PRACTICAL MANUAL

POTATO AND TUBER CROPS

B.Sc. (Hons.) Horticulture

Semester : II[nd] (New)

Course No.: H/VS-121
Credits : 2 (1+1)

College of Horticulture

Vasantrao Naik Marathwada Krishi Vidyapeeth
Parbhani-431 402

VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH,
PARBHANI-431 402

PRACTICAL MANUAL

PREPARED AND COMPILED BY

Dr. A.S. Lohakare,
Assistant Professor,
College of Horticulture, VNMKV, Parbhani.

PUBLISHED BY

Dr. G.M. Waghmare
Associate Dean and Principal
College of Horticulture, VNMKV, Parbhani.

College of Horticulture, VNMKV, Parbhani

COLLEGE OF HORTICULTURE,
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH, PARBHANI

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Reg. No._____ a student of II[nd] semester **B.Sc. (Hons.) Horticulture has completed all the exercises successfully for the** Course: **Potato and Tuber Crops,** Course No. **H/VS-121** during the **academic year**_____.

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SN.	Name of crop	Family	Botanical Name	Season of planting	spacing	Seed rate per ha	Varieties	Yield (t/ha)
1.	**Potato** 2n = 4X = 48 (Octaploid) Origin South America	Solanaceae	*Solanum tuberosum* L.	June-July *(Kharif)* and Sept-Oct *(Rabi)*	45 x 30 cm	Large size-25-30 q/ha Medium size-15-20 q/ha Small size-10-15 q/ha	**Newly released** Satha, Gola, Up-to-date, Phulva, Great Kufri Neelmani, Kufri Sheetman, Kufri Alankar, Kufri Jeevan, Kufri Moti, Kufri Lavkar and Kufri Dewa.	Early var 20 t/ha Late var 30 t/ha.
2.	**Sweet potato** 2n = 90 Origin Tropical America	Convolvulaceae	*Ipomoea batatas* L.	June-July *(Kharif)* for rainfed crop and Oct-Nov under irrigated conditions.	60X 30 cm	60,000-70,000 vine cuttings	Varsha, KonkanAshwini, SreeNandini, SreeVardhini, Samrat, SreeRatna, SreeBhadra, Sree Arun, Sree Varun	Irrigated 35-40 t/ha Rainfed 8-10 t/ha
3.	**Cassava** 2n = 2x = 36 Origin- Brazil	Euphorbiaceae	*Manihot esculenta* L.	Best time of planting is December-January (*Rabi*) but planting can also be done during *kharif* season	Non branching vars 75x75 cm Branching or semi-branching vars. 90x90 cm.	50,000 minisetts	H-97, H-165, H-226, Sree Sahya, Sree Vaisakham, Sree Prakash, Sree Harsha, Sree Jaya, Sree Vijaya, M-4, Sree Rekha, Sree Prabha, Nidhi, Kalpaka and CO-1, CO-2 & CO-3.	Short duration vars. 25-30 t/ha Long duration vars. 30-40 t/ha
4.	**Colocasia** *2n = 2x=28,42* Origin *South East Asia (SEA)*	Araceae	*Colocasia esculenta* L.	June-July *(Kharif) and Rabi*	60x45 cm or 60x30 cm.	Corms 7-10 q/ha	Sree Rashmi, Sree Pallavi, Sree Kiran, Bilaspuri Arum, ML1, ML 9 and Konkan Ghorkand	60-62 q/ha.

5.	**Xanthosoma** *2n = 26*	Araceae	*Xanthosoma sagittifolius* L.	June-July	1x1 mt	Corms and cormels 7-10 q/ha	Konkan Haritparni	60-62 q/ha
6.	**Amorphophallus** *2n = 28* Origin Western Africa	Araceae	*Amorphophallus paeoniifolius*	*Summer* and *Kharif*	90 x 90 cm for harvesting large size tubers. 60 x 60 cm for harvesting small to medium sized tubers.	Tubers or tuber pieces of about 1 kg are used for planting.	Sree Padma, Gajendra	50-60 t/ha.
7.	**Greater yam** 2n=40	Dioscoreaceae	*Dioscorea alata*	March –April (*Summer*)	90x90 cm.	The cut tuber pieces2.5-3.0 t/ha.	Sree Keerthi, Sree Roopa, Indu, Sree Shilpa, Sree Prakash and Sree Karthika.	20-25 t/ha.
8.	**Lesser yam** Origin- South Asia 2n=40	Dioscoreaceae	*Dioscorea esculenta*	March –April (*Summer*)	75x75 cm	The cut tuber pieces 1.8-2.7 t/ha.	Sree Latha , Dapoli-1 and Sree Kala.	20-25 t/ha.
9.	**Aerial yam**	Dioscoreaceae	*Dioscorea bulbifera*	March –April (*Summer*)	--	40 kg corms/ha.	Local- Black type, Greyish white type	3 - 5 t/ha.
10.	**Yam Bean** 2n=22	Fabaceae	*Pachyrrhizus erosus* L.	June-July	100 x 75 cm	Propagated by seed.3-5 seeds are sown per hill.	Rajendra Mishrikand	36-40 t/ha.

11.	**Chinese Potato** Origin- Africa	Labiatae	*Solenostemon rotundifolius*	*Kharif*	45x30 cm	Propagated by10-15 cm long vine cuttings.	Sree Dhara, Nidhi	25-27 t/ha.
12.	**Jerusalem Artichoke** 2n=102 Origin - Central and South America	Asteraceae (Compositae)	*Helianthus tuberosus*	July- August	60x30 cm or 90x45 cm.	Propagated by tubers or tuber pieces weighing 50g with 2-3 eye buds.	--	--
13.	**Horse Radish** 2n = 32	Brassicaceae	*Armoracia rusticana*	*Kharif*	--	Propagated by root cuttings or crown.	--	--

STUDY OF VARIOUS PROPAGATION METHODS IN TUBER CROPS

METHODS OF PROPAGATION IN POTATO

- Potato is propagated through tubers which have a dormancy of 8-10 weeks.
- Eyes on surface of tubers have axillary buds. Sprouted tubers when used for planting put up fast and vigorous growth.
- To increase sprouting, tubers are taken out from cold storage 10-15 days before planting and kept in pre-cooling chamber for 24 hours. It is then spread in cool and shady places to sprout.
- Planting of tubers of 40 g size at 60 x 20 cm spacing results in optimum stem number.
- If tuber size is increased or decreased, intra-row spacing is adjusted accordingly.
- Seed accounts for nearly 40% cost of potato cultivation. Use of large tubers is more expensive and hence, tubers are cut into pieces, each containing at least one eye.
- Use of cut tubers is not recommended as it enhances chance of transmitting viral and bacterial diseases.
- When cut tubers are used, it is kept at 10-15°C and 85-90% RH for 4-6 days to allow tuberisation and wound periderm formation before planting.

