# PACKAGE OF PRACTICES FOR HORTICULTURAL CROPS OF ASSAM 2023

*Published jointly by*

**Assam Agricultural University, Jorhat &**
**Department of Agriculture, Govt. of Assam**

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**Assam Agricultural University, Jorhat**
**&**
**Department of Agriculture, Govt. of Assam**

**Atul Bora**
**Minister**
**Agriculture, Horticulture, Animal Husbandry & Veterinary, Border Protection & Development. Implementation of Assam Accord.**

सत्यमेव जयते

**GOVERNMENT OF ASSAM**

# *MESSAGE*

I am very happy to know that the Assam Agricultural University, Jorhat jointly in association with Department of Agriculture, Government of Assam is going to publish the recent version of the "Package of Practices for Kharif/Rabi/Horticultural Crops of Assam, 2023" along with the "Organic PoP for selected Crops of Assam, 2023" with the inclusion of 59 number of recently developed technologies pertaining to crop improvement, management and protection. I am also happy to know that Assam Agricultural University, Jorhat has developed the "Package of Practices for Climate Resilient Technologies of Assam, 2023" for the first time to combat the adverse effects of climate change on agriculture in the recent times, which will provide impetus to the agricultural growth and development in the state.

Agriculture is the mainstay of the Assam's economy as the majority of the people depend on agriculture and allied activities for their livelihood directly or indirectly. Adoption of sustainable, cost effective and advanced agricultural technologies could help in achieving rapid agricultural growth through optimum utilization of available resources of the state.

I sincerely believe that this Package of Practices, 2023 will be a great help for our extension machineries and farming community to boost up production and productivity of major crops in the state.

I convey my best wishes on this auspicious occasion.

Date : 30th August, 2024

**( ATUL BORA )**

Block - C, Ground Floor, Assam Sachivalaya, Dispur, Guwahati - 781006, Tel. : 0361-2237008 (O), E-mail : ministeratulbora@gmail.com

**Aruna Rajoria, IAS**
Commissioner & Secretary to the Govt. of Assam,
Departments of Agriculture, Information & Public Relation and Printing & Stationery &
Agriculture Production Commissioner

सत्यमेव जयते

Block-I, 1st Floor,
Janata Bhawan, Dispur,
Guwahati-781006
Tele : +91 361 2237086
E-mail : apcagrivet@gmail.com

## MESSAGE

Agriculture plays a vital role in the economy of the state, contributing to about 45% of the State's Gross Domestic Product (SGDP) with an annual growth rate of 8.15% (2021-22). Owing to the availability of fertile soil and abundance of rain, the state provides a favourable environment to produce both food and cash crops. Over 70 percent of the state's population relies on agriculture as farmers, agricultural laborers, or both for their livelihood, which emphasizes the importance of agriculture in the state. Hence, a rapid growth of agriculture could help not only in achieving self-reliance on food grain production but also in attaining food security and to reduce poverty in the state.

I am glad to know that the Assam Agricultural University, Jorhat jointly with the Department of Agriculture, Govt. of Assam is going to publish the Package of Practices for Crops of Assam, 2023 with inclusion of recently developed technologies pertaining to crop improvement, management and protection. I am confident that this will serve as a handbook to empower our extension machineries and farming community towards production and productivity enhancement of the state. I am sure that the package of practices included will be adopted by the farming community of state boosting the agricultural production systems.

With best wishes,

27/8/24.

**Date: 27-08-2024**

**(Smt. Aruna Rajoria, IAS)**

**Dr. Bidyut C. Deka**
**Vice Chancellor**

**ASSAM AGRICULTURAL UNIVERSITY**
**JORHAT-785013, ASSAM (INDIA)**

(Recipient of Sardar Patel Outstanding Institution Award)

# Message

I am happy to learn that the Director of Research (Agriculture) of Assam Agricultural University in collaboration with the Department of Agriculture, GoA is bringing out the publication on *'Package of Practices for Kharif, Rabi and Horticultural Crops, 2023 as well as Organic Package of Practices,2023"* wherein a total of 59 new technologies pertaining to crop improvement, management, and protection have been incorporated as per the recommendations of a workshop jointly organized by AAU and Govt. of Assam.

I sincerely believe that the technologies so generated and included in the publication through the dedicated service of the scientists shall be great help to the farmers, scientists and extension functionaries of the state increasing agricultural growth, productivity and farm income.

I place on record my sincere gratitude to the team of scientists associated with the preparation of the manuscript.

(Bidyut C. Deka)

Phone: (91) 376 2340013(O), 2340050(R) Fax: (91) 376 2340001 Website: www.aau.ac.in Email: vc@aau.ac.in

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# FRUIT CROPS

## PINEAPPLE

*Ananas comosus* L. Merr.

**Cultivars**:

**Kew:** A late-maturing pineapple variety with few spines at the leaf tips. Fruit is spineless, weighs 2-3 kg, oblong in shape, slightly tapering towards the crown. Eyes are broad and shallow making fruits more suitable for canning. The fruit is yellow when fully ripe, flesh is light yellow with considerable aroma and flavor, almost fibreless, very juicy with 0.6-1.2% acid, and its TSS content varies from 12-16° Brix.

**Queen:** Fruits are spiny, golden yellow in color and emits pleasant aroma and flavor at the ripe stage. The fruits are harvested when eyes turn yellow during mid-May to mid-July. Average weight of fruit varies from 600 g – 1.0 kg. Juice is bright yellow colour, TSS varies from 10 to 14° Brix depending upon the stage of maturity and season.

**Mauritius:** The leaves are dark green with broad red central stripe and red spines on the margins. The fruit is small, 1.36-2.25 kg, yellow externally, has a thin core and very sweet flesh. It is suitable for table purpose and utilized for juice.

**Soil:** It can be grown on any type of well drained acidic soil

**Propagation:**

It can be propagated by sucker, slip and crown. These planting materials of 5-6 months age bear flowers after 12 - 16 months of planting except crowns which bear flowers after 19-20 months.

**Treatment of planting material:**

Planting materials should be dipped in azoxystrobin 23SC (1 ml/*l*) before planting to protect the plants against bud rot and leaf spot.

**Time of planting:** April to October

**Planting and population:**

Planting is done in a double row system in beds. In each bed, plant at 60 cm from row to row and at 30 cm from plant to plant. The distance between rows of two adjacent beds should be 90 cm. This will accommodate 44,444 plants/ha.

**Manure and Fertilizer:**

10 to 15 t/ha of FYM is to be applied at last ploughing. N, $P_2O_5$ and $K_2O$ @ 12g, 2g and 12g, respectively per plant per crop should be applied.

Half of N and the whole of $P_2O_5$ and $K_2O$ are to be applied as basal dose and the rest half of N to be applied as foliar spray.

For foliar application, 450 g urea is dissolved in 10 liter of water and sprayed on 200 plants. It will provide 1 g of N per plant. Thus, for giving 6 g of N as foliar application 6 such sprayings are required after every 2 months. In ratoon crop, soil application of 40% of the fertilizer recommended for main crop i.e. 4.8 g N, 0.8 g $P_2O_5$ and 4.8 g $K_2O$/plant after harvest of main crop.

**Cultural operation:**

- Weeding should be done at least three to four times a year.
- Hand weeding can be partially eliminated by chemical weedicide. Black polythene mulch (50 micron) can also be used for effective control of weeds.
- When there is a long drought, irrigation may be given at fortnightly intervals.
- To protect the fruits from sunburn, partial shade may be provided by planting arhar or dhaincha in between the beds. The spacing has to be adjusted accordingly. Covering the mature fruits with leaves adjacent to the fruits will reduce both sunburn and bird damage.

**Crop Cycle:**

One main crop followed by two ratoons

**Flowering:**

There are two main seasons of flowering: March-April and June-July. Sporadic flowering may take place in other periods also. Fruits usually ripen about 5 months after flowering.

**Regulation of flowering and early fruiting:**

In general, when no special treatment is given, only 50-60% plants flower in the main season.

With the application of agrochemicals, it is possible to get uniform flowering (over 80%) in the main season. For this purpose, ethrel @ 100 ppm (10 ml in 100 liter of water) solution should be applied to plants one month before flowering. About 30 ml of ethrel solution should be poured on the core of the plant. Since ethrel is a costly chemical one tenth of it can be made equally effective (1 ml in 100 liter) by adding 2% urea and 0.04% sodium carbonate or calcium carbonate.

To delay harvest by a few days (10-15 days) spray the fruit (just 60-70 days ahead of normal harvest) with 300 ppm Planofix.

To ripen the fruit earlier by about 10-15 days spray 500 ppm ethrel on the fruit about one month before normal harvest.

**Plant Protection:**

***Leaf spot*:** This can be controlled by spraying chlorothalonil 75 WP (2 g/*l*)

**Harvesting:**

Harvesting is done when the fruits become yellow in colour. Over ripening on the mother plant or any injury to fruits during harvesting should be avoided. For distant markets, the fruits may be harvested when fruit colour changes from green to yellow.

**Yield:** 50-80 t/ha depending upon spacing and cultural practices

**Benefit: Cost ratio:** Main crop: 3.70; Ratoon crop: 8.50

# BANANA

*Musa spp.*

**Cultivar:**

**Dwarf** : Jahaji (Dwarf Cavendish)

**Medium tall** : Chenichampa, Malbhog, Bar Jahaji

**Tall** : Pura Kal (Kach Kal), Manohar, Jati, Bhimkal

**Soil:**

Well drained friable loam soil with adequate organic matter is ideal

**Propagation:**

It is propagated by sword suckers. Select healthy sword suckers and uproot with corm. Trim all the roots without damaging the buds. Give a slanting cut to the pseudo stem 30 cm above the base of the sucker. Weight of such planting materials should be around 1.5 kg to 2.0 kg. Old tissue culture hardened plants (Dwarf Cavendish) of 45-60 days can also be used as planting materials.

**Planting:**

Planting is generally done in pits. Double planting (2 plants/pit) with a spacing of 1.8 m x 1.8 m for Jahaji gives higher yield.

