Potato Cultivation in North Eastern India

Central Potato Research Institute
(Indian Council of Agricultural Research)
Shimla-171 001, Himachal Pradesh
POTATO CULTIVATION IN NORTH EASTERN INDIA

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POTATO CULTIVATION IN NORTH EASTERN INDIA

North-East India consists of the seven ‘sisters’ Assam, Arunachal Pradesh, Mizoram, Nagaland, Manipur, Meghalya and Tripura states and now Sikkim is also added. The region lies between 21° and 29° North latitude and 89° and 98° East longitude. NEH region covers almost 9% of the area of the country, and about 4.5% of its population. About 10% of the Indian potato area lies in the North-East India. The area under potato in the region as a percentage of the net cropped area is about four times the national level. Although the yield level is quite low due to various reasons but the per capita availability of potato in the region is higher than at the national level. The main reasons for the low potato yields are inadequate availability of important inputs like fertilizers, plant protection chemicals, healthy seed and poor management practices, and prevalence of serious diseases like late blight and brown rot, and pests like potato tuber moth and white grubs.

An intensive survey by the scientists of the Institute, was undertaken during 1985-86 to take a close look of the problems of potato cultivation in the region with a view to develop the research programme for their resolution. The following aspects were identified:

1) Development of cultivars suited for rainfed cultivation, and low-input requiring cultivars for the entire region.

2) Development of agronomic practices for rainfed farming and brown rot management including potato based cropping system.

3) Testing the suitability of a) passive evaporating storing system for table potatoes, b) diffused light storage for storing seed potato; c) the management practices development for containing brown rot and potato tuber moth; d) true potato seed production, and e) seed plot technique for seed production, especially in the valley regions; and

4) Development of cultivars possessing durable resistance to late blight and moderate resistance to brown rot.
RESEARCH ACHIEVEMENTS

The Central Potato Research Station (CPRS), Shillong was established in 1959 to conduct research on the regional problems of potato cultivation. It is located at an elevation of 1800 meters above Mean Sea Level. Its farm area is 12.8 ha. The CPRS, Shillong is engaged in multi-disciplinary research on (i) breeding for high yielding late blight and brown rot resistant varieties suitable for the region; (ii) developing suitable agronomic and manural practices; (iii) conducting basic studies on the prevailing diseases and pests of potato with special reference to late blight, brown rot diseases and potato tuber moth; and (iv) producing quality seed potato required for the region. The station has evolved a few varieties which combine high yields with variable degrees of resistance to late blight and brown rot. The work carried out for the control of potato tuber moth indicated that the leaves of *Lantana* and *Eucalyptus* plants possess repellent action. Under indigenous storage conditions covering of the tubers with dried and crushed leaves of *Lantana* reduced the tuber and sprout damage to 5% and 3%, respectively as compared to over 70% and 45%, when no treatment had been given. Since these plants are readily available in the region, they can be collected by the farmers without any difficulty. They are easy to use for protecting potato tubers against tuber moth.

The work carried out on soil fertility aspects has shown that most of the areas of Meghalaya, Manipur, Tripura and Arunachal Pradesh and more than half the area of Mizoram are deficient in phosphorus. This is the result of the acidic nature of the soil and the presence of exchangeable aluminium. The soils of Tripura, Nagaland, Arunachal Pradesh and Meghalaya are low to medium in available potassium.

The work on aphid vectors showed that autumn potato crop is more suitable than summer crop for seed production in Meghalaya because the aphid population remains low. Besides, manural and cultural practices for potato and potato based cropping system and management practices for controlling of brown rot disease have also been worked out.
RECOMMENDED PRACTICES OF POTATO PRODUCTION

1. **Cultivars**
   
   Since late blight is a major disease the resistant varieties like Kufri Jyoti, Kufri Megha, Kufri Kanchan (red tuber) and Kufri Giriraj are recommended for main/autumn crops.

2. **Seed source**
   
   Seed should be procured from a reliable source, preferably from a Government agency. It is better to replace the seed every 3-4 years.

3. **Seed size**
   
   Best seed size for raising summer and autumn crops is 40-50 g.

4. **Seed preparation**
   
   Seed from the previous years harvest should be kept in seed trays or baskets or spread out on the floor or on racks in a store and exposed to natural diffused light to ensure proper sprouting. Unsprouted and rotten tubers should be sorted out periodically. The sprouted seed tubers should be taken to the fields in trays for planting to minimize sprout damage. Seed should not be kept in gunny bags up to one month before planting to avoid development of lanky, fragile, and etiolated sprouts, and need to be shifted in trays or spread on floor in diffused light.

5. **Planting time**
   
   The main crop is planted in the first fortnight of March and autumn crop is planted in the last week of August to first week of September (Annexure-III).

6. **Manuring**
   
   Apply 100 q/ha farm yard manure in furrows before planting. Chemical fertilizers should be applied as per the following table:
Fertilizer Source | Quantity to be applied (q/ha) | Ware potato | Seed potato |
<table>
<thead>
<tr>
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<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>At planting</td>
<td>At earthing</td>
<td>At planting</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>3.75</td>
<td>2.5</td>
<td>3.75</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>(75 kg N)</td>
<td>(50 kg N)</td>
<td>(75 kg N)</td>
</tr>
<tr>
<td>or Calcium Ammonium Nitrate (CAN)</td>
<td>3.00</td>
<td>2.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Phosphorus (P₂O₅)</td>
<td>Single Super phosphate</td>
<td>7.5</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>(120 kg P₂O₅)</td>
<td>(120 kg P₂O₅)</td>
<td></td>
</tr>
<tr>
<td>Potash (K₂O)</td>
<td>1.00</td>
<td>Nil</td>
<td>1.00</td>
</tr>
<tr>
<td>Munate of Potash</td>
<td>(60 kg K₂O)</td>
<td>(60 kg K₂O)</td>
<td></td>
</tr>
</tbody>
</table>

The fertilizer should be mixed with soil to avoid direct contact of the seed tubers.

