

## TUBER CROP AND VEGETABLES

### POTATO

Potato (*Solanum tuberosum L*) is one of the major food crops of the world. 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 isoleucine. The important potato growing countries are Russian Federation, Poland, 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 tons. It is cultivated on a large scale in Uttar Pradesh, West Bengal, Bihar and Punjab. North Eastern hill region also grows potato but its productivity is very low (8.64 t ha<sup>-1</sup>) except Tripura (17. t ha<sup>-1</sup>) 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.



**Photo – Potato crop in Meghalaya**

### **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 rich in organic matter. Well drained sandy loam and medium loam soils, rich in humus are most suitable for potato. Soil structure and texture has a marked effect on the quality of 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. Potato is 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. Adequate sunshine along with cool 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 pests 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 also 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
- b) 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 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-third 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 water table, even 8-12 irrigations may be required. 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. In case 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 depend upon, aeration, moisture availability and proper soil temperature. Therefore, proper earthing up is necessary. Earthing should be done when the plants are 15-22 cm high. 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 of 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 following pest management practices be adopted:

#### **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, inundative 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<sup>3</sup> 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) General 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 chances 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 10-20°C temperature, RH  $\geq$  80 %. Bordeaux mixture (1%) is quite effective in management of late blight (1 kg copper sulphate, 1 kg lime in 100 lit of water).
- 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 are 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 °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).

### **Pest identification and management**

1. **Aphids (*Myzus persicae* and *Aphis gossypii*)**

**Symptoms** - Nymphs & adults suck the cell sap from potato foliage and puncture the tender shoots causing leaves to curl down. Leaves turn down ward, become yellow and ultimately wilting of plant occurs. Growth of plant is stunted and yield is adversely affected

**Control measures** - Removal of alternate host plants to reduce the incidence of Aphids.

Use of yellow sticky traps. Prophylactic foliar application of NSKE-5 % or Neem Oil-3%. Foliar spray of soft soap alone or in combination of any other spray solution such as neem oil effectively manages the aphids.

2. **Jassids (*Amrasca biguttula biguttula*)**

**Symptoms** - Nymphs & adults suck cell sap from lower surface of leaves. The damaged leaves curl upward along the margins, turn yellow, then brown and show burnt patches. Tuber setting is adversely affected by infestation. Severely infested plants show stunted growth.

**Control measures** - Foliar spray of Ginger-garlic and chilly extract alone or mixed with some flour and soft soap. Foliar spray of 10% nettle leaf extract on 45th, 60th and 75th day after sowing. Foliar spray of *Verticillium/ Metarhizium* @ 5–10 gm/lit water.

3. **Cutworm (*Agrotis ipsilonis*)**

**Symptoms** - Larvae are dark grey or dull green with smooth and greasy skin. The full-grown larva is 40-50 mm in length The larvae damage the crop at initial stages i.e. seedling stage. Caterpillars feed on tender shoots during night by cutting the seedling near the ground level. The plants which receive only partial injury to the stem get dislodged at later stages of their growth. After tuber formation, larvae feed by boring and nibbling into tubers.

**Management**

**Cultural** - Deep summer ploughing to expose the resting stage (pupae) of the pest to scorching heat to kill them. Ploughing should be carried out during the day time as maximum bird predation of larva occurs during day time. Removal of weeds and other vegetation in field before planting of the crop, which serve as a source of oviposition by cutworm moths. Light traps are very much useful in trapping moths. Heaps of green grasses be kept at suitable intervals in infested field during evening and collected next day early in the morning along with caterpillars and destroyed.

**Control measures** - Soil application of *Beauveria bassiana* @ 5 kg/ ha with FYM at last ploughing or apply in furrows and irrigate the field. Application of neem cake @ 250 kg/ha minimizes the growth of pest.

#### 4. White grubs (*Lachnosterna coriacea* Hope)

**Symptoms** – White grub larvae are large in size, reaching a length of 2-3 cm and are generally C shaped. Have 3 pairs of legs, near the neck and head is hard reddish brown in colour. Eat tubers from outside and cause damage but damage is not deep as grubs do not enter the tubers. Severe infestation is in the fields covered with grasses.

#### **Management**

**Cultural** - Collect and destroy adult beetles during peak period of emergence. Avoid using immature compost or un-decomposed organic fertilizer. Flooding fields prior to planting

**Control measures** - Apply neem cake @ 250 kg/ ha mixed with FYM or compost. Setting up of light traps helps in collection and destruction of beetles during peak period of emergence. Application of *Metarhizium anisopliae* @ 5kg/ha mixed with compost. Application of aqueous suspension of EPN *Steinernema carpocapsae* with a dosage of 40-50 lakh infective juveniles/5 l water. Application of EPN *Heterorhynchus* sp @ 50 lakh IJ/5 lit of water is also effectively control the pest. Continuous application of EPN builds the native population and helps in managing the pest below ETL.