True Potato Seeds (TPS)

- Nearly 40% of total production of potato cultivation is for seed tubers.
- Bulky nature of tubers is a problem for transportation and it increases seed cost considerably.
- Transmission of viral diseases through tubers is another disadvantage.
- To avoid above bottle-necks, the concept of true potato seed (TPS) was evolved.
- Inadequate supply of seed tubers at an affordable cost to distant places is overcome by using TPS as planting material.
- TPS is required only in a small quantity, 100-150 g/ha compared to 10-15q/ha by tubers.
- TPS is free from viral diseases and by using TPS, storage loss of seed tubers can be avoided.
- In spite of great expectations, the TPS has not become popular due to heterogeneous nature of progenies and practical difficulties in crop raising.
- This is currently employed for development and exchange of varieties among research institutes.

SWEET POTATO

Sweet potato is propagated through stem or root cuttings or by adventitious roots called slips that grow out from tubers during storage. 60000-70000 vine cuttings, 25-30 cm long, are sufficient for one hectare. At planting, half of the length of the cutting is buried in the soil.

Tubers

- Medium sized healthy tubers free from disease, pests and bruises are planted in nursery (Primary) at 5 to 10 cm depth with 60x25 cm spacing.
- Sprouts are cut after 40-45 days and planted in secondary nursery.
- Cuttings of 20-30 cm length planted at 60x 25 cm in main field.
- Sufficiently grown vines are used to make cuttings for main field preparation.
- A mature tuber produces 5-7 sprouts and 100kg tubers produces 7000 shoots.
- For one hectare 250 kg tubers, 100 m^2 primary nursery, and 500 m^2 secondary nursery area are needed.
- Sweet potato is mainly propagated by vine cuttings of 25-30 cm length. Micro propagation also being followed.

CASSAVA

Preparation of Sets

- Stem cuttings, usually called as sets, for planting are taken from disease free stakes of 8-10 months maturity having a thickness of 2-3 cm diameter.
- Discard woody basal portion and tender top portion of stem.
- Prepare sets of 15-20 cm length with a smooth circular cut at the base and slanting cut at top for easy identification of base and top.
- The circular cut at base ensures uniform callus formation and root initiation.
- Sets prepared from stem stored for 15 days with leaves give better sprouting.
- Planting of cassava can be done by using two node cuttings (mini setts), developed by CTCRI, Trivandrum, Kerala

COLOCASIA

It is propagated vegetatively either from side suckers, small unmarketable corms of 20-25 g or from cut pieces of large corms. It is recommended to pre-sprout the corms in a nursery before planting in the field. 7-10 quintals of healthy corms are sufficient to plant one hectare. Under rainfed and limited irrigation conditions, planting is done in beginning of the rainy season. If the soil is deep and friable, the planting is done on the flat beds. Otherwise ridge planting is recommended at 60x45 cm or 60x30 cm distance.

XANTHOSOMA

In tannia, mother corm is more or less cylindrical and surrounded by cormels which develop from lateral buds adjacent to leaf scars on the corm similar to taro, mother corms and cormels are used for planting. Since plants grow vigorously, tannia is widely spaced at 1 x I m.

AMORPHOPHALLUS

Elephant foot yam has dormancy period of 3-7 months. Tubers or tuber pieces of about 1 kg are used for propagation. Corms harvested during November are stored in well ventilated rooms. Before planting during February, the corm is cut into sets of 750-1000 g. each bearing a portion of central bud. Cut corms are smeared with cow dung slurry or wood ash and allowed to dry in partial shade.

GREATER AND LESSER YAM

It is propagated through cut tuber pieces and planted in the middle of the pits. Completely covered with leafy materials to conserve moisture and maintain optimum temperature.

YAM BEAN

Yam bean is propagated through seed. Seeds 3-5 per hill are sown at 75x100 cm distance during June-July.

CHINESE POTATO

It is propagated by vine cuttings. Raise a nursery 45 days before planting on 500 m^2 area to produce vines for 1 ha area. Incorporate well decomposed FYM and prepare ridges or beds. Healthy tubers having 15-20 g weight may be planted. About 75-100 kg tubers will be required for 500 m^2 area. After 3 weeks of planting, top dressed 5 kg urea for vigorous growth of vines. Clip off terminal portion of 10-15 cm length vines at 45 days after planting. Plant the vines into the main field at 45x30 cm distance.

JERUSALEM ARTICHOKE AND HORSE RADISH

Jerusalem artichokeis propagated by tubers or tuber pieces weighing 50g with 2-3 eye buds whereas horse radish propagated by root cuttings or crown.

FIELD PREPARATION AND PLANTING OF SWEET POTATO, POTATO

POTATO

Field Preparation

- During April-May, field is ploughed to a depth of 20-25 cm by one or two deep ploughing followed by turning and land is left for some time.
- Before planting, farmyard manure is incorporated in soil and sloppy land is leveled and prepares flat beds on leveled land.
- Ridge planting is more common.
- Ridges and furrows are made either manually or mechanically.
- In mechanical method, furrows are made with help of 2-4 row maker-cum-fertilizer drill for applying fertilizers also in one sequence.
- This is followed by planting of tubers with help of 2-4 row planter-cum-ridgers.
- After application of fertilizers, ridges are also made with tractor drawn ridger and tubers are dibbled 5-7 cm deep on ridges.
- When bullock drawn implements are used, field is marked with rope or marker and fertilizers and tubers are placed on line and ridges are made.
- In all methods, utmost care is taken to avoid direct contact of tubers with fertilizer.