7. **Method of planting**

Make furrows against the slope keeping 50 cm distance between the rows. It is important to make the furrows and ridges against the slope to avoid soil erosion. Place the large size tubers in furrows in upper side of the field slope and small tubers in downward side slopes at 20-25 cm distance between the tubers depending upon seed size. Cover the seed tubers with soil immediately after planting, making ridges to a height of 6-10 cm.

8. **Intercultural operations,**

Weeding should be done as soon as the weeds appear. The final earthing up should be done when the plants are 10-15 cm high. While earthing up, the remaining dose of nitrogen (25 kg/ha in seed crop and 50 kg/ha in ware crop) should be applied. Use herbicides like metribuzin @ 0.7 kg/ha (1.0 kg Sencor) as pre emergence or paraquat @ 0.5 kg/ha (2.5 litre Gramaxone) as post-emergence treatment at about 5% emergence of potato plants for effective control of the weeds in potato crop.

9. **Plant protection measures**

Potato tuber moth (PTM) damages the potato both in the field and store (Plate 6) hence, integrated pest management (IPM) schedule as under may be practiced.
A. Fields

i) Use healthy seed potatoes for planting.

ii) Deep planting (10 cm) or more with proper earthing and timely irrigation.

iii) Installation of PTM sex pheromones traps @ 20 traps/ha for mass trapping of male moths

iv) Spraying crop with microbial agents like Bacillus thuringiensis (Bt) WG @ 300 gm/ha, Granulosis virus (GV) @ 2 larval equivalent (LE)/litre of water and monocrotophos 40 WSC @ 0.05% conc., alternately on PTM appearance.

v) If possible, inoculative release of potential parasitoid i.e. Copidosoma koehleri or Chelonus blackburni, in potato fields during pest build up stage and

vi) Proper sanitation viz. removal of left over tubers, volunteer plants and alternate host plants from and the vicinity of the crop

B. Stores

i) Provide 2-3 cm thick layers of chopped leaves of Lantana sp./Eucalyptus sp. below and above the stored potatoes.

ii) Install PTM sex pheromone traps @ 4 trap/100 m³ store area and

iii) Use GV formulation (to prepare 1 kg formulation, mix. 1 kg talc powder in one litre of water + 20 GV infected PTM larvae + 5 ml triton in the shade to make the formulation into dust form) 5 kg of GV formulated dust is sufficient for one ton of potatoes.

Soil pests viz. white grubs Brahminia (Lachnosterna) coriacea and H. longipennis; cutworm Agrotis segetum and A. ipsilon and red ants Dorylus orientalis cause moderate to heavy damage to potato tubers (Plate-6). These pests are manageable by adopting following IPM schedule in the potato fields

i) Timely planting and harvesting of potato crop.
ii) Two sprayings with chlorpyrifos 20 EC @ 2.5 l/ha. alone or alternately with bioagent *Beauveria bassiana* (1% conc.) first after observing 2% plant cut and second on the appearance of white grub beetles

iii) Removal of alternate/collateral hosts of beetle (white grub) host from the vicinity and within potato crop

iv) 2-3 ploughing before planting and after harvesting to expose the immature stages of white grubs should be done for natural mortality and for predation

v) Spraying the beetle hosts and bunds with endosulfan 35 EC @ 0.05% concentration.

vi) Conservation of natural enemies (predatory birds, parasites and predators)

and

vii) Fixing the light traps for mass trapping of beetles/moths.

(c) Control of fungal and bacterial diseases

In the north eastern 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. It is not sufficient to use only contact fungicides like mancozeb but for the proper and effective management, following integrated steps should be taken:

i) Grow only late blight resistant varieties recommended for the region namely *Kufri Giriraj*, *Kufri Megha*, *Kufri Jyoti* and *Kufri Kanchan* (red tubers)

ii) Seed potatoes 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 fields

iii) Ridges should be made high enough to cover daughter tubers and reduce chances of their infection upon exposure
iv) As soon as the weather becomes congenial for late blight appearance (temperature 10-20°C, RH>80%), the crop should be sprayed with 0.2% mancozeb (2 kg of mancozeb per ha of crop/2 g of mancozeb per litre of water) A sticker like Triton AE (0.1%; 1 ml of ,Triton AE in one litre of water) must be mixed with the fungicide solution. Subsequent sprays depending upon the weather conditions should be applied at 8 days interval till crop maturity. Alternatively, systemic fungicide like metalaxyl (Ridomil MZ 0.25% or 2.5 kg of Ridomil per ha or 2.5 g of Ridomil per litre of water) may be sprayed alternating it with mancozeb. A total of four sprays (two each of mancozeb and Ridomil MZ) are sufficient. Since the effect of Ridomil lasts for two weeks, mancozeb should be applied only 15 days after the Ridomil application.

v) Ground keepers/bolters should be rogued out as early as possible.

vi) Sprays on the resistant varieties like Kufri Glnraj, Kufri Megha and Kufri Kanchan should be need based to avoid misuse of chemicals and environmental pollution.

vii) When 75% crop foliage is killed by late blight, the haulms should be cut and removed from the field and burned deep in the soil.

viii) Harvest the crop 15-20 days after haulms cutting or when the skin has become firm, sort out the late blight infected tubers and store the seed after treating it with 3% borac acid (30 g per litre of water) This will also help to check some other tuber borne diseases.

For the effective management of early blight caused by *Alternaria solani* and leaf spots caused by *Phoma* spp., following integrated management practices should be adopted.

i) Use only disease free tubers for raising the crop.

ii) The crop must be given balanced doses of fertilizers, especially nitrogen because the incidence and severity of these diseases are generally high in the crop receiving imbalanced doses of fertilizers, particularly low doses of nitrogen.
iii) Spray of 1.0% urea (10 g per litre of water) at 45 days of crop growth and subsequent spray after 8-10 days may easily escape the severe onslaught of these diseases.

iv) Fungicidal sprays are effective in controlling early blight and other leaf spots. Mancozeb (0.2%) and Copper Oxychloride (0.3%) recommended for the control of late blight can take care of early blight and leaf spots.

v) Avoid cultivation of solanaceous crops like tomato, brinjal, chillies, etc. nearby potato fields because these crops are the collateral hosts of the pathogens causing early blight, brown rot and leaf spots.

vi) Removal and burning of haulms of the affected potato crop help in reducing the inoculum in the field.

vii) Fields should be kept neat and clean, free from weeds.

