

Symptoms

Tiny insects suckthe cell sap from tender parts mostly leaves. Under severe attack developing pods are also damaged.

Management

Spray Neem oil (0.2%) or Karanjin (Derisome- a plant product from *Pongamiag laubra*) 0.2% after germination at 10 days interval.

Harvesting

Green pod

Tender pod becomes ready for harvest at 50-55 days after sowing (DAS) in bush type varieties and 55-60 DAS in pole type varieties. Pods should be harvested at 3-4 days interval when they attain full size to get quality produce.

Seed purpose

August planted crop is very good for seed production as the chance of coinciding with rain during harvest is very meagre. For seed purpose, time of harvesting play a very important role, as premature harvesting results in poor quality seed, while delayed harvesting may cause in-situ germination in case of heavy rainfall. In pole type varieties, mature pods should be harvested twice. First harvesting should be done when two-third pods look dry and the second harvesting when 90 percent of the remaining pods look dry. In bush type varieties, harvesting can be done once due to their determinate growth and synchronisation in pod maturity.

Threshing and storage

The harvested crop should be threshed separately after sufficient sun drying. The seeds, which are shrivelled, unhealthy or broken, should be sorted out and discarded. After threshing, the seed should be dried up to 10-12 percent moisture level. The seed should not be stored in moist and high temperature conditions. Seeds are stored in gunny bags, earthen or steel bins.

Yield : A good crop of frenchbean yields about 10-15t/ha (green pods) and seed yield of about 1.5t/ha under organic production systems.

CARROT

Carrot **(*Daucas carota* L.)** is a one of the most important and major root vegetable used as salad and root vegetable besides, it is rich source of *beta-carotene*, which is precursor of vitamin A and contains appreciable quantities of thiamine and riboflavin. Sugar and volatile terpenoids are the two major components of carrot flavour. Carrot is heavy feeder of nutrients and removes 100 kg N,50 kg P_2O_5 and 180 Kg K_2O per hectare. Therefore, judicious and proper use of organic manures and bio-fertilizers are very essential not only for obtaining higher yield and quality produce but also to maintain soil health and sustainability for longer period.

Carrots are a brilliant source of carotenoids, powerful antioxidants. One cup (6oz/180g) of diced raw carrot provides approximately 843 per cent of the RDA for vitamin A. High carotenoid intake has also been linked with a decrease in the incidence of breast, lung, and prostate cancer. Carrots have a fairly low GI number. Eating foods rich in carotenoids make insulin uptake more effective, thus making blood-glucose control easier for diabetics.

Soil and climate

Being a root crop carrot requires deep, friable loamy soil. For early crop sandy loam soil is preferred. Carrot become rough and course as the roots fail to penerate the hard soil evenly. The optimum pH of soil is 6.0-7.0. Carrot is cool season crop. Carrot roots develop a good colour under the temperature range of 15-21^{O} C.

Field preparation

Soil should be prepared by 2-3 deep ploughing with plough or spade followed by harrowing. If necessary, planking may also be done to make the soil cloudless. Prepare the field up to a fine tilth, so small carrot seed is sown easily and germination is not affected.

Suitable varieties

New kuroda, Pusa Keasr, Pusa Meghali, Pusa Yamgagni, Nantes

Seed Rate

5-6 kg/ha

Sowing time

February to March in hill and August to November in plains.

Methods of Planting

Seed are sown in the line with a spacing of 30-40 cm row to row and 5-10 cm plant to plant distance is maintained. Thinning is necessary to optimum plant population and also less competition with in plant.

Manures and fertilizers

Well rotten FYM @ 10 t/ha aong with vermicompost 5 t/ha, neem cake 250 kg and rockphosphate 150 kg/ha should be applied for sowing of one hectare land. This combination of organic sources of nutrient supply was found statistically similar to inorganic and integrated sources of nutrient supply at ICAR Complex, Umiam, Meghalaya. The sources of nutrient supply should be based on the local availability.

Productivity of carrot under different sources of nutrient supply

Nutrient sources	Carrot						
	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Mean
Natural	39.40	37.8	36.2	45.2	36.2	12.29	34.52
Organic	77.80	65.8	62.1	140.6	62.1	118.68	87.85
Integrated	79.55	63.7	63.9	147.8	63.9	124.46	90.55
Inorganic	78.02	60.2	58.7	80.6	58.7	71.53	67.96
CD *(P=0.05)*	**-**	**3.44**	**5.04**	**5.47**	**3.74**	**4.28**	

Weeding and earthing

Carrot is a root crop and requires good soil depth for tuber formation. Hence along with weeding, earthing is also given at about 30 days after sowing the crop for higher yield.