For High density planting, 3 suckers per pit at 2 m x 3 m (5001 plants/ha) spacing should be planted. Pits should be filled up with 18 kg FYM along with topsoil. Planting should be done 30 cm apart in the pit.

**Size of Pit:** 45 cm x 45 cm x 45 cm and 1 $m^3$ for high density planting

**Spacing:** Dwarf cultivars: 1.8 m x 1.8 m

Dwarf cultivars: 1.4 x 1.4 m (without ratooning)

Medium tall cultivars: 2.1 m x 2.1 m

Tall cultivars: 2.4 m x 2.4 m

**High density planting:**

Jahaji: 1.0 m x 1.2 m x 2.0 m (6250 plants/ha)

Bar Jahaji: 1.2 m x 1.8 m (4629 plants/ha)

Malbhog: 1.0 m x 1.2 m x 2.0 m (6250 plants/ha)

**Time of planting:** March – May

**Manure and Fertilizer:**

1. 12 kg FYM/plant, 110 g N/plant, 33 g $P_2O_5$/plant and 330 g $K_2O$/plant FYM should be applied in the pits at planting time and full amount of $P_2O_5$ at 3$^{rd}$ month after planting.

Apply nitrogen and potassium of 100% RDF in splits as 22:49.5, 33:82.5, 33:99 and 22:99 g per plant at 3rd, 5th, 7th, 9th month after planting.

**2.** For Integrated Nutrient Management of banana, 12 kg FYM/plant, 55 g N/ plant, 33 g $P_2O_5$/plant, 330 g $K_2O$/plant and 25g each of *Azospirillium* and Phosphate Soluble Bacteria (PSB) per plant should be applied.

**3.** For High Density Planting, 18 kg FYM, 165 g N, 50 g $P_2O_5$, and 495 g $K_2O$ should be applied for 3 plants in each pit.

In the case of Jahaji, $K_2O$ may be increased up to 550 g/plant. In case of Barjahaji 200 g N/plant in three splits (3rd month, 5th month and shooting stage) should be applied.

Soil application of different micronutrient mixtures of B (6 g), Zn (9 g), Cu (6g) and Mo (1 g) per plant for Borjahaji is beneficial. Micronutrient mixture of B, Zn, Cu & Mo at the same rate for Chenichampa and B & Zn mixture for Jahaji increase the production.

**Irrigation:** 3 irrigations per month during dry periods

**Drip cum fertigation:**

1. Drip irrigation at 75% EpR during November to March can be applied for banana cultivar 'Barjahaji' with Benefit: Cost ratio of 5.72.
2. 75% recommended dose of N and K (82.5 g N and 247.5 g K) can be applied through drip.

**Intercultural:**

**De suckering:** Remove all the suckers till shooting and allow only one sword sucker after shooting to set as a ratoon crop.

**Weeding:** Remove weeds as and when required. Gramoxone @ 1.5 kg/ha should be applied to check weed growth.

Grow one crop of cowpea and incorporate it in soil followed by hand weeding at 30 days interval up to shooting stage.

**Crop Cycle**:

In a banana plantation one main crop followed by 2 ratoons should be allowed. However, in Kachkol, 5 ratoons can be taken.

For high density planting, after harvesting of the main crop, new plantation should be done in between the rows. Preparation of the pits for planting should be done before harvesting of the main crop.

**Plant Protection:**

1. **Corm borer** and **Nematodes:** Healthy corms free from nematodes should be selected as planting materials. In case of infected suckers, the infected portions should be

scraped out with a sharp knife. In such corms, Fluensulfone 2 GR (Nimitz) granules should be applied @ 40 g per corm after dipping in mud slurry.

2. **Leaf & Fruit scarring beetle**: Cover the bunch with 17-GSM non-woven polypropylene bag at the time of emergence of inflorescence to protect the bunch from fruit scarring beetle. Remove the bag just before harvesting. Spray Thiamethoxam 25 WG @ 100 g/ha.
3. **Bunchy Top:** To check the spread of the disease, the aphid vector should be controlled by application of imidacloprid 17. 8SL @ 0.3 ml/liter of water.
4. **Panama disease** or **Banana wilt:** Soil drenching with 1.0% Bordeaux mixture or azoxystrobin 23 SC @ 1 ml/*l* or trifloxystrobin 25 WP @ 1-1.5 g/ liter of water is effective.
5. **Sigatoka leaf spot:** Spraying of azoxystrobin 23 SC @ 1ml/lit or trifloxystrobin 25 WP @ 1-1.5g/ liter of water at first appearance followed by 4 sprays at 30 days interval.

**Harvesting:**

The bunch is harvested when the ridges on the surface of the skin change from angular to round, i.e., after the attainment of ¾ full stage. The dwarf bananas become ready for harvest within 11 to 14 months after planting, while tall varieties require about 14 to 16 months to harvest.

**Yield:**

The yield of bananas depends on a number of factors such as variety, plant density, management practices etc. Tall varieties usually yield 15-20 t/ha. Dwarf varieties like Dwarf Cavendish yield 30-40 t/ha.

**Benefit: Cost ratio**: Main crop: 4.1

Ratoon crop: 6.5

# ASSAM LEMON

*Citrus limon* L**.** Burm. F.

**Cultivar:** Assam Lemon (Local)

**Soil:** Loamy soil with uniform texture up to a depth of 3 m is ideal for cultivation. Avoid waterlogged conditions.

**Propagation:Stem cutting, Leaf bud cutting and Air layering**

1. **Stem cutting:** The cuttings are usually prepared from fully matured stems. The size of the cutting is 18 to 20 cm in length with a thickness of lead pencil. The upper cut is made 1 cm above the node and lower cut close below the node in a slanting manner.

   The cuttings are planted with a spacing of 20 cm x 15 cm in a slanting position in the nursery bed measuring 30 cm x 1 m x 10 m. The bed is prepared with a mixture of 1 : 1 : 1 decomposed cowdung, soil and sand respectively.

2. **Leaf-bud cutting:** Leaf-bud cutting should be taken from the branch having healthy well-developed bud and actively growing leaves. The cuttings consist of a leaf blade and short piece of the stem measuring 2 cm.

   The nursery bed should be prepared with a mixture of leaf-mould, soil and sand in a ratio of 3 : 2 : 1. The cuttings are planted at a spacing of 10 cm between rows and 5 cm within rows and buried up to 2/3$^{rd}$ to their length in a slanting position. Before planting, cutting should be treated with a plant growth regulator, *viz*. IBA (2500 ppm) or Seradex B or Rootex-2. The sprouted cuttings may be planted in polybags (8 cm x 5 cm size) filled with a mixture of garden loam : FYM : sand in 2:1:1 ratio or can be transplanted directly after 1 year in the field.

3. **Air layering:** The first step in air layering is to completely remove a strip of bark 3 cm in width at a point 15 cm or more below the tip end. Scraping the exposed surfaces to ensure complete removal of the phloem and cambium is desirable to retard healing. About one to two handfuls of only slightly moistened sphagnum moss or mud pudding with a mixture of well decomposed cowdung, soil and sand with a ratio of 1 : 1 : 1, respectively is placed around the stem to cover the cut surface. Then a piece of polyethylene sheet 15 to 20 cm wide is wrapped carefully around the branch so that the sphagnum moss or mud is completely covered. Both the ends of the polyethylene sheet should be tied firmly so that the moss or mud does not dry up.

   The best time for Stem cutting, Leaf-bud cuttings and Air layering is March-April and can be extended up to August. Stem cutting may be raised in polyethylene bags under partial shade as the best nursery techniques.

**Planting:**

Before monsoon, pits of 0.5 m x 0.5 m size with a spacing of 3 m x 3 m are to be

prepared and refilled with soil-manure mixture (1:1) and then allowed to settle. The planting time is from May to August.

**Pruning and Training:**

In the nursery stage, pruning should begin soon after the shoots start sprouting from the Stem cutting or Leaf bud cutting or Air layering. After planting in the main field, all side branches up to 50-60 cm from the ground level should be removed keeping only a single main trunk to develop mechanically strong trees with well-spaced scaffold limbs before the onset of fruit setting. At the bearing stage, during winter when bearing is low, the branches touching the ground should be cut close to the laterals without leaving any stub. All diseased, injured, criss-cross branches and water sprouts should be removed occasionally.

**Manure and Fertilizer:**

| Year | FYM | N | $P_2O_5$ | $K_2O$ | Remarks |
|---|---|---|---|---|---|
| ***A. Plain Zone :*** | | | | | |
| 1st yr. | 5 kg | 150 g | 100 g | 145 g | |
| 2nd yr. | 10 kg | 300 g | 200 g | 290 g | Per plant |
| 3rd yr. | 15 kg | 450 g | 300 g | 435 g | Per year |
| 4th yr.& above | 20 kg | 600 g | 400 g | 580 g | |
| ***B. Hill Zone :*** | | | | | |
| 1st yr. | 5 kg | 100 g | 100 g | 100 g | |
| 2nd yr. | 10 kg | 200 g | 200 g | 200 g | Per plant |
| 3rd yr. | 15 kg | 300 g | 300 g | 300 g | Per year |
| 4th yr.& above | 20 kg | 400 g | 400 g | 400 g | |

This mixture is to be applied in two split doses, i.e. during February/March and October/November.

Fertilizer should be applied leaving about 15-45 cm space around the tree trunk and well beyond the canopy spread. It should be incorporated into the soil by light hoeing.

**Micronutrient:**

Spray 0.2 % (2 ml per liter of water) of Polymax or Multiplex during new flushes.

**Orchard Management:**

Weeding should be done frequently at monthly intervals. Paddy straw or black polyethylene can also be used as mulch for controlling weeds.

To produce off-season crops, 15 cm pruning after the harvest of the main crop with a single spray of Cycocel at 3000 ppm is recommended. Three irrigations at 15 days interval @ 15 liter/plant combined with black polythene (50 micron) mulching beginning 1$^{st}$ week of November is effective in producing off-season crop (1$^{st}$ week of March).