Brown rot is another important disease in North-eastern hill region. Infected seed tubers and soil are the primary sources of infection carrying the bacterium from one season to another. For its integrated management following practices should be followed.

(i) Healthy seed, free from brown rot pathogen should be used for planting.

(ii) The severity of the disease can be reduced by planting the crop between the second week of February to first week of March and harvesting before first week of June.

(iii) Apply bleaching powder @ 12 kg/ha mixed with fertilizer in furrows at planting.

(iv) The incidence of this disease can also be reduced by adopting crop rotation with maize, finger millet, cereals, garlic, onion etc.

(v) Soil burning is also recommended in sick and infected fields.

(vi) Uproot the wilted plant with tubers and bury in a pit after drenching with bleaching powder. The uproot
spot should also be drenched with bleaching powder solution.

Besides late blight, early blight, phoma leaf spots and brown rot, 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 integrated management schedule.

i) Use disease free seed, preferably from disease free area/field.

ii) Treat seed potato with 3% bonc acid (30 g per litre of water) for 30 minutes.

iii) Do not grow potato every year in the same field. Rotate it with the crops like cereals, maize, millets and non-solanaceous crops.

iv) Follow hot weather cultivation in plains and plateau and cold weather cultivation in the hills.

v) In plains and plateau, harvest the potato crop before soil temperature rises above 28°C i.e. by the end of February.

vi) Avoid injuries to the tubers during harvest, handling and transportation.

vii) Allow the potato tubers to cure for 8-10 days immediately after harvest in shade preferably at 10-15°C.

viii) Store potatoes in well ventilated cool stores

ix) If field remains fallow, plough regularly to minimize weeds which harbour the pathogens. Alternatively, grow green manure crops (any legume).

Symptoms of late blight, early blight, phoma leaf spots, bacterial wilt and brown rot, some soil and tuber borne fungal diseases, important viral diseases and pests are given in the photographs (Plates 1, 2, 3, 4, 5 and 6).


Crop should be harvested soon after its maturity. Preferably, harvesting should be done on bright sunny days. All the
damaged and rotted tubers should be sorted out and marketable tubers should be graded in different sizes, packed in gunny bags and kept in cool place till it is marketed

SEED POTATO PRODUCTION

If the seed crop is to be grown, the following extra steps should be followed in addition to the above practices:

(i) Select such fields which are either free from brown rot pathogen or have minimum inoculum in the field.

(ii) Apply bleaching powder @ 12 kg/ha at the time of land preparation to manage the inoculum of brown rot pathogen.

(iii) Use properly sprouted seed only. Do not cut the tubers.

(iv) Adopt plant protection measures against foliar diseases.

(v) Apply a granular systemic insecticide such as phorate 10 G @ 10 kg/ha at the time of planting to prevent infestation of aphid vectors.

(vi) Spray the crop with imidachloprid (Confidor) @ 400 g/ha in 1000 liters water when the aphid count reaches 2 aphids/100 compound leaves. This happens usually by the first week of May in hills and middle of December in plains. Repeat the spray at 10-15 days interval based on the aphid population build-up in the crop and cut the haulms when its population reaches 20 aphids/100 compound leaves.

(vii) During the growing season, the seed plot should be inspected twice or thrice to remove all off-type and plants showing mottling, mosaic, crinkle, necrosis and leaf rolling symptoms. The first inspection may be done when the plants attain 10-15 cm height (40 days) and the second at flowering stage (60 days). During the later stages of the crop (75 days old crop), if plants show any symptoms of purple top roll, they should be also removed along with the mother and daughter tubers. However, purple top roll symptom
may be induced by injury to plants or due to water stagnation. Hence, such observations may be kept in mind while roguing of diseased plants.

(vii) Towards the beginning of June (in hills) and beginning of January (in plains), cut the haulms at the ground level. At this time, the crop also starts maturing. The cut haulms should not be left as such in the field. Ensure that there is no regrowth of stems after dahlumming as tender and succulent leaves are more attractive to the aphids.

(ix) Harvest the crop when the skin of the tubers has become firm. Harvesting is best done on sunny days. Heap the produce in shade for curing of skin and the heap is left undisturbed for 15-20 days. Sort out the infected tubers and grade them according to their sizes, preferably into four grades—small, medium, large, and extra large—depending upon their weight and diameter.

11. Seed treatment

After grading, wash the tubers in water then in 1% chloroform solution followed by rinsing in water and treating in 3% solution of boric acid for 30 minutes to control surface borne diseases. The once prepared solution can be used 20 times if the tubers have been thoroughly washed. After the treatment, ensure that the tubers are dried properly in shade. Pack the seed tubers in gunny bags with proper labeling for marketing as seed. Treated tubers being poisonous should not be used for table purpose.

Keep own seed from your produce. Such seed should be stored in wooden trays of convenient sizes or baskets or spread on floor in well ventilated rooms. To avoid tuber damage from tuber moth in the store, cover the potato tubers with a thin layer of dry sand and dust it with 1% malathion dust. Seed potatoes should be stored in gunny bags up to a particular period as thereafter it encourages development of etiolated and lanky sprouts. Only seed potatoes should be treated with malathion. Such treated potatoes should not be consumed.
PRODUCTION AND UTILIZATION OF TRUE POTATO SEEDS (TPS)

Potato is traditionally grown vegetatively through seed tubers. This results in continuous accumulation and increase of various tuber borne diseases in seed tubers and consequent reduction in crop yield. To maintain high yields, therefore, the potato varieties released from time to time need constant support of a well developed disease free seed production programme. This, however, puts a limit to the amount of availability of good quality seed produced in the country and also pushes up the cost of seed tubers. To overcome these problems, a new potato production technology making use of True Potato Seeds (TPS), instead of tubers for raising the crop, has been developed by Central Potato Research Institute (CPRI), Shimla and International Potato Center (CIP). This has also been under test in the All India Coordinated Potato Improvement Project. The results have shown that TPS could serve as a cheap and highly productive material for raising commercial potato crop, especially in areas where availability of good quality seed tubers at reasonable price is a major constraint in increasing potato production. The technology of potato production through TPS has been found suitable for adoption in all the potato growing areas of the country. TPS production is a specialised job which farmers cannot take up. Some State Govts. & NGOs are producing TPS in addition to CPRI. TPS may be obtained from them. Addresses of such organisations are given in this book.