Irrigation

In north eastern hills, carrot is grown during february-march with pre-monsoon rains. Pre-sowing irrigation is given to for rapid and uniform germination of carrot. Under insufficient soil moisture, irrigation should be done at a interval of one week depending upon the soil and climatic conditions. Over moisture in the soil is restricting the development of root and also rotting of roots.

Plant protection measures

The requires minimum attention on pest and disease management. Powdery mildew, bacterial blight and carrot fly are the major diseases and insects of carrot in NEH Region. Neem oil 3 % should be sprayed during vegetative stage for prevention against insect pests.

Harvesting and yield

The roots attain marketable stage when their diameter is 2-4 cm at the upper end. Before harvesting the crop light irrigation is to be given so that puling of root without any damage is facilitated. The yield varies from 18-22 t/ha depending upon the season and variety.

Table. Yield (t/ha) of carrot as influenced by nutrient management practices

Nutrient sources	Carrot						
	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Mean
Natural	3.9.40	3.7.8	3.6.2	4.5.2	3.6.2	1.2.29	3.4.52
Organic	7.7.80	6.5.8	6.2.1	14.0.6	6.2.1	11.8.68	8.7.85
Integrated	7.9.55	6.3.7	6.3.9	14.7.8	6.3.9	12.4.46	9.0.55
Inorganic	7.8.02	6.0.2	5.8.7	8.0.6	5.8.7	7.1.53	6.7.96
CD *(P=0.05)*	**-**	**0.34**	**0.50**	**0.55**	**0.37**	**0.43**	

Table. Quality parameters of carrot at harvesting stage

Treatments	Specific gravity (g/ml)	TSS (%)	Ascorbic acid (mg/100g)	Acidity (%)	Beta carotene (mg/100g)	Total caroteniodes (mg/g)	Total sugar (%)	Reducing sugar (%)
Natural	1.12	7.52	34.2	0.15	7.2	59.86	4.22	3.66
Organic	1.37	8.28	39.94	0.21	7.97	68.93	5.76	4.17
Integrated	1.91	7.25	39.24	0.17	7.38	62.17	5.91	4.29
Inorganic	1.40	6.54	35.12	0.14	6.19	58.51	5.08	3.93
CD *(P=0.05)*	**0.04**	**0.05**	**0.03**	**0.05**	**0.03**	**0.03**	**0.03**	**0.03**

TOMATO

Tomato (*Lycopersicon esculentum*) is a nutritious and popular vegetable all over the world. At present tomatoes ranked third, next to potatoes and sweet potatoes, in term of global vegetable production (FAO, 2002). Tomato is one of the most important vegetable crops sup porting the livlihood and improving the living standard of many vegetables growers in the north eastern region. It is used as a vegetable, salad, pickle, soup, ketchup, sauce and many other ways. It is good source of vitamin A,B and C.

Suitable varieties

Avinash-2, Rocky, Pusa Ruby, Punjab chhuhara, Mega Tomato-1, Mega Tomato-2, Mega Tomato-3

Soil and Climate

Sandy loam soil rich in organic matter is ideal for tomato cultivation. The optimum temperature required for its cultivation is 15-26 ^{O}C. Water accumulation during flowering and fruit setting stages adversely affect the yield of crop.

Land preparation

Land is prepared to a fine tilth by thorough ploughing or digging with power tiller or spade

Seed Rate

A seed rate of **400** g - 500 g is required per hectare depending upon the seed viability.

Time of Nursery Sowing

In high hills seed may be sown in nursery in the month December-January

Nursery Raising

Seeds are sown in the nursery and one month old seedlings are transplanted to the main field. An area of 100 m^2 is required for raising seedlings for one hectare. For sowing the seeds, raised seed beds of 90 to 100 cm width and convenient length are prepared in open space with fertile topsoil to which well decomposed organic matter has been incorporated. Care should be taken to prevent incidence of damping off in the nursery. For this add one kilogram of *Trichoderma* to 100 kg of dried farmyard manure and 10 kg of neem cake spread under shade to which water is sprinkled for maintaining moisture. Seeds are sown in line followed by covering with sieved FYM and sand moisture. Nursery bed is covered with dry grass/paddy straw or polythene for 3-5 days to induce early germination of seeds. Soon after the sowing, the beds are irrigated with water and ligt irrigation should given every day morning and evening till germination.The covering is removed immediately as soon sprouts come out. Watering with rose can should be continued at least once a days depending upon the soil and weather conditions.