**Harvesting:**

After the 2nd year of planting the plants start bearing. Bearing of Assam Lemon is continuous throughout the year. Harvesting should be done when fruits become fully matured. Peak period of bearing is July to September.

**Benefit: Cost ratio**: 3.50 after 4 years, 7.80 for full bearing plants

# KHASI MANDARIN

*Citrus reticulata* L. Blanco

**Cultivar:** Khasi Mandarin (Local)

**Soil:** Mandarin thrives well in deep loose well aerated soil devoid of any hard pan. Ideal pH range for mandarin is 5.5 to 7.5. It is also highly sensitive to moist soil conditions.

**Propagation: Seed and Budding**

1. **Seed:** Since seeds of mandarin are mostly polyembryonic, the nucellar seedlings are selected to retain the clonal characters as in vegetative propagation. Seeds should be sown first in (a) primary nursery and then seedlings should be transferred to the (b) secondary nursery.

   **(a) Primary nursery**: The site for the primary nursery should be on a highland in light soil with good drainage. Raised seed beds of 20-30 cm x 1 m x 5 m size should be prepared with a mixture of well decomposed cowdung, soil and sand at a ratio of 1:1:1, respectively. Seed from healthy and vigorous mother trees with uniform and good bearing capacity should be collected. The mother plant should preferably be 20-30 years old. Freshly extracted seeds should be washed and dried in shade. Seeds should be dibbled at 2.5 cm between the rows and 1.25 cm within rows at a depth of 0.5 to 1.25 cm. Adequate watering should be done at regular intervals.

   **(b) Secondary nursery:** Seedlings at 4 to 6 leaf stage should be transplanted from the primary nursery to the secondary nursery bed. The seedlings should be transplanted at 30 cm between and within the rows. Side sprouts should be regularly removed. Regular control measures against pests and diseases are essential. Three (3) year old seedlings are ready for transplanting.

2. **Budding:** 'T' or inverted T-budding is the best budding method for Khasi Mandarin:

   **(a) Root Stock:**

   1. Rough Lemon
   2. Volkamariana
   3. Rangpur Lime
   4. Cleopatra Mandarin
   5. Trifoliate Orange

   **Rootstock Seedlings:** The rootstock seedlings are ready for budding within one and half to two years. For grafting 6-12 months old seedlings are preferred.

   **(b) Scion or bud-wood:** Scion or bud-wood should be collected from known productive, vigorous, healthy and insect and disease-free trees with a regular bearing habit. The best times of budding is September and February. The best time for grafting is Feb-March and Sept-Oct.

**(c) Budding method:** Budding should preferably be done at a height of about 20-25 cm from the ground level. First a vertical cut (about 2 cm long) is made using a sharp budding knife in the stock plant. Then a horizontal crosscut at the top or bottom of the vertical cut is made as per 'T' or 'inverted T' method through the bark about 1/3$^{rd}$ the length around the stock. Then the flap of bark is opened by the knife for insertion of the bud. After making the proper cut in the stock plant, the shield piece is cut out of the bud stick. A shield shaped piece of bark containing a bud from 1 to 2 cm in length is removed from the bud stick including a thin sliver of wood on the cut side.

Then the shield is pushed under the two raised flaps of bark of stock until it is well covered by the two flaps of bark keeping the bud exposed. The bud union is wrapped using a transparent polyethylene sheet. This can be unwrapped after 6-8 weeks of budding. After success of the budding, just before new growth begins the root stock is cut off immediately above the bud. The budded plants are ready for transplanting within 6-9 months.

3. **Grafting**: Rootstock seedlings of 3-5 mm stem thickness should be selected. The seedling should be given a horizontal cut at about 10-15 cm height and the stem should be given a vertical cut down to 1.5-2 cm to obtain a "V" slit of 1.5-2 cm. The scion collected from selected bearing mother plants should be of 6-12 months age and should have similar thickness to that of rootstock seedling. The scion should be of 10 to 15 cm length and the basal end should be given a slanting cut on opposite sides to form a 1-1.5 cm long wedge. This wedge is inserted into the "V" slit of the rootstock seedling taking care to match the cambium layers on both the sides and this union is fixed tightly by wrapping with a piece of polythene-tape. A stick of 25-30 cm length should be put by the side of the grafted plant and a wet polythene bag should be inverted on the stick, so that the grafted seedling is fully covered by the wet polythene bag and saturated humidity is maintained around the grafted plant. The wetting of the polythene bag should be done every alternate day. The union of scion and rootstock is normally completed within 25 days and then the polythene bag should be removed. The grafted plants become ready for transplanting within 6-9 months.

**Planting:**

Before monsoon, pits of 0.75 m x 0.75 m x 0.75 m size are dug at a spacing of 5 m x 5 m and then refilled with soil-manure mixture (1: 1) and then allowed to settle. The time of planting is from May to August.

The plant is set at the center of the pit and the soil around is compacted. Mulching with dry leaves should be done. Plants should be irrigated regularly at fortnightly intervals during dry periods.

**Pruning and Training:** In the nursery stage pruning and training should be done soon after the seedlings start sprouting from the seed or scion buds have started growing.

After planting at the main field, all side branches should be removed up to 50-60 cm

from the ground level keeping only a single main tree trunk. Above 50-60 cm height, pruning is done to develop mechanically strong trees with well-spaced scaffold limbs before the onset of fruiting. The side branches at the main trunk should be allowed to grow in a spiral manner from base of the plant to top. At the bearing stage after harvest of the crop, the branches touching the ground should be cut close to the laterals without leaving any stub. All diseased, injured, criss-cross branches and water sprouts should be removed.

**Manure and Fertilizer:**

| Age | FYM | N | $P_2O_5$ | $K_2O$ | Remarks |
|---|---|---|---|---|---|
| 2nd yr. | 5 kg | 150 g | 120 g | 100 g | |
| 3rd yr. | 10 kg | 300 g | 240 g | 200 g | Per plant |
| 4th yr. | 15 kg | 450 g | 360 g | 300 g | Per year |
| 5th yr. | 20 kg | 600 g | 480 g | 400 g | |
| 6th yr. onward | 25 kg | 600 g | 300 g | 600 g | |

In the first year of planting no fertilizer is applied to the plant. For bearing plants, apply Neem cake @ 7.5 kg per plant per year.

Manures and fertilizers should be applied in two split doses, i.e. February/ March and September/October.

Fertilizer should be applied leaving about 15-45 cm space around the tree trunk and well beyond the canopy spread. Immediately after application of fertilizer, it should be incorporated into the soil by light or shallow hoeing.

**Integrated Nutrient Management (INM):**

75% recommended dose of fertilizers i.e. 450 g N, 225 g $P_2O_5$, 450 g $K_2O$ and 5.625 kg Neem oil cake along with VAM 500g, PSB 100g, *Azospirillium* 100g and *Trichoderma harzianum* 100 g are to be applied per plant per year in 2 splits i.e. in March/April and September/October. The required amount of biofertilizer is to be mixed together with 10 kg FYM and should be applied 15 days before the application of inorganic N-$P_2O_5$-$K_2O$.

**Stage wise requirement of nutrients in Khasi mandarin:**

Fertilizers (Recommended dose of fertilizer - 600g N: 300g $P_2O_5$: 600g $K_2O$) should be applied stage wise for better yield and quality of matured Khasi mandarin as given in the table below.

| Time of Application | N | $P_2O_5$ | $K_2O$ | Remark |
|---|---|---|---|---|
| | ----------g/plant---------- | | | |
| Jan-Feb | 0 | 0 | 0 | gram per plant |
| March-April | 180 | 120 | 60 | |
| May-June | 180 | 105 | 60 | |
| July-Aug | 120 | 75 | 180 | |
| Sept-Oct | 60 | 0 | 150 | |
| Nov-Dec | 60 | 0 | 150 | |

**Micronutrient:**

Foliar application of micronutrient viz. Zn, B and Mo is very much effective, @ 0.02%, 0.05% and 0.05% as $ZnSO_4$, Borax and Ammonium-molybdate respectively thrice in a year during Feb-March, June-July and Sept-Oct.

**Orchard Management:**

Weeding should be done from the month of April; first by hoeing followed by another hand weeding after 60 days of chemical spraying.

**Intercropping:**

Summer green gram/cowpea followed by toria as intercrop up to bearing stage and alternatively pineapple can be grown successfully as intercrop.

**Plant Protection for Citrus:**

**(1) Trunk borer**: It is a very damaging insect pest of mandarin oranges in Assam. The grub bores a hole into the tree trunk near the base and makes a tunnel through the pith upward and the plant eventually dies. Prophylactic smearing of lime and water (1: 25) should be applied upto one meter from the base of the tree during March/April which prevents the adult from laying eggs. Once the hole is made, it should be spiked with wire to kill the grub and then the hole should be cleaned and plastered with wet soil. Proper pruning and training are also essential to minimize the infestation. Smearing of tree trunks up to 1 m of height from the base with 2 kg lime/ 10 liter of water during March prevents infestation.

**(2) Shoot borer**: The shoot borer damages mostly young and new shoots of the plant. The grubs bore into the tip of the new shoot and make tunnels through the pith of the branch from top to bottom and the shoot dies due to infestation. The insect starts damaging from March to October. The insect can be controlled by pruning and burning the infested branches.

**(3) Bark eating caterpillar:** The insect damages the bark of the plant and as a result the

flow of nutrients is stopped and ultimately the plant dies. It is a serious pest in neglected and old orchards.

**(4) Leaf miner:** The larvae usually mine the undersides of new leaves making serpentine mines which are silver coloured because of entrapped air. Due to mining the leaves become distorted, curled and defoliation occurs during severe attack and the plant becomes stunted in growth. Two sprays with imidacloprid 17.8 SL @10 g ai/ha during flushes have been found effective in controlling the insect. First spray should be given during initiation of new flush and the second after 20 days of the first spray.