CROP PRODUCTION USING TPS

Two methods of raising a commercial potato crop from TPS have been successful. These are.

A) Using seedlings as planting material

B) Using seedling tubers as planting material

Whereas, the first method is successful in regions where the winters are mild e.g. Assam & Tripura, the second method is successful in all the potato growing regions of the NE states.

A) Crop from transplanted seedlings

The procedure followed is as under:
**Preparation of nursery beds**

i) About 100-120 g TPS and a nursery bed of 50-60 sq m area is required for raising seedlings for transplanting in one hectare.

ii) Mark the nursery bed area keeping its breadth as 1 m and the length as per convenience.

iii) Bring the soil in nursery bed area to fine tilth. Provide about 10 cm high border around it using bricks or any other suitable and easily available local material to prepare the four walls of the seed bed.

iv) Prepare substrate for the seed bed by mixing sterilized soil and well rotten FYM or compost or bio-gas slurry in 1:1 ratio. Use a higher proportion of FYM for heavy soils. Add fertilizers @ 4-5 g N, 6-8 g P\textsubscript{2}O\textsubscript{5} and 10 g K\textsubscript{2}O/m² in the substrate and mix well.

v) Fill the lower 7-8 cm depth of the nursery bed with this substrate. Cover the top of nursery bed with 2-3 cm thick layer of sieved FYM. The height of the bed is thus raised to about 10 cm from the field level.

(In areas where brown rot is endemic, the seed bed should be raised by about 25-30 cm above the field level so that the seedlings do not root in the native infested soil)

**Seedling raising**

i) Sow the TPS early in the *rabi* season in the plains when the ground is fairly warm. Sow 300 seeds.

ii) The freshly extracted seed have a dormancy period of 5-6 months. Fresh seeds, therefore, need to be treated with dormancy breaking chemicals. For breaking the dormancy, soak the seeds in 2000 ppm Gibberellic acid (GA\textsubscript{3}) solution (prepared by dissolving 150 mg Gibberellic acid in a few drops of alcohol and made up to 100 ml by adding water) for 24 hrs.

iii) Remove the seeds from Gibberellic acid solution, wash/rinse with water and dry in shade.

iv) Though not essential, pre-germination of TPS before sowing it in nursery beds is recommended in plains to catch on time and ensure good seedling stand in the beds.
Fig. 1. Sequence (A, B & C) of seedling transplanting in field.
Symptoms of late blight on different plant parts

Fig. A: On leaves, Fig. B: On foliage, Fig. C: On stem,
Fig D: On tuber, Fig. E: Infected cut tuber.
Fig. A: Early blight on potato leaves
Fig. B: Leaf spots caused by *Phoma exigua*, Fig. C: Leaf spots caused by *Phoma sorghina*
Fig. A: Potato plant wilted due to bacterial wilt

Fig B: Brown rot infected tuber with bacterial ooze from an eye.

Fig C: Vascular ooze on cut tubers.
PLATE - 4

Fig. A: Black scurf on potato tuber. Fig. B: Potato tuber showing common scab. Fig. C: Powdery scab on potato tuber. Fig. D: Powdery scab on potato roots.
Fig. A: Primary leaf roll, Fig. B: Leaf roll secondary infection, Fig. C: Mild mosaic, Fig. D: Severe mosaic, Fig. E: Paracrinkel due to PVM, Fig. F: Apical leaf curl severe infection.
Fig. A: Cutworm, Fig. B: Cutworm damaged tubers, Fig. C: White grub damage on tubers, Fig. D: Epilachna grubs feeding on leaf, Fig. E: Epilachna adult, Fig. F: PTM damaged tubers
This is done by soaking the seeds in water for 24 hrs.,
mixing it with sieved FYM (in 1:2 ratio) and keeping the
mixture moist for next 4-5 days to a stage when the radicle
just starts coming out.

vi) Lightly irrigate the nursery beds a day before TPS sowing.
Hoe and level the beds next day to get the soil in proper
texture and moisture level for seed sowing.

vii) Sow the TPS either in 1/2 cm deep furrows drawn 10 cm
apart across the breadth of the bed or thinly broadcast the
seeds in nursery bed @ 2-3 g seeds/m² area and cover
them with about ½ cm thick layer of sieved FYM.

viii) Irrigate the seed beds using a sprayer or a Gardener’s
water-can ensuring that the soil is kept moist. The seeds
should not be dislocated from the place of sowing and there
should be no water run off.

ix) Irrigate the seed beds 3-4 times a day or as needed, for
about a week after TPS sowing, ensuring that the beds are
kept moist. Subsequently, spray water once or twice a day.

x) In areas where maximum day temperature is above 30°C,
protect the nursery beds from direct sunlight by providing
shade using hessian cloth cover from 10 a.m. to 5 p.m. for
next 15 days after TPS sowing. Remove the covers in the
evenings.

x) After the germination is complete and the leaves start
emerging, spray the seedlings every 2-3 days with 0.1%
urea (prepared by dissolving 1 g urea in 1 litre of water) till
they are ready (4-5 leaf stage) for transplanting. This stage
is reached after 20-25 days of TPS sowing.