Transplanting and Spacing
The nursery is ready for transplanting after 30-35 days of sowing depending upon the temperature. Seedlings are transplanted at a spacing of 50 cm x 50 cm. Neem cake dust @ 4-5 g per hill is applied at the time of transplanting to prevent attack from caterpillar and cutworm. Planting is done preferably in the afternoon/evening hours or rainy days or cloudy days for better establishments. Irrigation is done immediately after transplanting if there is no rainfall on the day of transplanting.

Manuring
Furrow application of lime @ 500 kg/ha is recommended as ameliorative measure to soil acidity in northeast India 15 days before transplanting. Apply FYM or compost @ 15 t/ha as basal dose to which *Trichoderma* and PGPR mix 1 each @ 2.5 kg /ha are mixed and kept for 15 days in shade. Apply *Pseudomonas* and AMF at the time of transplanting. Integrated application of 10 t FYM + 5 t vermicompost along with neem cake 250 kg and rockphosphate 150 kg/ha is recommended for better growth and sustainable production. Dip the roots in 2% Pseudomonas or PGPR mix 1 before transplanting to the field. For phosphorus use efficiency, rockphosphate was applied before transplanting @ 150 kg /ha.

Weed Management
Two weeding are suficient for optimum growth and yield of tomato.

Top dressing of organic manure
Top dressing can be done at 7-10 days interval with any one of the following

1. Soil application of fresh cowdung slurry @ 1 kg/10 litres (50 kg/ha)
2. Soil application of biogas slurry @ 1 kg/10 litres (50 kg/ha)
3. Soil application of cow's urine 500 litres/ha (8 times dilution)
4. Soil application of vermiwash-500 litres/ha (8 times dilution)
5. Soil application of vermicompost / poultry / powdered goat manure-1 t /ha
6. Soil application of groundnut cake1 kg/10 litres (50 kg/ha)

Foliar spray can be given with cow dung slurry/ vermiwash/ cow's urine.

After cultivation
Give pre-transplanting irrigation, if the soil is not moist enough. Irrigate at two or three days interval during summer. Stake the plants if the growth is luxuriant for higher yield. Weeding followed by organic manure application and earthing up may be done at one and two months after transplanting. Provide mulch in the field throughout the crop growth period with materials like green leaves, plant residues, decomposed biomass, straw, etc.

Plant protection
Bacterial wilt is the most important disease of tomato observed under organic farming. Late and early blight are other diseases. The field sanitation, crop rotation, removal of infested plants from the field and summer ploughing are some of the common preventive measures. Fruit borer is the major insect of tomato. Application of neem oil (3ml /l) and entomo-pathogenic nematode (*Verticilium lecani)* are found useful to control fruit borer. Application of Panchagavya (3%)

along with Lantana extract 10% and vermiwash 10% at flowering and 10 days interval was found effective in controlling insect and diseases of tomato.

Cropping System

Tomato is a potential crop for rice and maize based cropping system in North East India. Crop rotation is the key to success of tomato production under organic farming. Some of the potential cropping systems are-

Rice-tomato
Maize-tomato
Tomato-bhindi-frenchbean
Tomato-frenchbean

Harvesting and Picking

Tomato fruits should be picked at appropriate stage of maturity depending upon the purpose to be used or the distance to be transported. Fully riped fruits are used for preaparing sauces and other processed products. For transporting to distant palces, the crop should be harvested at turning stage i.e., $1/4^{th}$ of the surface at blossom end shows pink (breaker stage).

Yield

A normal crop of tomato yields 20-25 t/ha under organic production system.

GINGER

Ginger (*Zingiber officinale* Rosc.) is a herbaceous perennial crop usually grown as an annual for its rhizomes. It is a valuable cash crop and widely used in food, beverage, confectionery and medicine. It is marketed in different forms such as raw ginger, dry ginger, ginger powder, ginger oil, ginger oleoresin, ginger ale, ginger candy, ginger beer, brined ginger, ginger wine, ginger squash, ginger flakes etc. Though it is also cultivated in Jamaica, Nigeria, Sierra, Leone, Brazil, China, Japan, and Indonesia, India still is the largest producer of dry ginger, Ginger is cultivated in almost all the states of India. The Major ginger growing ststes are Kerla, West Bengal and North Eastern Region. About 3 lakhs tones of ginger are being produced annually from 47,641 ha land and the northeast region is emerging as India's organic ginger hub. This region is one among the highest ginger productivity zone in the world. The ginger of the region is known for its quality (less fibre). Ginger produced from northeastern states are reported to have higher oil and oleoresin content than ginger from other parts of the country. Dry ginger has a good demand abroad and India is the largest exporter of dry ginger.