Planting of Potato Tubers

The seed requirements for a hectare on the basis of seed size are given below:

Size	Seed rate per ha.
Large size	25-30 q/ha
Medium size	15-20 q/ha
Small size	10-15 q/ha

Potato is mainly planted by two methods:

I) Ridges and furrow method

- In this method, the ridges are prepared.
- The length of the ridges depends on slope of the plot.
- Too long ridges and furrows are not supplied irrigation water conveniently.

II) Flat Bed Method

- In this method, the whole plot is divided into beds of convenient length and width.
- The shallow furrows are opened and potato tubers are planted at recommended distance.
- The tubers are covered with the original soil of furrows.
- When germination is completed and plants become 10 to 12 cm height, earthing should be done.
- Suitable plant spacing in relation to potato seed grades are given below

Diameter of tuber from longer axis	Planting distance (row x seed)
2.5 -3.5 cm	50 x 20 cm or 60 x 15 cm
3.5 -5.0 cm	60 x 25 cm
5.0 -6.0 cm	60 x 40 cm

Planting Time

In Plains

Early Crop: Third week of September to first week of October.
Main crop: First week of October to third week of October.
Late Crop: Third week of October to first week of November

In Hills

Potatoes are planted in hills from the third week of February to second week of April.

In Plateau Regions

Maharashtra, Karnataka Bihar and Madhya Pradesh, potato is raised in rainy(June-July) and winter seasons(September-October).

SWEET POTATO

Raising Nursery

- Sweet potato is mainly propagated by vine cuttings of 25-30 cm length.
- Cuttings for planting are multiplied in two nurseries - primary and secondary.
- Tubers in primary nursery are planted three months ahead of planting.
- A nursery area of 100 m^2 is required to raise vines for planting one hectare.
- Ridges are prepared at 60 cm apart and tubers of 125-150 g weight are planted at 25 cm spacing.
- 1.5 kg urea is applied at 15 days after planting and irrigate as and when required.

- Clip off vines to a length of 20-30 cm at 40-45 days after sowing tubers for planting in secondary nursery.
- A 500 m^2 secondary nursery is required to plant cuttings obtained from 100 m^2.
- Plant the cuttings at 25 cm apart in ridges taken at a spacing of 60 cm.
- 5 kg urea may be applied at 15-30 days after planting in secondary nursery.
- Clip off cuttings in 20-30 cm length after 45 days from middle and top portion of vines.
- Cut vines are stored with intact leaves in shade for two days prior to planting in main field. Vines are planted during June-July for a rainfed crop.
- Under irrigated conditions, plant during October-November in upland and during January-February in low lands for summer crop.

Preparation of main field and planting of vines

- Main field is prepared by making ridges of 25-30 cm height at 60 cm apart after thorough ploughing.
- 20-30 cm long vines are buried horizontally with 2-3 nodes below soil, leaving the remaining portion above soil.

Spacing and season of planting

Spacing: Planting of vines on ridges and furrows at 60x30 cm distance.
Season: In North India-February-March and September –October, Tamil Nadu- September, Kerla- September – December and May.

FIELD PREPARATION AND PLANTING OF AMORPHOPHALLUS, COLOCASIA

Field preparation and planting

Amorphophallus

Prepare pits of size 60 x 60 x 45 cm. Plant tubers at 90 x 90 cm for harvesting large size tubers or otherwise 60 x 60 cm distance maintained for harvesting small to medium sized tubers. Pits are half filled with top soil and well decomposed farmyard manure 2.0-2.5 kg/pit. Planting material is placed vertically in the pit. After planting of tubers, pits are covered with organic mulches like green leaves or paddy straw.

Colocasia

Depending on soil types and management practices, different methods of land preparation and planting are followed. In sandy loam, pit method is better while in alluvial soils raised mounds or beds or ridges are preferred. Ridges of 30 cm height are made. Mulching with green or dried leaves helps to hasten sprouting, controls weed growth, regulates soil temperature and retains soil. It is generally propagated by corms having20-25 g weight or cut pieces of large corms. About 7-10 q/ha corms are required for planting. Planting is to be done during June-July on flat beds or on ridges. Plant spacing is 60x45 cm or 60x30 cm.

FIELD PREPARATION AND PLANTING OF CASSAVA

Field Preparation

- Land is ploughed or dug properly for loosening soil to a depth of 20-25 cm. Depending on texture of soil and slope of land, mounds or ridges or raised beds are prepared.
- Mounds of 25-30 cm height are prepared in poorly drained soils.
- Ridges of 25-30 cm length are made in sloppy land for a rainfed crop and it should be leveled for irrigated crop. Ridges are taken across the slope and flat raised beds are taken in level lands having good drainage.
- Since cassava mosaic disease is a serious problem, care should be taken to select disease-free stakes for preparation of sets.

Planting

- Sets 25 – 30 cm length are planted vertically in beds, mounds or ridges to a depth of 5 cm.
- Care should be taken to avoid planting of sets inverted.
- Spacing depends on branching pattern of varieties.
- Normally erect and non-branching varieties are planted at 75 x 75 cm and branching or semi-branching varieties at 90 x 90 cm. In case, sets are dried after planting, 5% of stakes may be planted as reserve in field, separately at a closer spacing of 4 x 4 cm for gap filling after 20-25 days.
- As an irrigated crop, cassava can be planted during any part of year, but December-January planting is better.
- As a rainfed crop, planting is done during April-May before onset of South-West Monsoon and during September-October coinciding with North East monsoon.

Improved Techniques in Cassava developed by CTCRI, Trivandrum, Kerala

Planting minisets in nursery

- Furrows are made across the width of the bed with a khurpi or small hand hoe, about 5 cm deep.
- Two node cuttings are then planted in the furrow, end to end horizontally, with the buds facing either side.
- A spacing of 5 cm could be provided between two rows, minisetsareplanted in the furrow is then covered with a fine layer of soil: sand mixture.
- Tip portion minisetts and four node minisetts from the top tender portion of the stem must be planted vertically in the nursery rather than in horizontal position.
- This is because the chances of the tender minisetts getting decayed due to excess moisture are very high, if horizontally embedded in the soil.
- When vertically planted, a spacing of 5 x 5 cm could be adopted for facilitating growth of the minisetts.