Field preparation

i. Prepare the field by adding FYM @ 20 t/ha as in traditional
method for raising the potato crop, doing pre-sowing irrigation
(if necessary), ploughing and planking.

ii. Broadcast half the dose of nitrogen (the other half to be
given at earthing up) and full dose of P₂O₅ and K₂O, as per
recommendation for the region, at the last round of field
preparation and mix it in soil.
iii. Level the field and make about 20 cm high ridges 45-50 cm apart in East-West direction. Prepare long beds as these facilitate seedling transplanting. The beds can be subsequently divided into smaller units to facilitate irrigation. Provide a 45 cm broad path/irrigation channel after each bed.

**Seedling transplanting**

i. Do the seedling transplanting in the field in the evening only to reduce damage due to heat stress.

ii. Carefully remove the bare rooted seedlings from nursery beds and take them to the field in small baskets.

iii. Irrigate the furrows of two adjacent beds simultaneously, just before transplanting seedlings. Take care to fill only half of the furrow leaving the top 8-10 cm of the ridge dry.

iv. Transplant the seedlings immediately after irrigation, at 10 cm intra-row distance with the help of Khurpa (Hand hoe) at the water mark on northern side of the ridge. Place the roots of the seedlings in well moist soil. Plant only one seedling per hill. Transplant in two adjacent beds (both sides of irrigating channel) simultaneously (Fig. 1).

v. Give a second irrigation to the furrows immediately after transplanting. Irrigation and transplanting are successive operations and are to be done row by row.

vi. Irrigate the furrows every third/fourth day till the seedlings get established. The frequency of irrigation, thereafter, can be reduced to once in 8-10 days as per crop need, soil type and environment.

vii. Do earthing up after about 30-35 days of transplanting. Apply remaining half dose of nitrogen before earthing up which should be done in such a way that the seedlings come to lie in the centre of the ridge. Care should be taken to cover lowermost 2-3 nodes with soil.

viii. All subsequent cultural operations and plant protection measures may be taken as per standard cultivation practices for potato crop in the region.

ix. Stop irrigation at least 10 days before dehauling. Cut the 'haulms' of the crop on the date recommended for dehauling of the seed crop, if the produce is to be used for seed
purposes. Haulms need not be cut if the produce is to be used for table purposes.

Grade and select the tubers of 10 to 40 g size for use as seed next year. The large size (>40 g) tubers may be disposed off for table purposes. Soak the seed tubers in 3% boric acid solution for 30 min., dry in shade and store in a cool place.

B. Crop from seedling tubers

The method involves two major steps viz seedling tuber production and the crop production using seedling tubers as planting material.

B-1. Seedling tuber production

The seedling tubers can be produced in field by transplanting seedlings as per method detailed in section A. Since this method is successful only in few regions, an alternate method of seedling tuber production in nursery beds, found successful in all potato growing regions, has been developed.

Seedling tubers in nursery beds can be produced by two methods.

Method I

In this method the seedlings are raised in primary nursery beds and subsequently transplanted in secondary (Production) nursery beds for tuberization. This method is suitable for warmer regions (e.g. Assam and Tripura plains) where the recovery of seedlings from transplanting shock and their subsequent growth is fast. Various steps involved in producing seedling tubers by this method are as under

i) About 40 g TPS and 300 m² nursery bed area are required for producing enough seedling tubers for planting one hectare area the next year.

ii) Prepare the primary nursery beds and raise seedlings up to 4-5 leaf stage as detailed in Section A above.

iii) For preparing nursery beds, mark the nursery bed area keeping its breadth as 1 m and the length as per convenience.

iv) Remove the top soil up to a depth of 20-25 cm from the marked nursery bed area.
(In brown rot endemic areas the level of nursery beds should be raised by about 25 cm by providing borders all around it and filling the space with the substrate prepared as explained below)

v) Prepare substrate for the nursery bed by mixing sterilized soil and well rotten FYM or compost or bio-gas slurry in 1:1 ratio. Use a higher proportion of FYM for heavy soils. Add to the substrate and mix, basal dose of N, P and K as per recommendation for the potato crop in the region.

vi) Fill the nursery bed pit up to a height of 10 cm with this substrate mixture.

vii) Flood irrigate the nursery bed. Remove the seedlings from the primary nursery beds and transplant bare rooted seedlings in the production nursery beds as soon as the proper moisture of substrate is attained/arrived. Keep the inter and intra row distance between the seedlings at 10 cm x 10 cm.

viii) Give light irrigation with water-can on fourth or fifth day.

ix) Follow usual cultural and plant protection measures. Give further irrigations by flood method as and when needed.

x) When the seedlings become 15-20 cm tall cover the lower most 3 nodes of the seedlings with additional substrate mix (applied in 2-3 applications).

xi) Stop irrigation about 10 days before haulm cutting. Cut the haulms on the dates recommended for seed crop in the area.

xii) Harvest the seedling tubers after about 12-15 days of haulm cutting.

xiii) Grade the tubers. Treat them by soaking in 3% boric acid solution for 30 minutes, dry and store for use as seed in the following season.

Method II

i. Prepare the production nursery beds by following the steps iii to v as above.

ii. Sow the TPS in the plains early in rabi season when minimum day temperatures start touching 20±2°C.
iii. Irrigate the nursery beds a day before sowing of TPS. The seeds can also be pre-germinated before sowing as per method detailed in section A above.

iv. Mark rows in the nursery beds at 10 cm inter-row distance. Sow 2-3 seeds at 10 cm intra-row distance at a depth of 0.5 cm and cover them. It will be useful if a marker is prepared for providing 0.5 cm deep holes at 10 cm x 10 cm spacing.

v. Irrigate the seed beds using a sprayer or water-can ensuring that the soil is kept moist without any run off of water.

vi. Provide shade over the nursery bed area from 10 a.m. to 5 p.m if the day temperatures are above 30°C for the next 15 days after TPS sowing. Leaf or straw mulch can also be used to protect the beds from direct sunlight. This will hasten the germination by conserving moisture and reducing soil temperature.