Foliar spray with neem formulation 10000 ppm @ 5 ml/*l* followed by spinosad 45 SC @ 0.3 ml/*l* at 7 days interval is effective against citrus leaf miners during the new emerging flush stages (April and July)

**(5) Lemon butterfly:** The caterpillars feed on the leaves and defoliate the branches. Hand picking of larvae at the early stage is useful. For Biorational management of Lemon butterfly, foliar application of *Beauveria bassiana* @ 4 X $10^6$ cfu/ml 0.1% (1 g/*l*) should be done at the appearance of the larvae on leaves. It is effective for up to 14 days.

**(7) Fruit sucking moth:** The insect sucks the juice of the fruit and the fruits drop within a few days. Destruction and disposal of fallen fruits.

Spray neem oil 1% @ 10 ml/*l* at color breaking stage (August-September) to repel citrus fruit sucking moths (B:C ratio of 2.53).

**(8) Scales, mealy bugs, aphids and psylla:** These are sap sucking insects; Scales are brown tiny insects and are immobile. While sucking plant sap, mealy bugs secret honeydews on which sooty mould develops. Mealy bugs also cause fruit drops. The aphids infest the lower surface of the tender leaves, shoots and young fruits due to which the infested twigs are curled and the plant becomes sickly. The nymphs of psylla suck the cell sap from tender shoots, leaves and flowers causing curling, defoliation and drying of twigs.

To control these insects spray imidacloprid 17.8 SL @10 g ai/ha or 0.3 ml/*l*. Repeat the treatment and when necessary. For Biorational management of Citrus psylla, foliar application of novaluron 10 EC @ 0.005% (0.5 ml in 1 liter of water or abamectin 1.9EC @ 0.007% (0.4 ml in 1 liter of water) twice at 15 days interval during flushing period, with the appearance of nymphs on twigs, is recommended. For management of citrus butterfly, citrus psylla and other crawling insect pests, spray with 2% Petroleum oil and tie with paddy straw at a height of 1m around the tree trunk during April have been recommended.

9) **Citrus mite**: Two sprays with propargite 57 EC @ 1 ml/liter of water or spiromesifen 240 SC @ 0.4 ml/liter of water at 15 days interval can be applied during peak activity periods (May-June and Aug-Sept.).

**10) Nematode**: Apply 200 g *Trichoderma viride* (enriched with vermicompost/FYM)* per

plant around the base for management of citrus nematode, *Tylenchulus semipenetrans* (*20 kg *Trichoderma viride* mixed with 180 kg of Vermicompost / well decomposed FYM)

* This mixture should be covered with a gunny bag and to be placed in shade for 15 days. Periodical sprinkling with water to be done in order to maintain adequate humidity. 200 g of this mixture should be applied around per plant (1 m away from the base and at 6 inch deep) twice in a year, along with application of fertilizer along with sufficient amount of organic matter. This amount is sufficient for one hectare plantation.

10) **Gummosis or phytophthora foot rot:** Phytophthora disease produces symptoms of declining health of citrus trees causing rotting of roots, girdling of the tree trunk and defoliation. The first symptoms are dark staining of the bark followed by olive brown in color with a water-soaked appearance. In the advanced stage, the bark cracks, strips off lengthwise as in dries and gum starts exuding particularly in the late spring resulting in yellowing and die back. At the early stage, the affected portion should be scraped with a little extra healthy tissue without injuring the wood and then smear Bordeaux paste or Bordeaux paint (1:2 linseed oil).

Application of Bordeaux paste (1:1:10) (Copper sulphate + lime + Water) on tree trunk during pre-monsoon (May) and post monsoon (October) with two foliar sprays (May and October) of potassium phosphonate @ 0.3% can effectively manage Phytophthora root rot and gummosis of Khasi mandarin (B:C ratio of 2.82).

11) **Wither tip**: Wither tip, twig blight or dry-up twigs from top to the bottom is a serious problem in citrus. Pruning followed by spraying of 1% Bordeaux mixture after harvest of the fruit controls this disease. Twig blight or wither tip or dry-up twigs can be effectively managed by pruning in the month of January/February followed by two sprays of azoxystrobin 23 SC @ 0.1% and there after 2 sprays of copper oxychloride 0.3% (3 g in 1 liter of water) at monthly interval.

12) **Scab:** The scab lesions appear as minute water-soaked round spots which enlarge slightly, turn brownish and then corky on fruit, leaves and young twigs. Removal of infected leaves, twigs, fruit and spraying of Bordeaux mixture (1%) or copper oxychloride 50 WP (0.3% i.e. 3g in 1 liter of water) or azoxystrobin 23 SC (1 ml/*l*) or trifloxystrobin 25 WP (1 g/*l*) have been found effective in controlling the disease.

13) **Canker:** It is a bacterial disease. The disease occurs in lime, lemons and also primary and secondary nursery of Khasi mandarin. The canker lesions appear as minute water-soaked round spots, enlarge slightly, turn brownish, corky which can be managed by alternate sprays of copper oxychloride (0.3% *i.e.*, 3 g/*l*) + streptocycline @ 100 ppm (*i.e.*, 1 g /10 liter) and NSKE 5% during new flushes.

14) **Greening:** The infected plant blotchy mottle symptom of leaves, thickening of leaf blade, shortening of twigs internodes, off-season blooming, leaf shedding and die-back.

To control this disease, insect vector psylla should be first controlled (see psylla control).

Apply 2800 g/plant Phosphorus (50% more) along with recommended dose of nitrogen (1300g/plant) and potash (996 g/plant) in soil, two sprays of tetracycline hydrochloride @ 6 g/ 10 liters of water at an interval of 45 days during the month of October to December and 15 days later $ZnSO_4$ (200 g/plant) for management of citrus greening disease (B:C ratio of 2.48).

15) **Tristeza (CTV) disease**: This is a viral disease affecting lime, lemon and mandarin. To manage the disease, vector aphid (*Toxoptera citricida*) should be first controlled (see aphid control).

16) **Pre harvest stem end rot**: Four sprays of trifloxystrobin 0.1% (1 g in 1 liter of water) at monthly intervals from May i.e. after fruit set to control fruit drop due to pre-harvest stem end rot.

**Other Maladies:**

1. **Zinc deficiency:** Zinc deficiency is considered as the most widespread and damaging micronutrient deficiency of citrus. Deficiency symptoms develop only in the new growth. The leaves are small sized, chlorotic crowded on shoot stems giving a bunched appearance, mottling, twig die-back and ultimately the tree starts declining. It can be controlled effectively by foliar spray of 0.4 to 0.6% (4 to 6 g in 1 liter of water) Zinc sulphate during new flushes.
2. **Moss:** Remove the mosses mechanically by rubbing with a gunny bag.
3. **Loranthus:** The group of parasitic plants should not be allowed to develop on branches. It should be controlled by efficient pruning.
4. **Fruit drop:** Spray 10 ppm Planofix (1 ml in 4.5 liter of water) or bispyribac sodium 10 SL @ 25 g/100 liter of water immediately after flowering and again after one month. 3 sprays of 0.1% azoxystrobin 23 SC or trifloxystrobin 25 WP along with 30 ppm NAA starting from May onwards i.e. after fruit setting at bimonthly interval also can control fruit drop.

**Suggestions for management of Citrus-Decline:**

1) Proper drainage should be provided to drain out the excess water from the root-zone.
2) For vegetative propagation the mother plants should be ascertained of their freeness from virus and mycoplasma diseases.
3) It is advisable to establish new orchards with budded plants on resistant rootstocks.
4) Regular manuring of both non-bearing and bearing trees is essential.
5) Foliar feeding of micronutrients is essential as a regular practice.
6) Cultural practices like regular weeding, intercropping with only short duration, shallow rooted legume crops up to pre-bearing stage are suggested.

7) Pruning of dead and dried twigs, removal of plant parasites like *Loranthus*, etc. are desirable practices.
8) Soil working near the root zone should confine only up to 10 cm soil depth.
9) Application of Bordeaux paste may be practiced regularly to a height of about 50 cm of the trunk from the ground level
10) Pest and disease control measures should be followed strictly

**Schedule for rejuvenation of declining Khasi mandarin orchards:**

1. **Pruning and Training:** Unwanted, diseased and pest infected branches and twigs are to be removed by pruning and training during January/ February.
2. **Correction of soil pH:** Applying 1 kg Agricultural lime per plant for three years during January/ February and then mixed thoroughly with soil by light hoeing.
3. **Integrated nutrient management:** Application of nitrogen (N), phosphorus($P_2O_5$), and potash ($K_2O$) @ 600g, 300g and 600g per plant along with 7.5 kg. Mustard oil cake in two splits is to be done during March/April and Sept/Oct. Zn @ 2.5 g, B @0.6 g and Mo @ 0.1 g per plant are also to be applied along with N-$P_2O_5$-$K_2O$. Apply foliar spray using Green Harvest Crop Booster @ 25 g with 50 g Zinc Sulphate and 100 g Urea in 10 liter of water.
4. **Integrated management of Phytophthora foot rot, twig blight and stem end rot**

- For control of Phytophthora foot rot, soil drenching and spraying of tree trunks with metalaxyl @ 0.2% (2 g in 1 liter) followed by Bordeaux mixture (1%) during Feb-March and July-August.
- Following pruning and training in January, 2 sprays of trifloxystrobin @ 0.1% *i.e.*, 1 g per liter of water followed by two sprays of COC (0.3%) *i.e.*, 3 g per liter of water at monthly intervals for control of twig blight.
- Four sprays of trifloxystrobin @ 0.1% *i.e.*, 1 g per liter of water at 60, 80 and 120 days initiating from May onward for control of pre harvest stem end rot.

5. **Integrated management of trunk borer and bark eating caterpillar**

- Prophylactic smearing of 1 kg lime in 10 liters of water along with gum up to 1 m from the base of the trees during March every year to prevent adults from laying eggs.
- Afterwards 10 ml petrol is to be injected into the holes of the trunk borer and holes are sealed with mud and cowdung plastering.