Soil and climate

Ginger is cultivated in different types of soils, provided sufficiently well distributed rainfall or irrigation and adequate drinage facilities are available. The ideal soil for ginger cultivation is sandy or clay loam or red loam or lateratic loam with good drainage and aeration. A deep friable loam rich in humus is ideal for ginger cultivation. However, being an exhaustive crop it is not desirable to grow ginger in the same site year after year. Ideal pH range of ginger is 5– 7.5.

It grows well in humid climate and is cultivated from sea level upto an altitudes of about 1500 m above MSL. However, the optimum elevation for its successful cultivation is in the range of 300-900 m. Ginger can be grown both, under rainfed and irrigated conditions. Moderate rainfall at sowing time till the rhizomes sprout, followed by fairly heavy and well-distributed showers during the growing period and dry weather about one month before harvesting are optimum requirements for its successful cultivation.

Varieties

Cultivars suitable for NEH Region are Nadia, Maran, China, Varada, Himgiri, Mahima, Goru bathane, Rajetha and Rio-de-janeiro.

Site selection

For organic ginger production, a buffer zone of 25-50 feet is to be left all around from the conventional farm, depending upon the location of the farm. The produce from this zone shall not be treated as organic. Ginger being a annual crop, the conversion period required will be 2-3 years, ginger can be cultivated organically an as intercrop or mixed crop with other crops provided all the other crops are grown following organic methods. The selected site should be well drained and preferably the pace where the ginger is not grown earler.

Field preparation

The land has to be ploughed 4-5 times or dug thoroughly with receipt of early summer showers to bring the soil to medioum tilth. Beds of 1m width, 15cm height and of convenient length are prepared with an interspace of 30-50 cm in between beds. Solarisation of beds for 40 days with a transparent polythene sheets is recommended in areas prone to rhizome rot and nematode infestation. In velly region or high rainfall area, proper drainage channels should be provided in the inter- rows to drain off stagnant water.

Seed Selection and treatment

Carefully preserved seed rhizomes, free from pests and disease, collected from organically cultivated farms should be used for planting. However, to begin with, seed material from high yielding local varieties may be used in the absence of organically produced material. Seed rhizomes should be kept in the sun for a period of 20-30 days before planting. Dipping the rhizome sets in cow urine for half an hour is also beneficial. The optimum size of rhizome is about 50 g. The seed should be selected during the month of October – November during harvesting and the infested rhizome should be removed. The seed selected from a locality where pest and disease problems were not observed gives higher yield. Remove the infested plant with rhizome rot from the field selected for seed production. Rhizome treatment with bioorganic GF1 @ 30 ml/l has been found effective in managing soft rot of ginger and improving yield by more than 20 %.

Rhizome Treatment

Use of chemical fungicides for rhizome treatment is strictly prohibited in organic ginger production. To control the soft disease, slury of *Trichoderma viridae* @5 g/kg of seed is prepared and seeds are treated with the slurry. Acacia gum may be applied in to the slurry as sticker material. Trichoderma spray or drenching 1 % at 15 days interval is also useful for controlling ginger rot. Before planting, the rhizome bits are then soaked in the slurry for 30 minutes and then dried in airy place under shade.

Planting

The planting season for ginger is from March-April, with the onset of the monsoon. The crop duration is generally around 8-9 months (April/May to December/ January). Ginger is planted in rows, 30 cm apart at distances of 20-25 cm within the row. Bits of seed-rhizomes weighing 30-50 g each, 3-5 cm in length and having at least one bud are planted at the given spacing. The rhizome used for seed should be true to type and free from disease. About 2.0 t rhizome/ha is required for planting one hectare land. While planting, seed rhizomes mixed with well rotten cattle manure or compost mixed with Trichoderma (10 g of compost inoculated with

Trichoderma) may be put in shallow pits and covered with a thin layer of soil and levelled. The beds are covered with leaf mulch as protection against sun and heavy rains and for consequent enrichment of organic matter in the soil. Farmyard manure can also be used as mulch.