Transplanting minisets to main field

- The minisetts will be ready for transplanting in about 3-4weeks time.
- Two to three fully opened leaves stage is the optimum time for transplanting.
- Uprooting minisetts from nursery beds could be done with the help of a khurpi, taking maximum possible care not to break roots.
- Prior to uprooting, the main field should be properly prepared. It should be thoroughly ploughed and brought to a fine tilth.
- About 12.5 t/ha of dry FYM is spread in the field.
- On an average, about 50,000 minisetts could be transplanted in 1 ha of land.
- It is very essential that the transplanting of minisetts must coincide with rainfall, if the crop is to be raised as a rainfed crop.
- If it is a dry period, unless irrigation is given the minisetts may not establish and would eventually dry off.
- Availability of moisture in the field must be ensured till the transplanted minisetts are established.

Planting material

On harvest from a hectare, about 60,000 cassava stems and 75 to 80 tons tuber could be obtained by adopting miniset technique, whereas, in the traditional production system, about 24,000 stems and 30 t/ha of tubers could be obtained. If minisets technique is adopted for further multiplication, then minisets for planting 50 - 60 ha could be obtained in the next generation. Multiplication ratio in cassava planting material by this process is enhanced to 1:70 from the traditional 1:10.

FIELD PREPARATION AND PLANTING OF AERIAL YAM AND LESSER YAM

AERIAL YAM

Land preparation: The land is ploughed up to 15-20 cm depth. The pits of 45x45x45 cm size to be dug at a distance 90x90 cm. The 3/4th of the pits are filled with 1.0-1.25 kg cattle manure and top soil.

Time of Planting: Corms are normally planted during March –April and tubers start sprouting with the onset of monsoon. Sprouted corms in the storage condition are not suitable for planting.

Seed treatment: The cut pieces of corms are dipped in cow dung slurry and allowed to dry under shade before planting.

Seed rate: 40 kg/ha.

Method of planting: The corm pieces are planted in the middle of the pits and completely covered with leafy materials to conserve moisture and maintain optimum temperature.

LESSER YAM

Land preparation: The land is ploughed upto 15-20 cm depth. The pits of 45x45x45 cm size to be dug at a distance 75x75 cm. The 3/4th of the pits are filled 1.0-1.25 kg compost with top soil.

Time of Planting: Seed tubers are norzmally planted during March –April and tubers start sprouting with the onset of monsoon. Sprouted yams in the storage condition are not desirable for planting.

Seed treatment: The cut pieces are dipped in cow dung slurry and allowed to dry under shade before planting.

Seed rate: 1800-2700 kg/ha.

Method of planting: The cut tuber pieces are planted in the middle of the pits at 75x75 cm distance and completely covered with leafy materials to conserve moisture and maintain optimum temperature.

NUTRIENT MANAGEMENT IN TUBER CROPS

POTATO

- Potato is a heavy feeder and plants respond well to application of manures and fertilizers.
- Fertilizer requirement varies with soil and previous crop rose.
- The requirements of major nutrients depending on soil are given below:

Soil Type	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)
Alluvial	180	80	110
Black Red	115	45	50
Red	120	115	135
Hill Soils	115	135	95

- Half of N, full P and K are to be applied as basal dose before planting tubers.
- Remaining N is applied at the time of earthing up. Nitrogen is a limiting factor in all types of soils and it is required for growth of roots, foliage and tuber.
- Calcium ammonium nitrate and ammonium sulphate are better sources of N than urea.
- Phosphorus increases number of medium sized tubers while potassium enhances size of individualtubers.
- Potassium sulphate is better than murate of potash. Application of farmyard manures 30 t/ha meets the entire requirement of phosphorus and potassium and micro-nutrients for potato and succeeding cereal crop.
- Soils poor in organic matter content should be supplied with 250 to 500 q/ha of FYM or compost during land preparation, preferably a fortnight before planting. Potato plant is a heavy feeder.
- When it is grown in medium type of soils, it needs 100 to 150 kg nitrogen, 80 to 100 kg phosphorous and 80 to 100 kg potassium per hectare.
- Two - third to three fourth quantity of nitrogen along with whole quantity of phosphorus and potassium is applied at the time of planting.
- Remaining one fourth to one third nitrogen is applied 30 to 35 days after planting i.e. at the time of first earthing up or when plants become 25 to 30 cm in height either in the form of top dressing or as a foliar feeding.
- Spraying of essential micronutrients such as boron, zinc, copper, iron, manganese, molybdenum etc. is done when crop is showing deficiency symptoms.

SWEET POTATO

The application of 20 t/ha FYM and 100:50:50 NPK kg/ha is beneficial for getting more yield. The FYM and 50% of N, full P and K should be applied as basal dose at the time of field preparation and remaining 50% of N is applied one month after planting along with weeding and earthing up.

- Excess N_2 leads excessive vegetative growth at the cost of tuber development. Potassium: promotes tuber growth through accelerated translocation of photosynthates.
- Biofertilizers like Azatobacter and Azospirillum can be applied to reduce the N_2 fertilizer doses
- Azospirillum 2kg/ha vine dipping + 10 kg/ha soil application reduced application of nitrogen up to 2/3rd of recommended dose.
- Liming (2000 kg/ha) helped in neutralizing soil acidity and increased yield and quality.

CASSAVA

- Cassava is a heavy feeder and crop is to be adequately manure for getting high yield.
- Apply farmyard manure 25 tons/ha as a basal dose. For high yielding varieties, fertilizer dose of 50:50:50 NPK kg/ha is recommended at the time of land preparation.
- If planting of sets is done during hot condition, basal dose of fertilizers and manures may be postponed to one month after planting.
- This will avoid attack of termites and drying up of sets.
- Apply second dose of fertilizer i.e., 50:50:50 NPK kg/ha, 45-50 days after planting along with weeding and earthing up.
- In short duration varieties, fertilizer dose can be reduced to 75:50:75 NPK kg/ha.