6. **Integrated weed management**

- Light hoeing before application of fertilizers during March followed by glyphosate 41 SL @ 1 *l*/ha spray on the resurgent weeds during May followed by hand weeding at bimonthly intervals.

**Harvesting:**

After 7-8 years, the seedling trees start bearing. Harvesting should be done by using a ladder. Fruits should be collected in a bag and gently placed on a gunny carpet. Subsequently, they should be packed in baskets or cartoons for transportation to the market. About 800 to 2000 fruits per plant per year can be obtained from a 25-30 year old orchard.

**Benefit: cost ratio:** 3.30 after 7-8 years, 5.60 after 10 years

# COCONUT

*Cocos nucifera* L

**Varieties:**

**Kamrupa:** Selection from Assam Green Tall commences flowering 6-7 years after planting. Nut yield is 101 nuts/palm/year, copra yield 2.86 t/ha, oil content 65.0%, contains 253 ml tender nut water. High nutritive value of tender nut water with total sugars 5.16 g/ 100 ml, potassium 2294 ppm, Sodium 39 ppm. Tolerant to diseases (stem bleeding, bud rot), moisture stress, low temperature during winter and adaptable to a wide range of soil.

**Assam Tall:** Similar characters with Kamrupa except yield varies from 90-105 nuts/ palm/year.

**West Coast Tall** (WCT)**:** Tall palms, come to flowering after 7-8 years planting. Yields 96 nuts/palm/year, copra yield 2.96 t/ha and oil content 67.8%. Moderately tolerant to moisture stress, comes up well in varied types of soil including sandy, sandy loam and red sandy loam.

**Bengal Hazari:** Tall variety, flowering starts 7-8 years after planting. Yields 85- 90 nuts/palm/year, copra yield 2.5 t/ha and Oil content: 64.0 %. Moderately tolerant stem bleeding and moisture stress

**Kalpa Samrudhi (MYD x WCT):** This (D x T) hybrid palm is semi-tall with compact spherical canopy, commences flowering 5 years after planting. Yields 117 nuts/ palm/year, copra yield 4.38 t/ha and oil content is 67.5%. Tender nut water content is 346 ml, total sugars 4.17 g/100 ml, potassium 2370 ppm, Sodium 35.1 ppm. The hybrid is relatively tolerant to moisture stress, suitable for copra and tender nut purposes.

**Selection of Mother Palm:**

1. Select palm producing above 100 medium sized nuts /palm/year
2. Age of the mother palm should be above 20-25 years
3. Mother palm should have a well-developed crown with maximum number (>30 nos.) of horizontally oriented leaves.
4. Sept.-Dec. harvested nuts should be used

**Soil:** Sandy loam

If the soil is clay, 1 or 2 baskets of sand per pit should be applied.

**Sowing of nut:**

Sowing time is from December to February. 1 m wide and 30 cm raised beds of required length should be prepared. Large size nuts are planted horizontally with the widest of the three segments upwards which helps in the plumule emergence.

**Selection of seedlings:**

1. One year old seedlings should be planted.
2. The seedling with early splitted leaf is preferable. The seedlings having 5-6 leaves or just after splitting of leaves become ready for planting.
3. The seedlings should have a stout collar.

**Planting Distance:** 7.5 m x 7.5 m

**Pit size:** 1 m x 1 m x 1 m

**Time of Planting:**

March-April under high land condition September-October under low land condition

**Pit filling:**

Pit should be filled up with a mixture of topsoil, 20 kg compost or well-rotted cow dung and 2/3$^{rd}$ of the pit.

**Fertilizer Dose:** (per palm per year for bearing plants)

| Fertilizer | Improved varieties | Hybrid varieties |
|---|---|---|
| Urea | 1.50 kg | 1.10 kg |
| SSP | 2.50 kg | 3.12 kg |
| MOP | 1.75 kg | 3.34 kg |
| Borax | 25 g | 25 g |

The fertilizer should be applied in two equal split doses, i.e., in April and October. The fertilizer should be applied to a trench of 30 cm width and 10 cm depth at a radius of 1 to 1.75m away from the trunk depending upon the age of plant and covered with green leaves and then by soil. For seedling, the dose should be increased up to 4$^{th}$ year at the following rates:

**1$^{st}$ yr** – 1/5$^{th}$ of the full dose

**2$^{nd}$ yr** – 2/5$^{th}$ of the full dose

**3$^{rd}$ yr** – 3/5$^{th}$ of the full dose

**4$^{th}$ yr** – 4/5$^{th}$ of the full dose

From 5$^{th}$ year onwards-full dose of fertilizer for bearing palm

For integrated nutrient management in T x D hybrid (Chandrasankara) 500 g N wherein 50 % N substituted by vermicompost, 500 g $P_2O_5$ and 2000 g $K_2O$ per palm per year should be applied.

**Irrigation:**

Irrigation increases the total number of female flowers, nut setting, endosperm content, fruit weight and ultimately crop yield and reduces immature nut fall. Palms should be irrigated

at 10 days interval during the dry months @ 32 liters water per day.

**Weeding:**

Light ploughing or harrowing twice a year in February-March and September- October.

**Weed management by mulching in coconut nursery:**

Fifty-micron black polyethylene film mulch can be used as mulching material in coconut nursery with a benefit: cost ratio of 2.36.

**Intercropping:**

The crops, like black pepper, betelvine, grasses, turmeric, ginger, pineapple, banana (Chenichampa), Kachkal, Assam Lemon and vegetables like pumpkin, okra, brinjal etc. have been found to be very profitable as intercrop in coconut orchard. Intercropping with colocasia under half dose of recommended fertilizer and ginger and turmeric with full dose of fertilizer can be grown profitably.

**Coconut based cropping system:** Refer to Chapter

**Coconut based multiple cropping system:** Page No. 164-165

**Plant Protection:**

1) **White Ant:** Apply bifenthrin 2.5 EC @ 0.05% ha as soil application
2) **Rhinoceros beetle:** Keep Naphthalene balls @ 4 Nos. at axils of leaves to repel the insect
3) **Red palm weevil and Mealy bug:** Spray thiamethoxam 25 WG @ 26 g a.i./ha against sucking pests
4) ***Teratheba* and *Betrachedra* spp:** Clean the palm twice a year before and after monsoon and spray thiamethoxam 25 WG @ 26 g a.i./ha
5) **Crown choking:** Apply 50 g Borax in a trench of 15 cm width and 10 cm depth at a distance of 1 to 1.75 m away from the trunk along with the recommended dose of fertilizer. In acute cases repeat the application after one month of first application for three times.
6) **Stem bleeding:** Scrape out the infected portion completely and apply Bordeaux paste or coal tar. Chiseling out of the infected portions followed by wound dressing with hexaconazole (1 ml/*l*) or trifloxystrobin (1 g/*l*) and finally application of hot coal tar will manage the stem bleeding disease of coconut.
7) **Spindle rot:** Spray 1% Bordeaux mixture immediately after emergence of seedlings.
8) **Ganoderma disease:**
   a) Drainage should be improved.
   b) Recommended dose of fertilizer should be applied.
   c) When disease symptoms are observed, isolate the diseased plant by digging a trench

60 cm deep, 30 cm wide and 1 m away from the trunk and drench the trench with 0.2% carboxin.

d) Application of 5 kg Neem cake per palm in addition to organic matter.

e) Apply 1.5 to 2 kg Sulphur powder around the palm.

f) Palms showing initial disease symptoms should be treated with 0.2% carboxin three times at monthly intervals with 10 liters of solution per palm.

g) Strict phytosanitary measures should be taken by removing the diseased palm along with roots and burying them completely.

h) Grow one row of banana plants as a disease resistant crop in between two rows of coconut.

i) Soil drenching with 1 g copper sulphate + 1.5 g Auriofungin solution in 100 ml of water.

**9) Bud rot**: Clean the affected portion and apply 1% Bordeaux mixture.

**10) Leaf blight**: Remove the older affected leaves and spray 1% Bordeaux mixture.

**11) Immature nut shedding:**

a) Apply recommended doses of fertilizer per year.

b) Apply pesticides and fungicides against pests and diseases.

c) Irrigate the palms during dry months to prevent formation of abscission flowers at weekly intervals for a month after fruit set.

**Squirrel pest management:**

Trunk banding with aluminum sheet (0.5 mm thickness and 4 feet wide) at the height of 8 feet around the coconut tree for reduction of squirrel infestation

**Benefit: cost ratio:**

1.60 after 7 years

5.70 after 15-18 years (full bearing plant)

# JACKFRUIT

*Artocarpus heterophyllus* Lam.

**Cultivar**: Singapore Jack, Rudrakshi, Local types

**Soil:** It can be grown in a wide range of soil conditions. But the crop is successfully grown in rich deep alluvial soil.

**Propagation:**

1) **Seeds:** Seeds from fully ripe fruits of high yielding prolific bearing types should be selected. Freshly extracted seeds should be used for sowing.
2) **Air layering:** For obtaining true to type plant air layering of one year old shoot of bearing plant is the best method when treated with IBA (500 ppm).
3) **Epicotyl grafting:** Jack seeds should be sown in poly bags (10 cm x 20 cm) filled with sowing mixture in the 1st week of July. The seedlings reaching 12-14 cm height (10- 12 days old) should be used as rootstock for grafting. Scions from the terminal shoot of selected good variety of one season old having well developed buds should be used. Grafting should be performed by decapitating the seedlings at a height of 6 cm from the base. The top of the stem should be split vertically to about 3.5 cm length forming a V-shape. At the base of the individual scion a wedge of 4.0 cm should be prepared and inserted in the split epicotyl region of the stock and tied firmly by polythene strip.