Cropping system and pat tern

Different types of cropping systems are followed for ginger cultivation in the region. Generally farmers prefer mono cropping of ginger. However, they also practice mixed cropping with maize, chili, soybean, brinjal, papaya, cucumber, pumpkin, yam, tree tomato, tapioca and different types of leguminous crops in *jhum*. Sometimes they intercrop ginger with maize and pineapple. Ginger can tolerate shed and hence suitable for agroforestry based farming system models. The ginger should be rotated with other crops such as legumes, cereals etc. for higher productivity and prevention from disease problems.

Cultural practices

Mulching ginger beds with green leaves is an important operation in ginger. Apart from being an organic manure, it helps in soil and water conservation. Mulching may be done with green leaves thrice in ginger, once immediately after planting @ 10 to 12 tonnes /ha to enhance germination, increase organic matter, and conserve soil moisture and prevent washing of soil due to heavy rains. It is repeated @ 4-5 tonnes /ha at 40^{th} and 90^{th} day after planting preferably at the time of weeding, hoeing and earthing up. Use of *Lantana camara* and *Vitex negundo leaves* as mulch may reduce the infestation of shoot borer. Cow dung slurry or liquid manure may be poured on the bed after each mulching to enhance the microbial activity and nutrient availability.

Two weedings are generally given to the crop. The first weeding just before the second mulching and repeated depending on the intensity of weed growth. The weeded material may be used for mulching. If necessary weeding is to be repeated a third time. Plants are earthed up once or twice with sufficient soil from inter row spaces for covering the rhizome. Proper drainage channels are to be provided in the inter rows to drain off stagnant water.

Conservation techniques

Mulching conserves soil moisture by checking evaporation loss. Bunds are constructed to prevent soil erosion and to retain the topsoil and proper drainage channels are provided to drain off stagnant water. Seasonal legumes are also grown along with ginger to suppress weed growth, minimize soil erosion and enhance soil fertility.

Nutrient Management

Being exhaustive crop, ginger requires heavy manuring. About 20-25 t FYM/ha is required for a good yield of ginger. However, integrated application of 10 t FYM, 5 t vermicompost, 5 t green leaf together with 250 kg neem cake and 150 kg rock phosphate per hectare is optimum for organic ginger production and sustaining soil health. Well rotten cow dung or compost has to be applied either by broadcasting over the beds and incorporating to soil prior to planting or applied in the pits at the time of planting. Application of neem cake at the time of planting helps in reducing the incidence of rhizome rot disease/nematode and increase the yield.

Plant protection

Pests

Shoot borer is the major pest infesting ginger. Regular field surveillance and adoption of phytosanitary measures are necessary for pest management. It appears during July -October period. Spot out the shoots infested by the borer and cut open the shoot and pick out the caterpillar and destroy them. Spray neem oil (0.5%) at fortnightly intervals if found necessary. Light traps will be useful in attracting and collecting the adult moths.

Diseases

Soft rot or rhizome rot is a major disease of ginger. While selecting the area for ginger cultivation care should be taken to see that the area is well drained as water stagnation pre-disposes the plants to infection. Select seed rhizomes from disease free areas since this disease is seed borne. Solarisation of soil done at the time of bed preparation can reduce the fungus inoculum. However, if the disease is noticed, the affected clumps are to be removed carefully along with the soil surrounding the rhizome to reduce the spread. *Trichoderma* (1%) may be applied at the time of planting and subsequently as foliar spray or drenching if necessary. Restricted use of Bordeaux mixture (1%) in disease prone areas may be made to control it as spot application.

Harvesting and curing

The crop is ready for harvesting in about 8 to 9 months depending upon the maturity of the variety. When fully mature the leaves turn yellow and the pseudo-stems begin to dry. Rhizomes are lifted either with a digging-fork or with a spade. They are cleaned of roots and adhering soil particles. The removal mother rhizome is practiced by farmers in about 5 months duration of the crop. Such practice increase the incidence of disease in the crops and hence, should be avoided to the extent possible.