COLOCASIA

Taro is a heavy feeder of nutrients. High dose of potash is essential for starch accumulation in the corms. It is estimated that to produce 170.0 q of corms per hectare, it removes from the soil 59.5 kg N, 26.4 kg P and 71.4 kg K. The soils therefore should be liberally manure.In addition to 20-25 t of FYM per hectare, apply 40:45:50 kg NPK/ha. Half of N and whole of P and K is applied at the time of planting while remaining half of N is applied 35-45 days after planting or at the time of first hoeing, weeding and earthing-up.

AMORPHOPHALLUS

Apply fertilizer 40 kg N, 50 kg P_2O_5 and 50 kg K_2O/ ha.Top dressing is done with equal dose of NPK again 45 days after planting.

GREATER YAM

Incorporate 10-15 t of FYM/ha. Along with the application of 80:60:80 kg NPK/ha. Apply full dose of P and half of N and K as a basal dose and remaining half of N and K should be applied at 30 days after planting.

LESSER YAM

Add FYM 10-15 t/ha along with 80:60:80 NPK kg/ha. Apply full dose of P and half of N and K as a basal dose and remaining half of N and K should be applied at 30 days after planting.

CHINESE POTATO

Broadcast 10-15 t/ha FYM and apply30:60:50 NPKkg/ha at the time of land preparation. Top dressed again 30 kg N and 50 kg K_2O at 45 days after planting. This is followed by inter culturing and earthing up.

EXERCISE - 8

INTERCULTURAL OPERATIONS IN POTATO

- Mulching ridges is advantageous in many ways and is usually done by use of paddy straw, wheat husk, jowar stalk, etc.
- In potato crop, both types of weeds are found i.e. broad-leaved as well as narrow leaved weeds.
- Weed growth can be controlled during initial stages and is managed by hoeing and weeding up to one month after planting followed by fertilizer application and earthing up.
- The use of herbicides in potato crop in general is not essential because earthing up operation destroy almost all weeds, if somehow, weed plants are growing on ridges, they may be pulled out by hands.
- Pre-emergence application of nitrofen 1.0 kg a.i./ha or alachlor2.0 kg a.i./ha or post emergence application of propanil 1.0 kg a.i./ha may be used.
- Care should be taken while spraying of post-emergence herbicides that they should not come in the contact to potato plants.
- 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 to 22 cm hill height.
- Generally earthing is done at the time of top dressing of nitrogenous fertilizers.
- The ridges should be 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 a ridger may be used for earthing up in large area.

Haulm cutting

- Delaying the haulm cutting by spraying the crop with insecticides to control aphids has been found to adversely affect the quality of seed (Vashisth *et al*., 1990).
- Haulms (foliage) of the seed crop should be cut close to the ground at fixed date in the month of January or when aphid levels reach 3-5 aphids per 100 compound leaves.
- However, Kumar *et al*., 2001 reported that delay in dehaulming resulted in increase in tuber numbers of all grades.

- The crop with dehaulming done 80 days after planting increased the potato yield of all the grades.
- This higher yield might be attributed to the continuous translocation of photosynthates from tops to the tubers over a longer period of time, which increased the size as well as number of tubers.
- This led to the suggestion that removal of haulms could be delayed advantageously to maintain yield and health standards of seed crop.

Use of plant growth regulators

Soaking of potato seed tuber in CCC at 500 mg/l or foliar sprays with ethephon at 400 mg/l (Murti and Banerjee, 1978, Sekhon and Singh, 1985), CCC at 25 mg/l or garlic acid at 10-100 mg/l(Kumar and Agarwal, 1978) increased tuber yield.

Irrigation

Water is one of the essential components required for growth and development of crop. The total water requirement varies between 350-550 mm depending upon soil type, climate and crop duration. Pre-planting irrigation is advantageous for uniform germination. Second irrigation is given after about a week and subsequent as and when required. Water is applied efficiently and economically at critical stages in crop development, i.e. at stolon formation, tuber initiation and tuber development stages of crop. The furrow method of irrigation is commonly followed in potato. Excessive ground water application may help for leaching of nutrients; reduce water/fertilizer use efficiency.Hence use of micro irrigation in potato helps to increase production, saving vital resource for future generations. Irrigation is stopped about 10 days before harvesting of crop to allow firming tubers skin.

INTERCULTURAL OPERATIONS IN TUBER CROPS

Intercultural operations in
SWEET POTATO

Spray the crop with growth retardant i.e cycocel (CCC) 500-1000 ppm, twice on 30 and 45 days after planting to increase tuber yield. Weeding at early growth stages between 7-14 and 30-45 days after planting is essential. Second earthing up should be done at 60 days after planting. It is quick growing crop and it covers the soil quickly and suppresses the weeds .Chemically weed can be controlled by alachlor 3.5-6.5 kg a.i./ha.Sweet potato vine has tendency to form roots from the nodes which results in diversion of food energy. To save the nutrient loss, it is essential to turn the vines after a month of planting. This operation helps in better tuber growth and is to be followed during early stage of vine growth.

CASSAVA

Pinching off excess sprouts emerging from sets is necessary in cassava cultivation. This may be done 30-45 days after planting. As sprouts from top buds are more vigorous than those emerging from lower nodes, retain only two sprouts from top portion, that too on opposite sides of set. Inter-culture operations are aimed at removing weeds in early stages of crop and to improve physical condition of sets for proper tuber development. First inter-culture operation may be done sufficiently deep at 45-60 days after planting and a shallow inter-culture by way of weeding or earthing up may be given one month after the first.

COLOCASIA

Weeding and earthing up are to be done along with application of fertilizers. Small, unhealthy suckers from mother plant have to be removed along with second weeding and earthing up operation.