**Planting distance:** 10 to 12 m

**Manure and Fertilizer:** **For a bearing tree**

| | | |
|---|---|---|
| FYM | : | 20 to 30 kg |
| N | : | 200 g |
| $P_2O_5$ | : | 320 g |
| $K_2O$ | : | 960 g |
| Ash | : | 5 kg |

**Cropping:** First fruiting takes place 6 to 8 years after planting.

**Plant Protection:**

1. **Shoot and trunk borer**: Application of Thiamethoxam 25 WG @ 26g .ai./ha in the flowering season.
2. **Fruit rot**: Spray Chlorothalonil 75 WP @0.2% as prophylactic measure

**Harvesting:** The fruit matures towards the end of summer in June. Harvesting is done by cutting the stalk of the fruits.

**Yield:** 200 to 500 fruits per tree/year.

**Benefit: cost ratio**: 4.10 for bearing plants

# MANGO

## *Mangifera indica* Linn.

**Cultivar:**

**Amrapali**: Dwarf and regular bearing cultivar ideally suited for high density planting. It is being popularized for its high orchard efficiency. The fruit is oblong in shape, size is little smaller than Dusehari, but ripens later than Dusehari. Yellow coloured fruit has good keeping quality and fruit flavor. The TSS ranges between 18-20° Brix.

**Dashehari**: One of the most popular cultivars of North India, with excellent quality and size of fruit. Trees are moderately vigorous, spreading with rounded top. Fruit is oblong with a round base, beakless and shoulders are equal. Skin is medium thick, smooth, yellow and pulp is firm and fibreless with pleasant flavor. Taste is very sweet with TSS 19 – 20° Brix. Stone is medium covered with fine fibre. It is a regular bearer. Fruits ripen in mid-season from June-July.

**Langra**: Tree is very vigorous and spreading. It is alternate and bearer requires more planting distance due to its vigour. It is a heavy yielding mid-season variety with TSS 19-20° Brix. Fruit size is medium, ovate, light green at maturity, very strong and pleasant flavor with medium keeping quality. Stone has fine fiber all over.

**Malda**: It is a very popular cultivar of Ganga-Jamuna plains. It is a heavy bearer with medium-sized fruits of light green color. Trees are medium to large, spreading and moderately vigorous. Fruits are beakless with round apex. Skin is medium thick, the flesh soft, fibreless, yellowish with TSS of 17–18° Brix. The stone is densely covered with small hairs. Fruits ripen from May–July.

**Fazli**: The tree is vigorous and spreading. This late season variety bears large- sized fruits with TSS 17 – 18° Brix, heaving little fiber on stone. The fruits remain light green even at ripening.

**Kishan Bhog**: Mid-season heavy bearing variety producing medium-sized fruits, oval oblique in shape. Fruits are yellow colored having good keeping quality

**Mallika**: Tree is semi-vigorous, medium to heavy cropper and has a strong tendency to bear regularly. The fruits have an attractive appearance and the average fruit weight is 307 g with pulp percentage is 74.0. The pulp is firm, fibreless and the stone is very thin. The total soluble solid is higher (25° Brix) than that of Dashehari, has better keeping quality and also matures later than Dashehari.

**Soil:** It can be grown in a wide range of soil conditions. But the crop is successfully grown in rich deep alluvial soil.

**Time of Planting:** During monsoon

**Planting Distance:** 12 m x 12 m

**Propagation:**

1) ***Air layering:*** For obtaining true to type plant air layering of one year old shoot of bearing plant is the best method when treated with IBA (500 ppm).
2) ***Wedge Grafting***: Seedlings are raised from seeds of local hardy vigorous mango plants in polybags (18 cm x 20 cm). The rootstocks become ready for grafting at 9-10 months while the scions should be 4-5 months old. The rootstock is headed back 15-20 cm above the soil and given a 4.0 – 4.5 cm long downward vertical cut. The scion, 15 – 18 cm long having 3 - 4 active buds, is prepared by giving a 4.0 - 4.5 cm long wedge cut and is inserted into a split of the stock and pressed properly so that the cambium layers come in contact with each other. The union is then firmly tied with a 150 gauge polythene strip of 2 cm wide and 25–30 cm long. Immediately after grafting the graft is covered with a 2.5 cm x 18 cm long white polythene cap and tied with a rubber band at the base. The scion starts sprouting in 9 – 12 days and the cap is removed after 25 – 50 days depending upon the growth. After removal of the cap the grafted plant is shifted to the net house for hardening.

**Manure and Fertilizer:**

| Non-bearing stage (up to 3rd year) per plant/year | Bearing tree per plant/year | Old declined tree per plant/year |
|---|---|---|
| 10–15 kg FYM | 20-25 kg FYM | 50-60 kg FYM |
| 73 g N | 730 g N | 1 kg N |
| 18 g $P_2O_5$ | 180 g $P_2O_5$ | 0.5 kg $P_2O_5$ |
| 68 g $K_2O$ | 680 g $K_2O$ | 1 kg $K_2O$ |

(In case of old declined trees 3% urea as foliar spray per year after pruning).

**Pruning and Training:**

Pinch off sprouts below the graft union regularly and pluck off panicles up to 3 years. Practice thinning of terminal shoots every year. Prune criss-cross branches once in 5 years.

**Bee Pollination:**

Five *Apis cerana* colonies/ha (1 colony/bigha) for getting effective yield of mango.

**Plant protection:**

1) **Stem borer**: Plug with kerosene dipped cotton.
2) **Mango hopper**: Spray thiamethoxam 25 WG @ 26 g. *a.i*/ha
3) **Red Ants**: Apply thiamethoxam 25 WG @ 26 g. *a.i*/ha
4) **Pulp weevil**:
   i. Spray Imidacloprid 17.8 SL @ 0.4-0.8 gai/plant or 1-2 ml/plant

ii. Cultural practices like clean cultivation, light hoeing and smearing of lime on the base of the trunk.

iii. Combined treatment of cultural practices and spraying of Thiamethoxam 25 WG@ 26 g. *a.i*/ha

3) **Fruit Fly**: Use of methyl eugenol trap @ 20 number / ha at the time of fruiting

4) **Pink disease and anthracnose**: Spray copper fungicide @ 0.2%

5) **Mango malformation**: De-blossom affected panicles and spray 200 ppm NAA.

6) **Fruit drop:** Spray bispyribac sodium 10 SL twice at full bloom and again after two months of 1st spray.

**Harvesting:** After 4 years of planting during June to August

**Yield:** 10 years old plant gives a yield of 200-250 fruits. Plant of 20 years and above: 400-600 fruits.

**Benefit: cost ratio**: 4.10 for bearing plant

# PAPAYA

*Carica papaya* Linn.

**Cultivar:**

**Dioecious Type:**

**CO-1:** It is selection from cultivar Ranchi done by TNAU, Coimbatore. The plant is dwarf in habit, producing the first fruit within 60-75 cm from the ground level. Fruit is medium-sized, spherical, has smooth greenish-yellow skin, flesh orange-yellow, soft, firm. It is moderately juicy with good keeping-quality. The objectionable papain odor is practically absent in the fruits.

**CO-2**: It is a selection purified from a local type. Fruits are medium-sized, ovate, greenish yellow, ridged at the apex, flesh red in colour, soft to firm, moderately juicy with good keeping-quality. It is a suitable type for extraction of papain. It gives 4-6 g dried papain/fruit or 250-300 kg papain/ha.

**Washington:** It is a table purpose variety. Fruits are round to ovate, medium- large in size with few seeds. When ripe, skin attains a bright yellow colour. The average weight of fruit ranges from 1.5-2 kg. Male and female plants are separate.

**CO-5:** It is a selection from Washington and isolated for its high papain production. It produces consistently 14-15 g dry papain/fruit. It gives 75-80 fruits/trees in two years with an average yield of 1,500-1,600 kg dried papain/ha.

**Ranchi:** It is a variety from Bihar and popular in south India. The fruits are oblong with dark yellow pulp and sweet taste.

**Hermaphrodite type:**

**Coorg Honey Dew:** Popularly known as 'Madhu bindu' and is cultivated for table as well as processing purposes. The variety bears greenish-yellow oblong-shaped fruits with orange thick flesh and good flavor. The variety can be maintained pure by growing in isolation. Due to its excellent fruit quality, it fetches a good market price.

**Pusa Majesty:** A gynodioecious line, tolerant to viral diseases and root knot nematodes. The variety is suitable for papain production and is comparable to CO-2 variety for papain yield. The fruits are medium-sized, 1- 1.5 kg in weight, round in shape and have better keeping quality. It starts fruiting 146 days from the time of transplanting. The variety is tolerant to root knot nematodes.

**Pusa Delicious:** This is a gynodioecious line with medium-tall plants, starts yielding 8 months after planting and has good quality fruits (10-13°Brix). The fruit is medium-sized (1-2 kg) with deep orange flesh having excellent flavour. It is grown as a table purpose variety.

**Solo:** It is a table purpose variety. The fruits are small with deep pink pulp and a sweet taste. Excellent for kitchen gardens.

**CO-3:** The fruit of this hybrid (CO-2 x Sun Rise Solo) is larger in size when compared with Solo and exhibits all the desirable attributes of Solo. Total soluble solids (TSS) is as high as 13.8° Brix and average fruit weight ranges from 1-1.5 kg. The fruits have a good keeping quality. Each tree yields 100-120 fruits in two years.

**Halflong:** Plants grow as tall as 3.0 m in height, stem girth 29.8 cm and come to bearing in 130 days after planting. Fruits are elongated 18.5 cm long and 19.5 cm girth weighing 580 g. Plant yield varies from 22.7 – 30.5 kg with a total yield of 65.8 t – 75.5 t/ha. The variety is susceptible to mealy bug infestation but has moderate resistance to ringspot virus.

**Soil:** Well drained high and rich sandy loam.

**Propagation:** By seeds

**Seed requirement:**

Hermaphrodite/Hybrid varieties 50 g/ha (7 g /bigha) OP varieties 250 g/ha (35 g/bigha)

**Raising Nursery:**

Sow the seeds in poly bags (5 cm x 8 cm) filled with garden loam: FYM: sand at 2:1:1 ratio in Feb-March. Dibble seeds at 1 cm depth; give a light irrigation to keep the sowing media moistened. Seeds germinate after 15 days of sowing. Keep seedlings in the nursery for 1 month. In case of dioecious varieties, 3 seeds should be sown so as to remove the weak and male plants keeping only 1 healthy seedling per pit.