The green ginger is soaked in water to facilitate the removal of the skin. The skin is scraped off with pieces of sharpened bamboo. The scraped produce is washed and dried in the sun for 3 or 4 days and hand-rubbed. It is again steeped in water for two hours, dried and then rubbed to remove all the remaining bits of the skin. Sun-drying also bleaches the produce. Peeling should be done with great care and skill. The essential oil which gives ginger the aromatic character is present in the epidermal cells and hence excessive or careless scraping will result in damaging these cells leading to the loss of essential oils. Steel knives are not used as they are found to stain the produce. Storage of dry ginger for longer periods is not desirable. The yield of dry ginger is 15-25 percent of the fresh ginger depending upon the variety and location where the crop is grown. Burning of sulphur for processing ginger is not allowed.

Preservation of seed

The rhizomes to be used as seed material should be preserved carefully. Indigenous practices like spreading layers of leaves of *Glycosmis pentaphylla* being followed by farmers can very well be adopted for this purpose. In order to get good germination, the seed rhizomes are to be stored properly in pits under shade. For seed material, big and healthy rhizomes from disease-free plants are selected immediately after harvest. For this purpose, healthy and disease-free clumps are marked in the field when the crop is 6 - 8 months old and still green. Seed rhizomes are stored in pits of convenient size made in the shed to protect from the sun and rain. Walls of the pits may be coated with cow dung paste. Seed rhizomes are stored in these pits in layers along with well-dried sand/saw dust (i.e. put one layer of seed rhizomes, then put 2 cm thick layer of sand/saw dust). Sufficient gap is to be left at the top of the pits for adequate aeration. Seed rhizomes in pits need inspection once in twenty days to remove shriveled and disease affected

rhizomes. Seed rhizomes can also be stored in pits dug in the ground under the shade of a tree provided there is no chance for water to enter the pits. In some areas, the rhizomes are loosely heaped over a layer of sand or paddy husk and covered with dry leaves in thatched sheds.

Yield

Ginger become ready for harvesting after 8-9 month of sowing (in the month of December) when the leaves start yellowing and drying. The average yield of gingerrhizome is estimated at about 7 to 12 tonnes per hectare. The recovery of dry ginger varies from 16 - 25 per cent.

TURMERIC

Turmeric (*Curcuma longa*) (Family: Zingiberaceae) is used as condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. The tuberous rhizomes or underground stems of turmeric are used from antiquity as condiments, a dye and as an aromatic stimulant in several medicines. Presently it is cultivated in China, Taiwan, Indonesia, Sri Lanka, Australia Africa, Peru and West Indies. India is a leading producer and exporter of turmeric in the world. In India, Turmeric is mainly grown in Andhra Pradesh, Tamil Nadu, Orissa, Karnataka, West Bengal, Gujarat, Meghalaya, Maharashtra, Assam are some of the important states cultivates turmeric, of which, Andhra Pradesh alone occupies 35.0 % of area and 47.0 % of production. Turmeric has been used in Indian systems of medicine for a long time. Recently, the demand for organic turmeric is growing rapidly in the global pharmaceutical market due to its anticancer properties. The turmeric of northeast are known for its high Curcumin content and other quality parameters.

Climate and soil

Turmeric can be grown in diverse tropical conditions from sea level to 1500 m above sea level, at a temperature range of 20-35oC with an annual rainfall of 1500 mm or more, under rain fed or irrigated conditions. Though it can be grown on different types of soils, it thrives best in well-drained sandy or clay loam soils with a pH range of 4.5-7.5 with good organic status.The crop cannot withstand water logging and alkalinity.Like other crops, turmeric also requires deep tilth and heavy manuring for high yields.

Varieties

The cultivars suitable for NEH Region are Lakadong, Megha Turmeric 1

Site selection

For organic turmeric production, a buffer zone of 25-50 feet is to be left all around from the conventional farm, depending upon the location of the farm.The produce from this zone shall not be treated as organic. Turmeric being a annual crop, the conversion period required will be 2-3 years, turmeric can be cultivated organically an as intercrop or mixed crop with other crops provided all the other crops are grown following organic methods. The site selected should have good drainage facilities.


Preparation of land

The land is prepared with the receipt of early monsoon showers. The soil is brought to a medium tilth by giving about three deep ploughing. In NEH region, farmers starts land preparation little early (February-March). Immediately with the receipt of pre-monsoon showers, beds of 1.0 m width, 15 cm height and of convenient length are prepared with spacing of 50 cm between beds. Solarization of such beds is beneficial in checking the multiplication of pest and disease causing organisms. To ameliorate soil acidity, hydrated lime @ 400 kgs/hectare should be applied and mixed with soil. In valley region or high rainfall area, proper drainage channel should be provided in the inter-rows to drain-off stagnant water.