AMORPHOPHALLUS

Shallow intercultural operations like weeding, light digging and earthing up is necessary in amorphophallus.Though, it is mainly grown as a rainfed crop but light irrigation is given at early stages of crop if late receipt of monsoon. Mulching immediately after planting is most important operation in amorphophallus as it is not only conserves the soil moisture but also regulates soil temperature and suppresses weed growth.

GREATER AND LESSER YAM

Weeding- The crop should be kept free from weeds.
Earthing up- It should be practiced to avoid the exposure of tubers.

Training- Trailing is essential to expose the leaves to sunlight. It is done within 15 days after sprouting by coir rope. The vine should be trained properly as and when side shoots are produced.

YAM BEAN

It flowers in 75 days after sowing. It is desirable to remove flowers for encouraging tuber yield. Provide trellis or props for plants to trail.

CHINESE POTATO

The weeding and earthing up should be done 6 weeks after planting along with top dressing of fertilizers. It is important to cover a portion of the stem with soil to promote better tuberization and development. One more earthing up has to be given 1 month after the first earthing up.

JERUSALEM ARTICHOKE- Irrigate the crop at weekly interval during dry period. Also 1-2 weedings are needed.

NUTRIENT DEFICIENCIES AND PHYSIOLOGICAL DISORDERS IN TUBER CROPS

PHYSIOLOGICAL DISORDERS IN POTATO

I) Uneven sprouting in the field- Adequate crop stand cannot be maintained for this disorder which happens due to planting has done soon after their removal from cold storage, soil moisture deficiency and untreated cut tuber pieces if infected by the fungus.

Control measures

- Hold tubers in storage till end of the dormancy period.
- Treat the cut tuber pieces with 0.25% diathane M-45 for 10 minutes.
- Place tubers somewhat deep, particularly in light soil with the cut surface facing downwards.

II) Dormancy- Dormant or even semi-dormant tubers do not sprout readily after planting causing delayed and erratic crop stand. This physiological hindrance becomes a problem when two potatoes are taken in rotation and tubers in the hills are used as seed immediately soon after harvest.

Control measures

- In advanced stage of dormancy, cutting of tubers may terminate dormancy.
- Cut tuber pieces are immersed immediately in 1% thiourea solution for 1hour and then plant them as soon as possible.
- Triple treatment: Spraying the whole tubers with 3% ethylene chlorohydrin 20 ml/kg of tuber in an air tight chamber for 4 hours; thereafter dip the tubers in 1 ppm GA_3 solution for 10 minutes. Dry the treated tuber pieces in shade before planting.

III) Black heart- It occurs in condition of restricted airflow and high respiration, especially when potatoes are stored in pile. High soil temperature and waterlogged soils are contributed to black heart development in the field. Due to poor oxygen availability, tubers develop an internal brown discoloration, which eventually becomes black. The discoloration occurs in an irregular pattern, usually with a distinct line between healthy and affected tissues.

IV) Greening- Exposure of tubers to bright light during post-harvest handling or longer periods of low light intensity results in the development of greening in potatoes. It is associated with the formation of alkaloids such as 'solanin'. Solanin is also formed in response to bruising, wounding, sprouting and improper earthing up. Though consumption of such potatoes are not cause serious health hazard yet such potatoes taste bitter and may result in temporary discomfort. Peeling off green skin with a layer of flesh removes most of the solanin content.

V) Hollow heart- It consist of cavities in the tubers, which are lined with brown, necrotic tissues. Excessive use of nitrogen and water application increases incidences of hollow heartwhereas, application of potassium containing fertilizers, especially potassium chloride reduces the incidence of hollow heart.

PHYSIOLOGICAL DISORDER IN YAMS

I) Dormancy- yam tubers do not sprout in early part of storage even under favourable growing conditions. The period of dormancy varies from 4-8 weeks in lesser yam and 12-14 weeks in greater yam. Treatment of tubers by quick dipping in 4-8 % solution of ethylene chlorohydrine breaks the dormancy in yam.

Fig. 10.1 : Black heart in potato

Fig. 10.2 : Greening in potato

Fig. 10.3 : Hollow heart in potato

STUDY OF MATURITY INDICES AND HARVESTING OF VARIOUS TUBER CROPS

Potato-

Depending upon the market requirements, the potato crop can be harvested any time after 60-70 days of planting till 120 days after planting. However, immature tubers bruise easily during harvest due to soft and thin skin. At maturity, the tuber skin is thicker, tough and more firmly attached. The plant tops show withering at maturity. Harvesting begins by end of January in the central and the eastern plains and by 15th February in the western plains. Before harvesting, tops are cut close to the ground level. Harvesting is done both manually and mechanically. After harvesting, potatoes are kept in heaps at a cool place for 10-15 days for drying and curing.

Sweet potato-

It can be harvested any time after a sufficient percentage of tubers has attained marketable size. Depending upon the variety, sweet potato can be harvested 3.5 to 5.5 months after planting. Yellowing of the leaves indicate maturity of the crop. Tubers from early harvest are comparatively soft and indicate maturity of the crop. Tubers from early harvest are comparatively soft and suitable for table purposes. A smaller acreage can be dug with the help of a turning plough. For larger plantings, harvesting is done with mechanical diggers. Most harvesters require vines to be cut with flail or rotary mower so that they do not interfere with digging. The tubers are cleaned after harvesting.

Cassava/Tapioca-

The crop is ready for harvesting in 10-11 months after planting. Short duration varieties can be harvested in 6-7 months. Delayed harvest results in deterioration of quality of tubers. Harvesting is usually done by uprooting plants gently by holding stem and after harvesting, stack stems vertically in well aerated place for use in subsequent planting. Yield is 25-30 t/ha for short duration varieties and 30-40 t/ha for other varieties.

Colocasia-

Tubers are ready to harvest in 5-6 months after planting. Decline in height and yellowing of leaves are indications of maturity. Harvesting is generally done manually by carefully uprooting the plants. The soil around the corm is loosened and grabbing base of the petiole pulls up the corm. After harvesting, the leaves with the stalk are removed with a sharp knife from base and mother and side corms are sorted out.