**Time of planting:** April to June

**Planting Distance:** Pits of 45 cm x 45 cm x 45 cm size are prepared at a spacing of 1.8 m x 1.8 m. Plant 4 seedlings per pit in case of dioecious type and 1 seedling per pit in case of hermaphrodite type.

**Manure and Fertilizer:**

N-$P_2O_5$-$K_2O$ @ 500 g, 500 g and 500 g per plant to be applied in 10 equal splits at 2-month intervals starting from planting.

**Maintenance of Sex Ratio:**

In dioecious type, after flowering, keep 2 male plants for every 10 female plants and remove excess male plants.

**Plant Protection:**

**(1). Mosaic and leaf curl:** Protect the nursery with nylon net (60-80 mesh) to prevent infection by insect vectors. Before transplanting give a prophylactic spray of imidacloprid 1 ml/3 liter. Rogue out affected plants from the main field. Control the aphid vector using imidacloprid 17.8 SL @0.3 ml/ liter of water.

**(2). Collar rot and foot rot**: Maintain good drainage and spray 1% Bordeaux mixture in the collar region of the plant. Soil drenching with chlorothalonil 75 WP @ 2 g/*l* water

controls the disease effectively.

**(3). Management of papaya mealy bug (*Paracoccus marginatus*)**

- **Legislative**: Restricted movement of infested plants/planting materials from endemic areas to prevent spreading of the insect pest
- **Survey and Surveillance**: Monitoring the crop to detect infestation of the papaya mealy bug early in order to initiate management practices effectively
- **Mechanical**: Removal and burning of infested parts/plants
- **Cultural**: Removal of weeds/ alternate hosts like *Hibiscus* sp. and application of sticky bands or alkathene sheet on main stem of the plant to prevent upward movement of crawlers
- **Biocontrol**: Prevention of the movement of ants with destruction of already existing ant colonies in the vicinity, conservation of natural enemies like *Coccinella septumpunctata*, *Coccinella transversalis*, *Cheilomenes sexmaculata* and *Spalgis epius*, release of *Acerophagous papaya* (Hymenoptera: Encyrtidae) @ 500 - 1,000 per ha for three times at weekly interval.
- **Chemical**: spot spraying of Neem oil (1 to 2%), NSKE (5%), profenophos 50 EC (2 ml/*l*), thiamethoxam 25 WG (26 g ai/ha) and imidacloprid 17.8 SL (1 ml / 3 *l*).

**(4). Damping off:** It is the most serious and common disease in nurseries caused by *Rhizoctonia, Pythium* and *Phytophthora spp*. (Soil drenching with Ridomil MZ 0.2 %, 2 g/*l*) seed treatment (Nabam or Dithane D-14 @ 2 g/kg seed).

**(5). Papaya Ringspot virus:** Control-Raise papaya seedlings under insect proof conditions. Plant disease free seedlings. Raise sorghum / maize as a barrier crop before planting papaya. Rogue out affected plants immediately on noticing symptoms. Do not raise cucurbits around the field. Select to grow the tolerant varieties.

**(6) Nematode:** Apply fluensulfone 2GR per nursery polybag and 25g per plant in field condition.

**Harvesting:** Almost throughout the year, after 1 year

**Crop cycle:** As yield declines after 3 years, start new plantations after the 3rd year. The yield of the fruit varies according to cultivar.

**Benefit: cost ratio**: 4.60 for unripe fruits; 12.40 for ripe fruits

# LITCHI

*Litchi chinensis* Sonn.

**Cultivar:**

**China**: Fruits ripen when most of the other cultivars have been harvested. Trees are dwarf (4.0 m high, 6.0 m spread) and high yielders (80- 100 kg/tree), but prone to alternate bearing. Fruits are large sized (3.86 cm length and 3.26 cm diameter), medium- heavy in weight (22.0 g/fruit), oblong in shape and tyrant rose in colour with dark tubercles at maturity. Possess a tiny under-developed fruit attached to the fruit stalk of each fully developed fruit. The flesh is soft, juicy and very sweet, but not as good as Shahi. Aril is creamy-white, soft, juicy, sweet having TSS 18.20° Brix, 11.0 percent total sugars and 0.43 percent titrable acidity. It is also known as Purbi, Calcuttia, Bengalia, Bombaiya and Manragi in different regions.

**Bombai**: The trees are regular bearers and yield 80 to 90 kg of fruit. Ripe fruits have an attractive deep-red colour. Tubercles turn carmine red on maturity and interspaces are uranium green. It is a vigorously growing cultivar attaining a height of 6-7 m and spread of 7-8 m. The cultivar matures early (second week of May). Fruits are large in size (3.5 cm long and 3.2 cm diameter), obliquely heart shaped, and weigh 15-20 g and bear in large bunches. Like the China cultivar, this cultivar also has a tiny under-developed fruit attached to the fruit stalk of each fully developed fruit. The pulp is grayish-white, soft, juicy, sweet, containing 17° Brix TSS, 11 percent total sugars and 0.45 percent acidity and pulp: seed ratio is 4.5-5.5: 1. The elongated, smooth and shining seed of light chocolate colour is 2.3cm long. It is an important cultivar of West Bengal in India and Bangladesh.

**Muzaffarpur**: Trees are medium in vigour and attain an average height of 5.5 m and spread of 6.0 m. It bears profusely and regularly and the average yield is 80-100 kg/tree. Fruits are less prone to cracking and generally ripen in the first week of May. Fruits are large with 3.7 cm length and 3.2 cm diameter and average fruit weight is 18.2g. The fruit shape is oval and oblong conical. The colour at maturity of pericarp is uranium green, that of tubercles is crimson red. Fruit pulp is white, soft and juicy (60%). The pulp has TSS 17.7° Brix and 0.48 percent acidity. Seeds are large, 2.4 cm long and 1.54 cm in diameter, the skin, seed and aril percentage is 13.7, 16.5 and 69.8, respectively. It is one of the best litchi cultivars grown in Bihar and is also known as Late Large Red.

**Elaichi**: The tree is moderately vigorous, 5-6 m high, 6-7 m spread and mostly regular bearer. Fruit yield is 50-60 kg/tree. It matures in the mid-season, i.e. in the first week of June. Fruits are mostly conical, a mixture of nasturtium red and marigold orange in colour, weighing 12-15 g. Fruit pulp is creamy-white, sweet, soft, juicy with an agreeable flavour. TSS is 18.0° Brix, sugars 11.5 per cent, acidity 0.45 per cent, pulp: seed ratio 6.91:1. Seeds are relatively small, shining with an average weight of 1.5-2.0 g. The fruits are less susceptible to sunburn and cracking.

**Rose Scented:** The fruits have a distinct aroma and hence are called Rose Scented. It is also known as Shahi in Bihar. It is one of the most popular mid-season cultivars, which ripens during the last week of May to first week of June. Trees are very vigorous (7.6 m high and 8.2 m spread) and high yielders (80-90 kg/plant) but mature fruits are prone to sunburn and cracking. Fruits are medium to large (3.2 cm length and 3.1 cm diameter), medium in weight (18.44 g/fruit), and globosely-heart or obtuse in shape with rough skin and having purplish rose colour with red tubercles at ripening. Pulp is grayish- white, soft, moderately juicy (54.8%) and sweet with TSS 21.7° Brix, 14.57% total sugars and 0.30% total acidity. Seeds are small (1.89 cm length, 1.32 cm diameter and 2.07 g weight), smooth, shining, round-ovate in shape and blackish-chocolate in colour. Rind: pulp: seed ratio is 12.22: 75.93: 11.85.

**Pyazi**: The fruits of this cultivar are 3.4 cm long, oblong-conical to heart-shaped; have a blend of orange and orange red, with yellowish-red and not very prominent tubercles. Skin is leathery, adhering. The flesh is gray white, firm, slightly sweet, with flavour reminiscent of boiled onion. Seeds are cylindrical and fully developed. It has moderate quality fruits and is early in maturity.

**Early Bedana** (**Early Seedless**): Tree has medium canopy attaining an average height of 5.0 m and spread of 6.2 m. It is a regular bearing and medium yielder (50-60 kg/tree) cultivar. Fruits are medium sized (15-18 g), oval or heart-shaped, with rough, deep red skin at maturity. It is known as Early Seedless because of its early ripening and small seeds. Aril is creamy white, soft, juicy (69.0%) and sweet containing TSS 19.50° Brix, 13.91 percent total sugars and 0.24 percent titrable acidity. Seed is very small, shrunken, glabrous, dirty chocolate in colour with an average weight of 1.47 g. The rind: pulp: seed ratio (by weight) of the cultivar is 13.06: 83.19: 3.75.

**Late Bedana (Late Seedless)**: In this cultivar the seeds are present, but are shriveled and very small. This is a late maturing cultivar, usually ripening in the second week of June. The trees are vigorous having an average height of 5.5 m and spread of 7.0 m. It is a high yielder, giving an annual yield of 80-100 kg/ tree. The new flush is dark pink in colour and its leaf can be distinguished from other cultivars. The panicle is compact; fruits are conical with vermilion to carmine in colour having dark blackish brown tubercles at maturity. The fruit skin is rough, firm and non-adherent. Pulp is creamy white, soft, juicy (65.4%), sweet having TSS 19.5° Brix, 13.0 percent total sugars and 0.30 percent acidity. Although the fruit size is medium, the pulp content is high and the fruits are of very good quality. Seeds are small (2.0 x 1.0 cm in size and 2.18 g in weight), shrunken, glabrous, chocolate coloured having fusiform shape similar to dog's tooth. The rind: pulp: seed ratio is 14.76: 81.89: 3.35.

**Soil:** Loamy Soil

**Propagation:** Air layering during the rainy season (April-August)

**Planting Material:** Layers of 15 months

**Time of Planting:** August to September

**Planting Distance:**

Pits of 1 m x 1 m x 1 m size are to be prepared at a spacing of 10 m x 10 m.