vii. Irrigate the seed beds 3-4 times a day for about a week after sowing. Subsequently, spray water once or twice a day and keep the nursery beds moist.

viii. Spray the seedlings with 0.1% urea (prepared by dissolving 1 g urea in 1 litre of water) on every third or fourth day, starting after 15 days of emergence.

ix. When the seedlings attain a height of about 15 cm, cover the lower most 3 nodes of the seedlings with additional substrate mix (applied in 2-3 applications). Repeat the earthing up three times at intervals of 7-8 days.

x. Follow usual cultural practices like flood irrigation, weeding, etc.

xi. Stop irrigation and cut the haulms on the dates recommended for seed crop in the area.

xii. Harvest the seedling tubers after about 12-15 days of haulm cutting.

xiii. Grade the tubers in four grades viz. below 5 g, 5-10 g, 10-20 g and above 20 g. Treat them by soaking in 3% boric acid solution prepared by dissolving 30 g boric acid in 1 litre water for 30 minutes, dry and store for use as seed in the following season.

xiv. Plant the seed of below 5 g size in production nursery beds next year. Use other grades for planting in field.
**B-2 Crop production in field**

i) Use the seedling tubers produced in the previous crop season as seed for raising the crop for ware use.

ii) For mechanical cultivation, keep the inter-row distances at 60 cm and for manual cultivation at 45 to 50 cm. Keep the intra-row distance (plant to plant distance in a row) according to the tuber size given below:

<table>
<thead>
<tr>
<th>Seed size (g)</th>
<th>Manual cultivation</th>
<th>Mechanized cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spacing (cm)</td>
<td>Approx. seed rate (q/ha)</td>
</tr>
<tr>
<td>20-40</td>
<td>45-50 x 20</td>
<td>30-33</td>
</tr>
<tr>
<td>10-20</td>
<td>45-50 x 15</td>
<td>20-22</td>
</tr>
<tr>
<td>5-10</td>
<td>45-50 x 10</td>
<td>15-17</td>
</tr>
</tbody>
</table>

iii) Follow all the cultural and manurial practices for raising the crop as recommended for the region

iv) Follow the seed plot technique viz., timely spray of insecticides and haulm cutting before the critical level of aphids is reached in the crop, if the produce is to be used for seed purposes. In traditional areas of seed production (e.g., Assam & Tripura plains), the produce can be retained as seed for another 3-4 years if seed plot technique is followed strictly.

**TPS source**

Besides, Central Potato Research Institute and its stations at Shillong, Patna, Modipuram, TPS can be obtained from:

1. Director, Horticulture, Govt. of Tripura, Agartala-799001
2. Economic Botanist-III, West Bengal Agriculture Directorate, Mission Compound, Midnapore-721001
3. Director, Horticulture, Govt. of Karnataka, Lal Bagh, Bangalore-560004

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For further information, contact

Head,
Central Potato Research Station, Shillong 793 009, Meghalaya
Phone: 0364-2560885, Fax: 2560097
Gram: POTATOSEARCH, SHILLONG-9

or

Director
Central Potato Research Institute, Shimla 171 001, H.P.
Phone: 0177-2625073, Fax: 2624460
Gram: POTATOSEARCH, SHIMLA-1

E mail: director@cpri.hp.nic.in
Web site: http://cpri.hp.nic.in
ANNEXURE-I

Area (000 ha), Production ('000 tonnes), Yield (q/ha) and per capita availability (kg/year) of potato in North Eastern States (2000-2001)

<table>
<thead>
<tr>
<th>States</th>
<th>Area (000 ha)</th>
<th>Production ('000 tonnes)</th>
<th>Yield (q/ha)</th>
<th>Per capita availability (kg/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arunachal Pradesh</td>
<td>4.8</td>
<td>324</td>
<td>680</td>
<td>29.7</td>
</tr>
<tr>
<td>Assam</td>
<td>80.5</td>
<td>677.3</td>
<td>84.1</td>
<td>25.4</td>
</tr>
<tr>
<td>Manipur</td>
<td>2.6</td>
<td>13.7</td>
<td>52.7</td>
<td>5.7</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>20.0</td>
<td>181.6</td>
<td>90.9</td>
<td>78.7</td>
</tr>
<tr>
<td>Mizoram</td>
<td>0.3</td>
<td>2.4</td>
<td>80.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Nagaland</td>
<td>4.5</td>
<td>47.9</td>
<td>106.4</td>
<td>24.1</td>
</tr>
<tr>
<td>Tripura</td>
<td>5.5</td>
<td>96.3</td>
<td>175.1</td>
<td>30.18</td>
</tr>
<tr>
<td>Sikkim</td>
<td>6.2</td>
<td>25.5</td>
<td>41.1</td>
<td>47.18</td>
</tr>
<tr>
<td>State</td>
<td>Location</td>
<td>Altitude (m)</td>
<td>Area (sq/km)</td>
<td>Temperature range (°C)</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------</td>
<td>--------------</td>
<td>--------------</td>
<td>------------------------</td>
</tr>
<tr>
<td></td>
<td>(Lat)</td>
<td>(Long.)</td>
<td></td>
<td>Minimum Maxime</td>
</tr>
<tr>
<td>Arunachal</td>
<td>25°32' - 29°30'N</td>
<td>91°51' - 97°31'E</td>
<td>150-7300</td>
<td>0          35</td>
</tr>
<tr>
<td>Assam</td>
<td>24°15' - 25°45'N</td>
<td>89°75' - 97°32'E</td>
<td>100-200</td>
<td>10-22       28-40</td>
</tr>
<tr>
<td>Manipur</td>
<td>25°50' - 25°41'N</td>
<td>93°02' - 94°47'E</td>
<td>833-3017</td>
<td>5          32</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>25°71' - 26°71'N</td>
<td>89°47'</td>
<td>200-1500</td>
<td>0          27</td>
</tr>
<tr>
<td>Mizoram</td>
<td>22°15' - 24°30'N</td>
<td>92°20' - 92°09'E</td>
<td>30-2210</td>
<td>8          30</td>
</tr>
<tr>
<td>Nagaland</td>
<td>25°60' - 27°40'N</td>
<td>93°20' - 95°15'E</td>
<td>110-2630</td>
<td>5          35</td>
</tr>
<tr>
<td>Tripura</td>
<td>22°56' - 24°32'N</td>
<td>90°10' - 92°21'E</td>
<td>28-790</td>
<td>13         35</td>
</tr>
<tr>
<td>Sikkim</td>
<td>27°1' - 28°4'N</td>
<td>87° - 88°3'E</td>
<td>*</td>
<td>4          32</td>
</tr>
</tbody>
</table>