Yams –

At maturity the leaves turn yellowish and plants show withering. Harvesting is done manually and is labour intensive. Avoid damage to tubers while harvesting as that will lead to tuber rot and lesser market value.The lesser yam varieties take lesser time and reach marketable maturity in 7-8 months after planting whereas the greater yam and white yam varieties take longer and reach marketable maturity in 9-10 months after planting.

Amorphophallus -

It is long duration crop and takes 8-10 months from planting to reach harvestable maturity. Yellowing of leaves and drying up of the plant are indication of crop maturity. Harvesting is done manually and care is taken that the tubers are not injured while harvesting. Underground corms are harvested with pick axe or by digging when the shoot is completely withered.The tubers are then dried in shade and cleaned before marketing.

Chinese potato –

Harvest the crop when vines shows withering in 4-5 months after planting. It is done by digging and pulling out plants with tubers.Tubers are then separated, cleaned and marketed in gunny bags.

Yam bean-

The crop is ready to harvest within 150 days. If harvesting delayed, it results in cracking of tubers.Harvested tubers can be stored for 2-3 days without any deterioration.

Jerusalem artichoke-

The tubers are ready to harvest when leaves begin to wither and die. It is usually lifted manually.The tubers cannot be kept more than a few weeks under normal condition.It can be stored well in cold storage at 90-95% RH.

POST-HARVEST HANDLING, CURING TO STORAGE OF TUBER CROPS

POTATO

- Great care should be taken in handling of potatoes especially for seed purpose.
- Nearly 1/5 of potato production in the country is utilized for planting in next season.
- Harvested potatoes are heaped under shade for a couple of days, so that their skin becomes hard and soil adhering with them is also separated out.
- After harvesting, tubers are kept in heaps in a cool place for 10-15 days for drying and curing of skin.
- Heaps of 3-4 m long and wide at base and 1 m central height is the best. In hills tubers are spread in well ventilated rooms.
- The sorting operation is the most important, in that all cut tubers, bruised, injured by insects-pest and disease are removed.
- Sorted healthy tubers are graded in to different grades based on diameter of the tubers otherwise attract reduced prices in the market. Therefore, such tubers should be sorted and marketed separately.
- The oversized tubers are great in demand for chips making.
- The oversized and under sized tubers are quite unsuitable for seed purposes.
  Four sizes used for grading potatoes are small (below 25 g), medium (25-50 g), large (50-75 g) and extra-large (above 75 g).
- Potatoes for seed purpose are treated with 3% boric acid solution for 30 minutes for protection against soil borne diseases like black scurf, common scab etc before storing in bags.
- In plains, cured tubers after grading are stored in cold storage at 2-4°C and 75-80% RH.
- Potatoes stored at less than 0°C suffer from internal break down known as "Black heart". Low temperature prevents sprouting and rotting. High relative humidity reduces weight loss in tubers.
- In indigenous method, seed tubers are stored in a single layer on sand. Frequent examination is necessary to discard tubers showing symptoms of rotting.
- Tubers are also stored in pit method. Here, pits of 60-75 cm depth 240 cm length and 90 cm width are made in cool shady places. Water is sprinkled inside the pit to cool it. After two days, pits are lined from inside with neem leaves, dry grass or sugarcane trash.
- Bamboo chimneys of 1.2 to 1.5 m length placed inside the pit at 1.2 to 1.5 m apart for escaping moisture due to evaporation of tubers. Pits are then filled with tubers up to 15 cm from top followed by a 30 cm layer of trash. A thatch is also provided over the pit as a protection from rain and sun.
- Sprouting is a serious problem in storage hence pre-harvest spray of Maleic Hydrazide (500-2500 ppm) helps to check sprouting of tubers in storage.

Curing

- Freshly harvested tubers are kept in a cool place under shade or in heaps at 1.5 meters height and 3.5 meters broad for 10 days to further cure the skin of tubers.
- Heaps are covered with paddy or wheat straw to protect from direct sunlight.
- If it rains, the heaps should be provided with tarpaulins.
- More time for curing may be required in heavy treatment soil as compared to sandy loam.

Grading

- Seed size tubers should be graded with the help of mechanical graders for ease and efficiency (Shyam and Singh, 1979). Cut and crack tubers should be sorted out.

Seed treatment

- Treatment of seed tuber with 0.25 organo-mercurial compound (OMC) against surface-borne diseases by soaking for 20 minutes has been recommended.
- For successful treatment, they are first washed in water to remove the adherent soil and then dipped in OMC solution for 20 minutes.
- Boric acid (3 per cent) has also been found effective for control of surface borne diseases (Jagpal Singh, 1993). After treatment, tubers are dried well before storage.

Storage

- Storage temperature and exposure of tubers to light strongly influence sprout growth and the resulting vigour of seed tubers.
- Sprouts occur on tubers stored at temperatures higher than about 4°C.
  Excessive sprout growth causes dehydration of the tubers and reduces the vigour of the crop grown from them.
- Light retards sprout growth, and potatoes that are stored in light develop green sprouts that are much shorter and sturdier than sprouts on tubers stored in the dark.
- Consequently, storing seed tubers in light can compensate for some of the negative effects of high storage temperatures.
- The storage life of potatoes held without refrigeration can be prolonged by exposing them to light.
- Light storage cannot, however, be used for consumer potatoes, since greening makes them taste bitter.

SWEET POTATO

- Before storage curing is must

Curing

1. 29-32^{0}C, 85-90% RH, for 4 to 7 days heap tubers, curing heals wounds.
2. Store at: 10-12^{0}C at 85-90%RH for months together
3. At 15- 12^{0}C at RH > 70% can be stored for 4 to 12 weeks.
4. Red skinned varieties store better than white skinned varieties.
5. Tubers are stored better at 15°C and 85% RH.
6. Tubers can also be stored for 2-3 months in a pit covered with straw.

Post-Harvest Management

- After harvest, tubers are spread in partial shade for 5-6 days, for healing and curing.
- They should be stored in semi-dark condition in a well-ventilated room.
- This type of storage invites infestation of pest and diseases.
- In some parts of the country, tubers are stored in a layer of dry sand/soil after curing under ambient conditions.
- For storing, graded tubers free from sweet potato weevil and bruises should be selected.
- Farmers store the graded tubers in a pit, shade and covering the pit with paddy straw.
- Finally, the heap is plastered with mud or cow dung slurry.