Seed material and Treatment

Whole or split mother and finger rhizomes are used for planting and well developed healthy and disease free rhizomes are to be selected. The source of seed should be selected carefully. In the beginning seed material from high yielding local varieties may be used in the absence of organically produced seeds. But afterwards only carefully preserved healthy seed rhizomes which were collected from organically cultivated farms should be used for planting. A seed rate of 25 tone kg of rhizomes is required for planting one hectare of turmeric. Micro-rhizome produced through tissue culture can also be used for planting. Rhizome treatment and drenching with bioorganic RCHE 22 @ 30 ml/l has been found effective in increasing turmeric productivity by 15%.

Use of chemical fungicides for rhizome treatment is strictly prohibited in organic turmeric production. To control the rot disease, slurry of *Trichoderma viridae* @5 g/kg of seed is prepared and used for treating the seed materials. Accacia gum may be applied in to the slurry as sticker material. Before planting, the rhizome bits are then soaked in the slurry for 30 minutes and then dried in airy place under shade. Rhizome bits should be stirred 3-4 times to ensure uniform soaking. Alongwith with *Trichoderma*, rhizome can be treated with biofertilizers (*Azospirillum*, *Azotobactor*, PSB etc.). For controlling of soil born diseased, turmeric crop should be rotated with cereals/legumes after every 2-3 years. It is beneficial, if legume crop such as groundnut and frenchbean was rotated.

Planting

The planting season for turmeric is from March-April in hill and April-May in valley. Small pits are made with a hand hoe on the beds with a spacing of 30 cm x 25 cm. Pits are filled with well

decomposed cattle manure or compost mixed with *Trichoderma*. The optimum spacing in furrows and ridges is 45-60 cm between the rows and 25 cm between the plants. At the time of planting apply 25 g neem cake per sqm mixed well with soil in each pit. A light irrigation is beneficial after planting followed by mulching.

Manuring and fertilizer application

Farmyard manure @ 15-20 t/ha along with 250 kg neem cake and 150 kg/ha rockphosphate or vermicompost @ 10 t/ha along with, 250 kg neem cake and 150 kg/ha rockphosphate is useful for optimum turmeric yield. Integrated application of FYM 10t /ha and vermicompost 5t/ha along with 250 kg neem cake and 150 kg/ha rockphosphate is the best option for sustainable turmeric production. It is more beneficial if biofertilizers such as *Azospirillum* (Nitrogen fixer) and *Bacillus* (Phosphate Solublizing Bacteria) is applied along with FYM or vermicompost.

Table : Rhizome yield as influenced by different organic sources

Treatments	**Rhizome yield (t/ha)**					
	2008-09		**2009-10**		**2010-11**	
	Flat bed	**Bun**	**Flat bed**	**Bun**	**Flat bed**	**Bun**
FYM	27.9	30.0	13.0	15.9	19.8	20.7
Vermicompost	26.0	28.4	12.8	11.0	17.4	16.5
FYM +VC	28.0	31.6	17.2	15.9	22.3	26.1
Farmers practice	19.6	21.5	6.26	9.31	15.1	15.3
CD (*P =0.05*)	**0.70**	**0.72**	**0.59**	**0.62**	**0.50**	**0.50**

Mulching

Mulching of turmeric with paddy straw or green leaves or available wwed biomass (*Ambrosia spp., Eupatorium spp.*) is an essential operation to enhance germination of rhizomes and to prevent soil erosion during heavy rains. This also help to add organic matter to the soil and conserve moisture during the later part of the cropping season. he first mulching is to be done immediately after planting with green leaves @ 10 t/ha. Mulching may be repeated @ 5 t/ha at 45 and 90 days after planting after weeding and earthing up. Cow dung slurry may be poured on the bed after each mulching to enhance microbial activity and nutrient availability.

Water Management

Turmeric is generally grown as rainfed crop. However, irrigation has to be given when soil becomes totally dry. To loosen the soil, a light irrigation has to be given when soil becomes totally dry. A light irrigation may also be given 2-3 days before digging up the rhizomes. In water scarcity areas (like hilly terrain), suitable water conservation techniques (rain water harvesting) has to be adopted for providing life saving irrigation.

Weed management

Weeding has to be done thrice at 60, 90 and 120 days after planting depending upon weed intensity. Mulching reduces the weed problem.

Mixed cropping
Turmeric can be grown as an inter crop with with chillies, colocasia, onion, brinjal and cereals like maize, ragi, etc.