#### 5. Leaf-eating caterpillars or tobacco caterpillar (*Spodoptera litura*) [Syn. *Prodenia litura* (Fab.)]

**Symptoms**- The young larvae first feed voraciously on leaves and scrape the tissue. Older larvae spread out and may completely destroy the leaves resulting in poor growth of plants

#### **Management**

**Cultural** - Plough the soil to expose and kill pupae. Grow castor crop alongside the border and irrigation channel as trap crop. Flood the field to drive out the hibernating larvae

**Control measures** - Set up light trap @1/ha. Pheromone traps (**Pherodin SL**) @ 15/ ha to attract male moths. Collect and destroy egg masses in castor and tomato crop grown as trap crop. Hand pick grown up larvae and kill them. Spray SI-NPV @  $1.5 \times 10^{12}$  POBs/ha + 2.5 Kg crude sugar + 0.1 % teepol (or soft soap). Foliar spray



of Garlic-chilli extract with 3% neem oil and soft soap. 10 plants leaf extract (Dashparni) is also effective.

#### 6. Tuber moth (*Phthorimaea operculella*)

**Symptoms** - The adult moth is very small (about 13 mm) and dark brown in colour. The larvae are 20 mm in length, pinkish-white or greenish in colour with dark brown head. Mined leaves and drooping twigs of the plants are the main symptoms of attack in field. Tunnelling by larva leads to rotting and foul smelling of tubers due to bacterial infection. Larvae make irregular galleries and tunnel deep inside the tuber in storage.

#### **Management**

**Cultural** - Avoid shallow planting & plant the tubers at optimum depth of 10-15 cm. Earthing up at 60 DAP to avoid egg laying in the exposed tubers.

**Control measures** - Install pheromone traps in field (@ 12/ha) & also in godowns. Foliar application of NSKE- 5%. Foliar application of Herbal Pesticide @ 10 lit slurry diluted to 200 lit. water for 1 acre

Heaps of harvested tubers should not be kept exposed in the field but covered with paddy straw/Neem leaves//*lantana* leaves and infested tubers should be rejected before storage. In godowns cover the upper surface of tubers with *lantana* to repel ovipositing moths.

#### 7. Epilachna beetle [*Henosepilachna vigintioctopunctata* (Fab)] in Assam and Arunachal Pradesh

**Symptoms** – It is one of the serious pests of North Eastern states, especially in Assam and Arunachal Pradesh. Adults and grubs both are damaging stages. Grubs. Larvae are sluggish in nature and move slowly while feeding. Yellowing in colour with erect spines on the body. Feed on leaves. Grubs scrape the soft tissue of leaves leaving only the veins. Severe infestation can damage the crop by up to 70%.

#### Management

**Cultural** - Hand picking of grubs using hand nets.

**Biological** - Augmentation of pest parasitoids viz: *Pediobius faveolatus*, *Pleunotrogrus faveolatus* and *Tetrastichus* sp.

**Control measures** - Soil application of Neem cake and mahua cake @ 250 kg/ ha fir reduction in pest population. Application of garlic-chilly extract with 3% neem oil is

effective. Prophylactic spray of 10 plant leaf extract followed by 2-3 sprays at 10 days interval can effectively control the spread.

#### 8. Red ants (*Dorylus orientalis* Westwood) in Meghalaya and Arunachal Pradesh

**Symptoms** - Red ants (*Dorylus orientalis*), is one of the most important soil pests of potato. Mainly the potato stems and tubers are attacked by the pest. The pest made hole on the surface of tuber which reduced tuber yield as well as market quality. Chewing holes can be seen on stem and tubers. In case of severe attack plants develop wilt symptoms in direct sunlight and may eventually dry up.

##### **Management**

Being soil insect, it is difficult to control. Long term crop rotation and use of neem cake help in minimization of problem. Soil drenching with Neem, karanj and Nirgundi (*Vitex*) extract or oil (in a ratio of 20:20:2) @ 2 lit per ha can manage the pest.

#### 9. Early blight (*Alternaria solani*)

**Symptoms** - Small brownish to black concentric leaf lesions appear on lower & older leaves. Dark brown lesions are also formed on stem and petioles. Under dry conditions, these spots dry and become hard. These spots may enlarge and coalesce to form large necrotic areas. In severe infection, tubers may also be infected forming brown, circular to irregular depressed lesions with dry rot symptoms.

##### **Management**

**Cultural** - Summer ploughing to increase the desiccation of pathogen. Burn the infected plants and debris. Adopt crop rotation with non host crop. Mulching helps to prevent splashing of spores from soil up to lower leaves. Late maturing varieties are tolerant to early blight.

**Control measures** - Seed treatment with *Trichoderma harzianum* or *Pseudomonas* @ 5 gm/kg seed. Soil application of *Trichoderma/Pseudomonas* @ 5kg/ha mixed in 400 kg FYM/compost. Foliar spray Bordeaux mixture (1%).