CASSAVA

Post-harvest handling-

Cassava tubers are perishable and are not stored for longer periods. Discoloration due to vascular streaking, reduction in starch and increase is sugar content is associated with storage. Blue streak formation is due to increase in polyphenol oxidase and peroxidase activities and increase in phenolic content. Cassava tubers can be stored for more than a month in moist soil, sand and sawdust medium. However, excessive moisture in the medium promotes tuber rotting. The storage life of cassava can be extended by another 15 days by immersing fresh tubers in 0.04 %Thiabendazole solution for few minutes and drying under shade before packing in perforated polybags.

COLOCASIA

Post-harvest handling –

The corms are graded before marketing according to the size and weight. Diseased, damaged and poor quality corms are culled. It constitutes about 65% water. The corms are fragile and easily bruised. They are perishable and can be stored for few days at ambient temperature.

YAMS

Post-harvest handling –

Yams are cured at 29^{0}C for four to six days immediately after harvesting. Curing heals small surface bruises and hence decreases chances of decay in storage. Post-harvest treatment of tubers with GA_3 75mg per kg improves shelf life of tubers by increasing dormancy period by 3-7 weeks. White yam is stored for 6-7 months at 12-16^{0}C temperature and 80 per cent relative humidity. Lower temperature causes chilling injury. Greater yam is stored for several months at 30^{0}C and 60^{0}C per cent relative humidity and lesser yam for two months at 25^{0}C due to high moisture content of tubers (70-80 %), yams are susceptible to infections by microorganism during storage. Yams are also stored in underground structures, ditches and clamps. These are suitable for limited storage periods.

ELEPHANT FOOT YAM

Post-harvest handling-

It can be stored for longer periods under ordinary room temperature conditions. At 10^{0}C temperature, elephant foot yam can be stored for several months.

EXERCISE - 13

MARKETING OF TUBER CROPS

Assignment:

Visit to local markets and collect data regarding kind of crop, variety grown, yield obtained per hectare, cost of cultivation, net profit to the farmer, mode of transportation used for commodity, problems in marketing of various tuber crops and market availability in this region.

WORKING OF COST OF CULTIVATION OF IMPORTANT TUBERS

Yield and Economics of Potato Under Drip and Sprinkler Irrigation Methods

Table 1: Yield and economics of potato under drip method of irrigation/fertigation

Treatment	Graded tuber yields (q/ha)			Total Yield (q/ha)	Total tubers (000/ha)	Cost of Cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Large (>75g)	Medium (25-75g)	Small (<25g)						
% NPK under drip	31	117	34	181	570	39,509	42,250	5,741	1.15
25% NPK Fertigation	75	174	32	280	677	40,488	70,000	29,512	1.73
50% NPK Fertigation	112	205	29	346	727	41,467	86,500	45,033	2.09
75% NPK Fertigation	157	239	29	426	795	42,446	1,06,500	64,054	2.51
100% NPK Fertigation	165	238	28	431	831	43,426	1,07,750	64,324	2.48
Drip Irrigation	113	206	30	349	800	43,426	87,250	43,824	2.01
Furrow Irrigation	97	180	32	309	705	39,082	77,250	38,168	1.98
CD (5%)	20	19	N.S.	28	59	-	-	-	-

Table 2: Yield and economics of potato under sprinkler irrigation/fertigation

Treatment	Graded tuber yields (q/ha)			Total Yield (q/ha)	Total tubers (000/ha)	Cost of Cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Large (>75g)	Medium (25-75g)	Small (<25g)						
0 kg N/ha under sprinkler	29	94	40	163	553	39,140	40,750	1,610	1.04
20 kg N/ha under sprinkler fertigation	82	134	40	254	657	39,756	63,750	23,994	1.60
40 kg N/ha under sprinkler fertigation	87	141	36	264	663	39,910	66,000	26,090	1.65
60 kg N/ha under sprinkler fertigation	95	152	31	278	683	40,064	69,500	29,436	1.73
80 kg N/ha under sprinkler fertigation	108	160	29	297	697	40,218	74,250	34,032	1.85
Sprinkler Irrigation	133	176	23	331	704	40,526	82,750	42,224	2.04
Furrow Irrigation	115	151	29	293	658	39,082	73,250	34,168	1.87
CD (5%)	20	26	9	23	36	-	-	-	

Table 3 The cost of cultivation per hectare of tapioca.

SN.	Com ponents of different cost concepts	Co st/ha (Rs)	% distribution of cost "A"
1	Hired human labor	16274	62.59
2	Animal labor	13	0.05
3	Machine labor	300	1.15
4	Seed/seedlings	517	1.99
5	Farmyard manure and chemical fertilizers	5322	20.47
6	Plant protection	79	0.30
7	Land tax and irrigation charges	39	0.15
8	Repair and maintenance charges	133	0.51
9	Interest on working capital	2348	9.03
10	Other expenses	978	3.76
11	Total costs 'A' (1-10)	26003	100.00
12	Interest on fixed capital	1426	
13	Cost 'B1' (11+12)	27429	
14	Interest on land value	93442	
15	Cost 'B' (13+14)	120871	
16	Inputted value of household labor	2424	
17	Cost 'C' (15+16)	123295	

Table 4 Percent distribution of hired human labor hours.

Sex	Holding Size Class			
	Small	Medium	Large	All Size
Male	52.2	60.21	54.96	56.43
Female	8.95	13.96	37.34	21.96
Total	61.15	74.17	92.30	78.39

PREPARATION OF COMMERCIALLY VIABLE PROJECT PROPOSAL

Assignment: Prepare a commercially viable project proposal for tuber crops and submit it.

EXERCISE - 16

VISIT TO TUBER RESEARCH STATION/ FARMERS FIELD

Assignment: Visit to the different tuber research stations or progressive tuber crop growers field and submit detail report to the college.

College of Horticulture

Vasantrao Naik Marathwada Krishi Vidyapeeth
Parbhani-431 402