* Exact figure could not be traced out. Height of Gangtok is about 3,800 m. Some mountains are above the height of 7000 m.
## Optimum planting and harvesting time in different parts of NE region

<table>
<thead>
<tr>
<th>Height above Sea level</th>
<th>Planting time</th>
<th>Harvesting time</th>
<th>Part of NE region</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plans' (upto 500 m)</td>
<td>Sept-Oct</td>
<td>Jan-Feb</td>
<td>Assam, Tripura, Manipur valley Dimapur district of Nagaland and lower parts of Arunachal Pradesh</td>
<td>Irrigation is necessary for good crop growth</td>
</tr>
<tr>
<td>Mid-hills (upto 1500 m)</td>
<td>Feb-March</td>
<td>End June to end July</td>
<td>Siang district (Basar area) of Arunachal Pradesh, Jowai sub division of Jainta hills, some areas in Khasi hills</td>
<td>Rainfed crop</td>
</tr>
<tr>
<td>High hills (upto 2400 m)</td>
<td>Mar-April</td>
<td>July-August</td>
<td>Parts of Arunachal Pradesh, Upper Shillong, Mawphlang and Mairang area of Meghalaya, Mao and Ukrl area of Manipur, Blue Mountains in Mizoram</td>
<td>Rainfed crop</td>
</tr>
<tr>
<td>Very high hills (above 2400 m)</td>
<td>-do-</td>
<td>-do-</td>
<td>Tawang, Se la upper Subansin, Siang and Kameng districts of Arunachal Pradesh</td>
<td>Rainfed crop</td>
</tr>
</tbody>
</table>
### Common diseases and pests

<table>
<thead>
<tr>
<th>Common name and pathogen</th>
<th>Symptoms</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diseases:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late blight (Phytophthora infestans)</td>
<td>Water soaked lesions and white cottony growth on lower surface of leaves, light brown elongated lesions on the stem and petioles which may encircle the stem, reddish brown, shallow to deep, dry rot lesions on the tubers, affected tuber flesh becomes 'caramelized' with a sugary texture, frequently metallic tinge develops on the margins of the affected tissue (Plate-1, figs A to E)</td>
<td>Resistant varieties-Kufri Megha, K Giriraj, K Jyoti, K Kankan, use of disease free seeds preferably from disease free area/field, prophylactic spray with 0.2% mancozeb as soon as the weather becomes congenial for disease development (temp 10-20°C, RH &gt; 80%), subsequent sprays at 8 days interval, alternative use of metalaxyl based fungicides viz Ridomil MZ 0.25%, haulms cutting at 75% disease severity</td>
</tr>
<tr>
<td>Early blight (Alternaria solani)</td>
<td>Initially the symptoms occur on the lower and older leaves in the form of small (1-2 mm), circular to oval. brown spots which have the tendency to become large and angular at later stage. Mature lesions on foliage look dry and papery and often have the concentric rings, looking like 'bulls' eye (Plate-2, fig A). Tuber symptoms comprise brown, circular to irregular and depressed lesions with underneath flesh turning dry. brown and cory. Lesions tend to enlarge during storage and affected tubers become shriveled.</td>
<td>Spray of mancozeb 2 kg/ha. Number of sprays according to disease intensity, balanced doses of fertilizers, especially nitrogen, disease free seed, destruction of affected foliage</td>
</tr>
<tr>
<td>Leaf spots (Phoma spp.)</td>
<td>Necrotic lesions of various shapes and sizes on the leaves. Leaf spots due to Phoma exigua are larger, 1</td>
<td>Spray of mancozeb 2 kg/ha. Number of sprays according to disease severity, Application of balanced</td>
</tr>
</tbody>
</table>

(Continued...)
<table>
<thead>
<tr>
<th>Common name and pathogen</th>
<th>Symptoms</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial wilt and brown rot (<em>Ralstonia solanacearum</em>) previously (<em>Pseudomonas solanacearum</em>)</td>
<td>Drooping of leaves leading to complete wilting, vascular browning of tuber with white slimy bacterial ooze (Plate-3, figs A, B &amp; C).</td>
<td>Crop rotation with maize and cereals, earthing up at planting time, use of disease free seed, application of stable bleaching powder @ 12 kg/ha mixed with fertilizer in furrows while planting. Deep ploughing of the fallow fields.</td>
</tr>
<tr>
<td>Black scurf (<em>Rhizoctonia solani</em>)</td>
<td>Sprout killing cankers in the underground parts and scurf (brown to black sclerotial bodies on tubers) (Plate-4, fig A)</td>
<td>Tuber treatment with Organomercurinal compound (OMC) (0.25-0.5%) for 30 minutes or with 3% borax acid for 30 minutes. Crop rotation with cereals, deep ploughing in fallow fields, use of disease free seed.</td>
</tr>
<tr>
<td>Common scab. (<em>Streptomyces</em> spp)</td>
<td>Rough skin, deep pits, raised brown to black, corky pustules which may be ‘star’ shaped or irregularly circular (Plate-4, fig B)</td>
<td>Same as in case of black scurf.</td>
</tr>
</tbody>
</table>