#### 10. Late blight (*Phytophthora infestans*)

**Symptoms** - It affects leaves, stems and tubers. On leaves it appears as water soaked irregular pale green patches on tips and margins. In moist weather the spots enlarge rapidly with central tissue turning necrotic and dark brown. Later it advances rapidly causing wet rot of leaves and stem with offensive odour. It spreads on twigs and tubers get infected with brown to pink discoloration of skin of tubers.

##### **Management**

**Cultural** - Healthy seeds should be used for planting. Grow late blight resistant varieties. Removal & destruction of weeds, alternate host and infected plants.

**Control measures** - Seed treatment with *Trichoderma/Pseudomonas* @ 5 gm/kg seed. Soil application of *Trichoderma/Pseudomonas* @ 5 kg/ha mixed with 200-300 kg well decomposed FYM. Spray of fine wood ash solution @ 5 kg with 100 lit of water/acre or Spray of 1% Bordeaux mixture (copper sulphate+lime). Spraying of Agnihotra ash (200 g ash soaked in 1 lit cow urine for 15 days and diluted in 10 lit. water before spraying) thrice at monthly interval

#### **11. Stem canker and Black scurf (*Rhizoctonia solani*)**

**Symptoms** - The disease appears in two phases, viz. Stem canker and Black scurf phase. Symptoms appear on both above and below ground portions of the plant i.e sprouts, stems, tubers, stolon and roots. In Stem canker phase, sprouts show dark brown lesions on their surface and sprouts are killed before their emergence thus delaying their germination. The disease may cause wilting of plants.

Brown sunken lesions also appear on underground stems & stolon. In Black scurf phase, the fungus forms dark brown to black hard masses on the surface of the tuber. Diseased plants or tubers show brown to reddish lesions above and below ground on stem causing girdling and rolling of leaves or rough black encrustification of tubers thus reducing their market value. Such plants show formation of aerial tubers.

#### **Management**

**Cultural** - Soil solarization with transparent polythene mulching for 4 weeks during hot summer months to reduce soil borne inoculum. Use disease free seed tuber. Removal & burning of crop debris. Suitable crop rotation should be followed.

**Control measures** - Incorporate the cruciferous cover crop (Mustard, etc) in the soil as it releases some cyanide compounds which act as Biofumigants & restrict the inoculum. Soil amendment with *Pseudomonas* bacterial culture @ 3-5 kg/ha incorporated with FYM/compost 300-500 kg/ha. Foliar application of cow urine 5 lit + vermiwash 10 lit with 100 lt. water per acre

#### **12. Common scab (*Streptomyces spp.*)**

**Symptoms** - It appears as skin abrasions or brownish raised rough and corky pustules. Proliferated lenticels with corky depositions gives rise to star shapes. Wrinkled layers of cork around brown spot core can be seen.

#### **Management**

**Cultural** - Deep ploughing during hot summer is to be practiced. Use scab free seed tubers for planting. Use resistant cultivars. Adopt crop rotations with wheat, rice, cabbage, berseem or pearl millet for 3-7 years. Maintain good soil moisture especially at tuber initiation. Green manuring with Dhaincha.

**Control measures** - Apply *Pseudomonas fluorescens* @ 3-5 kg/ha incorporated in FYM/compost 300-500 kg/ha

### 13. Wart (*Synchytrium endobioticum*)

**Symptoms** - It mainly appears on tubers, but may also appear on stems and stolons. The major symptom of wart disease is formation of gall at the base of the potato stem. The gall, which is white when underground, and black when decaying, may be as small as a pin or as large as a fist. The gall surface is rough and corrugated-warty in appearance. In severe infestation, the tip of the stolon becomes infected and develops a gall instead of a tuber. Severe infestations destroy the potato crop by preventing tuber production, however, the plant itself does not appear damaged above ground.

#### **Management**

**Cultural** - Observe strictly Plant Quarantine regulations. Do not use seeds transported from the wart infected areas. Use only healthy seed of immune varieties

### 14. Potato leaf and mosaic virus

**Symptoms** – Major symptom of PLRV is rolling of upper leaves which gradually advances to lower leaves. Rolled leaves get leathery and may show pink colour discolouration. Infected tubers produce plants with rolling of lower leaves. Mosaic virus causes mild to severe mosaic and veinal necrosis on leaves. It appears as mild or barely perceptible mosaic or mottle on leaves. The infected leaves show heavy blotching and crinkling, developing wavy margin. Plants become stunted and tuber number and size are reduced.

#### **Management**

Use virus free Potato tubers. Grow resistant varieties. Rouging of virus infected plants. Management of Aphid vectors by spraying Neem leaf extract-5% / NSKE 3 to 5%. Foliar application of garlic-chilli extract with 2.5% neem oil and soft soap to prevent insect vectors.

#### **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. Sort 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.