Plant protection

Diseases
***Leaf blotch*-** Leaf blotch is caused by *Taphrina maculans* and appears as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become dirty yellow or dark brown. The leaves also turn yellow. In severe cases the plants present a scorched appearance and the rhizome yield is reduced. The disease can be controlled by spraying of copper oxy chloride 3 gm in 1 litre of water .
Rhizome rot-The disease is caused by *Pythium graminicolum* or *P. aphanidermatum*. The collar region of the pseudostem becomes soft and water soaked, resulting in collapse of the plant and decay of rhizomes. Selection of healthy rhizomes, soil solarization and incorporation of Trichoderma, seed treatment and soil application of biocontrol agents like Trichoderma or Pseudomonas multiplied in suitable carrier media such as coir pith compost, well rotten cow dung or quality neem cake may be done at the time of sowing and at regular intervals to keep the rhizome rot disease in check

Insect pests
***Shoot borer*-**The shoot borer is the most serious pest of turmeric. The larvae bore into pseudo stems and feed on internal tissues. The presence of a bore-hole on the pseudo stem through which frass is extruded and the withered central shoot is a characteristic symptom of pest infestation. The adult is a medium sized moth with a wingspan of about 20 mm; the wings are orange yellow with minute black spots. Fully-grown larvae are light brown with sparse hairs. Spraying Neemgold in the ratio of 50 ml in 15 litres of water or neem oil 50ml in15 litres during July-October (at 21 day intervals) is effective against the shoot borer. The spraying has to be initiated when the first symptom of pest attack is seen on the inner most leaf.

Harvesting
Depending upon the variety, the crop becomes ready for harvest in 7-9 months after planting during January-March. Early varieties mature in 7-8 months, medium varieties in 8-9 months and late varieties after 9 months. The land is ploughed and the rhizomes are gathered by hand picking or the clumps are carefully lifted with a spade. The harvested rhizomes are cleared of mud and other extraneous matter adhering to them.
A good crop may be yielded around 18-20 t/ha.

Processing
Curing
Fresh turmeric is cured for obtaining dry turmeric. The fingers are separated from mother rhizomes. Mother rhizomes are usually kept as seed material. Curing involves boiling of fresh rhizomes in water and drying in the sun. The cleaned rhizomes are boiled in water just enough to immerse them. Boiling is stopped when froth comes out and white fumes appear giving out a typical odour. The boiling should last for 45-60 minutes when the rhizomes turn soft. The stage

at which boiling is stopped largely influences the colour and aroma of the final product. Over cooking spoils the colour of the final product while under-cooking renders the dried product brittle. In the improved scientific method of curing, the cleaned fingers (approximately 50 kg) are taken in a perforated trough of 0.9 m x 0.5 m x 0.4 m size made of GI or MS sheet with extended parallel handle. The perforated trough containing the fingers is then immersed in a pan; 100 litres of water is poured into the trough so as to immerse the turmeric fingers. The whole mass is boiled till the fingers become soft. The cooked fingers are taken out of the pan by lifting the trough and draining the water into the pan. The water used for boiling turmeric rhizomes can be used for curing fresh samples. The processing of turmeric is to be done 2 or 3days after harvesting. If there is delay in processing, the rhizomes should be stored under shade or covered with sawdust or coir dust.

Drying

The cooked fingers are dried in the sun by spreading them in 5-7 cm thick layers on bamboo mats or drying floor. A thinner layer is not desirable, as the colour of the dried product may be adversely affected. During night time, the rhizomes should be heaped or covered with material which provides aeration. It may take 10-15 days for the rhizomes to become completely dry. Artificial drying, using cross-flow hot air at a maximum temperature of 60 degree centigrade also gives a satisfactory product. In the case of sliced turmeric, artificial drying has clear advantages in giving a brighter coloured product than sun drying which tends to undergo surface bleaching. The yield of the dry product varies from 10-30% depending upon the variety and the location where the crop is grown.

Preservation of seed rhizomes

Rhizomes for seed purpose are generally stored by heaping in well ventilated rooms and covered with turmeric leaves. The seed rhizomes can also be stored in pits with saw dust, sand along with leaves of *Strychnos nuxvomica* (kanjiram). The pits are to be covered with wooden planks with one or two openings for aeration. The rhizomes are to be dipped in litres of water to avoid storage losses due to fungi

Yield

A good crop of turmeric may yield about 20-25 t/ha under organic production**.**