(Continued Annexure-IV)
<table>
<thead>
<tr>
<th>Common name and pathogen</th>
<th>Symptoms</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powdery scab (Spongospora subterranea)</td>
<td>Initially raised pimple like pustules, later forming cavities filled with spore mass and surrounded by loose skinning. The spots may be isolated, crowded or even coalesced. Small galls some time occur on the roots of affected plants (Plate-4, fig C &amp; D)</td>
<td>Tuber treatment with OMC (0.5%) for 15 minutes</td>
</tr>
<tr>
<td>Potato leaf roll (PLR)</td>
<td>Primary symptoms are confined to top young leaves, which usually stand up right, roll and turn slightly pale/reddish/pink (Plate 5, fig A). Secondary symptoms develop when plants are grown from infected seed tubers. Such symptoms are rather prominent in older leaves. Infected plants have characteristic pale, dwarfed and upright appearance with rolling of lower leaves that turn yellow, brittle and are leathery, in texture (Plate 5, fig B)</td>
<td>Plant virus free seed potatoes; multiply virus free seed only in aphid free areas/periods coupled with practices for ensuring sanitation, roguing of infected plants, if any and dehauling the crop as soon as the vector aphid populations exceed critical limit of 20 aphids per 100 compound leaves, build-up of incoming aphid vectors be controlled by application of suitable contact/systemic insecticides</td>
</tr>
<tr>
<td>Potato mosaics</td>
<td>Different types of mosaic symptoms are seen on potato foliage due to single or multiple infection of PVX, PVA, PVM and PVY. PVS is generally symptomless. PVX and PVA may cause mild mosaic in single infection (Plate-5, fig C). PVY generally causes a rugose mosaic comprising mosaic and rugosity of leaves. PVX in combination with PVA and or PVY causes very severe symptoms comprising mosaic, stunting, veinal necrosis,</td>
<td>Strict sanitation in the field and also in stores, right from harvest to planting. Disinfect all field equipments by dipping in or washing with 3% Inosodium phosphate or calcium hypochlorite (1% solution), planting of disease-free seed stocks from approved or reliable sources, use of resistant varieties, if available, roguing of diseased plants along with their tubers and disposing them away from the field at least twice during the</td>
</tr>
</tbody>
</table>
(Continued Annexure-IV)

<table>
<thead>
<tr>
<th>Common name and pathogen</th>
<th>Symptoms</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato Apical Leaf curl (PALCV)</td>
<td>Apical leaf curl symptoms in potato comprised curling and bunchedness of apical leaves along with mosaic and chlorosis (Plate-5, fig F)</td>
<td>Use of disease-free seed, sanitation, roguing of the diseased plants, control of the vector (white flies) by spraying suitable insecticides like Confidor (0.1%).</td>
</tr>
<tr>
<td>Pests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Aphid, <em>Myzus persicae</em>, <em>Aphis gossypii</em></td>
<td>Adult and nymphs suck sap from potato fields. Leaves curl downward, turn yellow, also transmit potato viurs Y. (PVY) PVA and leafroll (PLRV)</td>
<td>Apply phorate 10G @ 10kg/ha at planting, Spray the crop in the initial stage with Thiomethoxam WG @ 100 gm/ha</td>
</tr>
<tr>
<td>ii) White flies, <em>Bemisia tabaci</em></td>
<td>Nymphs and adults damage by sucking sap, leaves turned sticky due to secretion of honey dew and ultimately dries up. Also transmits gemini viruses</td>
<td>Spray the crop in later stages once or twice with Imidochlopnd (confidor) @ 400 gm/ha</td>
</tr>
<tr>
<td>Soil pests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Cutworm, <em>Agrotis ipsilon</em>, <em>A segetum</em></td>
<td>Caterpillars in the initial stage of the crop damage the plants by cutting them at base during nights. After tubersensation they feed on tubers by making deep circular holes (Plate 6, Fig. A &amp; B)</td>
<td>Spray the crop and drench the ridges with chlorpyrifos 20 EC @ 2.5 lit/ha in 1000-1200 lit of water in the initial stage</td>
</tr>
</tbody>
</table>

(Continued...)
(Continued Annexure-IV)

<table>
<thead>
<tr>
<th>Common name and pathogen</th>
<th>Symptoms</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii) White grubs, <em>Brahminia conacea</em>, <em>H longipennis</em></td>
<td>Grubs, mainly II &amp; III instar feed on potato tuber and make large and circular holes. Tuber becomes unfit for marketing (Plate 6, Fig C)</td>
<td>Repeat the spray at later stage (in hills) with the onset of monsoons. Same as for cutworms.</td>
</tr>
<tr>
<td>ii) Red ants, <em>Dorylus orientalis</em></td>
<td>Workers of red ants feed on potato tubers by nibbling and making small but deep circular holes</td>
<td>Same as for cutworms</td>
</tr>
</tbody>
</table>

**Defoliators**

1) *Eplachna beetle, Henosephelachna ocellata & H vigintioctopunctata*  
   Caterpillars feed on the foliage by making large circular holes and sometimes feed on the entire leaf | Spray the crop with any contact insecticide (viz Endosulfan or carfynyl @ 15 lit or 2.0 kg/ha) or Chemical recommended for the control of vectors and soil pests will take care of defoliators pest also |

2) *Gram pod borer, Heliothis armigera* and *Pea Semiloapor, Plusia onchalea*  
   The adult and grubs voraciously feed on leaves by scraping chlorophyll resulting in pre-mature destructions of foliage (Plate 6, Fig D & E) | |

**Potato Tubermoth, Phthornimaea operculiella Zeller**  
   Newly hatched larvae feed on the foliage or stems by mining them with the result leaves and stem dried up. On tubers they make tunnel inside the tuber and feed on pulp. Due to the secondary infection by bacteria or fungi tuber generally rots (Plate 6, Fig F & G) | In fields on the appearance of the pest spray the crop once with Monocrotophos 40 WSC @ 1.2 lit/ha dissolved in 700-800 lit of water/ha or with Bi 300 gm/ha alternatively. In stored use `Lantana` or *Eucalyptus* leaves for covering the stored tubers or use pheromone traps for mass trapping the adult male moths. Maintain proper sanitation in fields and stores. |