**Manure and Fertilizer:**

**For bearing Tree:**

Urea: 110g

Super Phosphate: 250g

Sulphate of Potash:125g

Oil Cake: 2 kg

Bone Meal: 2 kg

Wood ash: 4 kg

**Pruning:**

Remove the dead or diseased branches, damaged shoots or crossed limbs. Skipping of old branches is desirable to promote new growth.

**Mulching:** Dry leaves or rice straw is used as soil mulch.

**Plant Protection**:

(i) To control bats and birds during fruit ripening, the tree should be covered with bird proof nets.

(ii) Leaf curl or "Erinose" caused by the mite should be controlled by spraying Bifenthrin 8SL @60 g ai/ha against mite or two sprayings of Propargite 57 EC @ 1 ml/ liter of water at 10 days intervals before flowering.

(iii)Fruit cracking: Spray 2, 4, 5-T or NAA at 35-100 ppm

**Cropping:**

Litchi bears fruits 5 to 6 years after planting. Flowering time is from February- March and the harvesting time is May-June

**Harvesting:** Mature ripe fruits should be harvested with fruit stalks

**Yield:** A healthy mature tree can yield a crop of 75 to 100 kg

**Benefit: cost ratio**: 4.60 for bearing plants

# GUAVA

*Psidium guajava* Linn.

**Cultivar**:

**L-49 (Lucknow-49):** It is a prolific bearer, greenish yellow with milky white sweet pulp and rough surface. Shell is fairly thick, containing a few fairly soft seeds in the inner portion of pulp. Since the number of seeds is less, keeping quality is medium. It is suitable for table purpose and yields about 25 t/ha.

**Allahabad Safeda:** Tree is medium in height (5.8-6.5 m) with vigorous branching and dense foliage. Fruits are medium in size (180 g), round in shape with few seeds. The fruit is white fleshed with good keeping quality. This variety issuitable for table purposes.

**Chittidar:** The Chittidar is similar to the Safeda except that it has many pinkish red dots, the size of a pinhead on the surface of the fruit.

**Arka Mridula:** Plants are semi-tall in nature and spreading. Fruits are round in shape and weigh about 180 g. Skin is yellow, smooth and white in colour. The TSS is around 12 °Brix. Fruits are soft seeded and have a good keeping quality. It is good for processing due to high pectin content (1.041%).

**Lalit**: Fruits (185-200 g) are saffron yellow in colour with red blush, pulp firm and pink in colour with a good blend of sugar and acid. TSS of 12° Brix and vitamin C content 250 mg per 100 g pulp. Fruits are suitable for both table purposes as well as processing. The pink colour of the beverage remains stable for more than a year in storage. This variety yields 100 kg/plant/year, higher than any other commercial guava variety. Responsive to pruning, suitable for high density plantings and is adopted in meadow orchards.

**Soil:** Well drained loamy soil

**Propagation:** Air layering during rainy reasons (April-August)

**Time of Planting:** May to June.

**Planting Distance:** 4-5 m x 4-5 m

**Manure and Fertilizer:**

20-30 kg FYM, 260 g N, 320 g $P_2O_5$and 260 g $K_2O$/plant/ year in two split doses in February-March and September-October.

**Pruning:** Sprouts arising from the base of the trunk should be removed immediately.

**Shoot Bending:** The straight branches may be bent and tied on the pegs driven to the ground. In bent branches dormant buds are activated and induced to bear flowers and fruits heavily.

**Plant Protection:**

1. **Fruit fly:** Destruction or burn the infected fruits. Apply methyl eugenol trap @ 20

trap/ha from the time of fruiting.

2. **Wilt**: Drench the soil with chlorothalonil 75WP (0.2% i.e. 2 g/liter of water) and spray the plant with trifloxystrobin 25 WP @ 1 g/liter of water at an interval of 15 days in the early stage of infection.

**Harvesting:**

Layered plants start bearing at the age of 2 to 3 years. Mature or half-ripe fruits are harvested by hand picking.

**Yield:** Average yield is 75 to 175 kg/plant/year

**Benefit: cost ratio**: 4.20 for bearing plants

# SAPOTA

*Achras zapota* Linn.

**Cultivar**:

**CO-1**: Semi vigorous trees bear fruits after 4 years. Fruits are medium sized, round with few seeds, dull yellow flesh, mellowing, sweet in taste having TSS 24.2° Brix. Trees yield 25-28 kg fruits per plant and has low incidence of leaf spot, bud borer,

**CO-2**: Fruit size medium, oblong round, light brown coloured pulp, mellowing with pleasant aroma, 24.8 °Brix. This variety also shows low incidence of leaf spot, bud borer and produces 22-27 kg fruits per plant.

**Cricket Ball**: Vigorous tree with a dense canopy produces large round fruits like cricket balls. Fruits have thin peel, moderately sweet (TSS 21.3° Brix), light brown coloured pulp with granular and gritty texture. This variety is susceptible to bud borer. Fruit yields 32-40 kg per plant.

**Soil:** Well drained deep sandy loam, laterite and old alluvium

**Propagation:** Propagation is by inarch grafting during the rainy season. In case of inarch grafting the rootstock should be Khirni (*Manilkara hexandra*).

**Time of Planting**: Early monsoon

**Planting Distance**: 7-9 m x 7-9 m

**Manure and Fertilizer**:

For a bearing tree, 40 kg FYM, 200g N, 80 g $P_2O_5$and 300 g $K_2O$/tree/year

**Pruning:**

Remove all the sprouts appearing on the rootstock below the graft or bud joint. After 3 to 4 years of planting the lower branches up to height of 60-90 cm should be removed. Remove the over shaded and crowded branches.

**Plant Protection**:

**(1) Stem borer**: Plug with kerosene dipped cotton.

**(2) Scale insects:** Spray with imidacloprid 17.8 SL (0.3 ml / 1 liter of water)

**(3) Leaf spot**: Monthly spray 0.2% (2 g in 1 liter of water) of chlorothalonil 75 WP

**(4) Sooty mould** : Spray starch solution (100 g in 18 liter of water)

**Cropping**:

Grafted Sapota bears fruits 3 years after planting. Fruit production increases up to 30 years and declines thereafter. Sapota blossoms continuously in several flushes at short intervals throughout the year.

**Harvesting**: Mature fruits should be harvested with fruit-stalks

**Yield**: A mature tree bears 1500 to 3000 fruits a year with a total yield of 25-30 kg/plant.

# ARECANUT

*Areca catechu* Linn.

**Cultivar**:

**Kahikuchi**: High yielding variety with medium thick stem, longer internodes, partially drooping crown, regular bearer, consistent in yield. Bunches are well placed on stem, orange color, bold & round shaped nuts, high recovery of dry kernel (25.16%) from fresh nuts, yielding 3.70 kg dry kernel/palm/year. Comes to bearing by 5$^{th}$ year and economic yield can be realized up to 40-45 years.

**Nalbari**: Tall palms with medium thick stem, longer internodes, partially drooping crown, regular bearer, bunches well placed on stem, round shaped yellow colour nuts, high recovery of dry kernel (25.18 %) from fresh nuts, yielding 4.15 kg dry kernel/palm/year. Comes to bearing by 5$^{th}$ year and economic yield can be realized up to 40-45 yrs.

**Soil**: Well drained soil. Avoid stiff clay and waterlogged soil

**Seed Selection:**

Select the healthy round nut of average weight 40 g. Dip the nuts in a bucket containing water. The nuts which are floating on the water vertically are suitable for raising seedlings.

**Nursery**:

Remove the perianth from the healthy seed nut and place vertically in the raised nursery bed 15 x 15 cm apart. Provide adequate shade in the nursery bed containing sand, soil and compost. When the seedlings attain 25-30 cm height transfer the seedlings to the 2$^{nd}$ nursery bed at 30 x 30 cm apart. Keep the seedlings in the second nursery upto maximum age of 18 months.

**Planting Distance**: 2.75 m x 2.75 m

**Pit Size**: 60 cm x 60 cm x 60 cm

**Planting Time**: Spring/Autumn

**Manure and Fertilizer**:

| Age | FYM kg/Plant/yr | N g/plant/yr | $P_2 0_5$ g/plant/yr | $K_2 0$ g/plant/yr |
|---|---|---|---|---|
| 1st yr | 5 | 30 | 15 | 50 |
| 2nd yr | 10 | 60 | 30 | 100 |
| 3rd yr & onwards | 20 | 100 | 40 | 140 |

Apply the entire manure and fertilizers in 2 splits, one during March/April and the other during September/ October.

**Weeding**:

Remove weeds by hand hoe twice a year, once after pre monsoon and once after monsoon.

**Intercrops**:

Turmeric and ginger can be grown profitably as intercrops. Besides, one line of banana or lemon or three rows of pineapple can be grown as intercrops.

For both bearing and non-bearing plantations, combination of banana and pineapple with an additional crop like black pepper or betelvine can be grown as intercrops.

**Disorder**:

1) ***Phula Tamul*:** In Arecanut cultivation, the phenomenon of the soft/leathery kernel, i.e. lack of proper hardening of kernel associated with moisture stress in the endosperm in ripe and mature fruit may be termed as *phula tamul*. This condition of fruit is generally found in the first bunch of the palm which ripens earlier and gets ready to be harvested in the beginning of the harvesting season (Late March to Early April). The incidence is observed when the palm experiences scanty or irregular rainfall during the fruit development period.

   **Control:** Providing irrigation to the arecanut plants especially during the dry months with proper drainage facilities followed by improved cultural practices are some of the remedial measures to be adopted.

2) **Nut Splitting:** It is considered to be a physiological disorder. Improvement of drainage in areas of high water table is known to help in minimizing the incidence. Spraying of Borax at the rate of 2g/l per palm during the early stage of the problem also reduces the splitting.
3) **Pencil tip:** Apply adequate manures and fertilizers regularly and improve cultural practices. Improvement of drainage is essential in areas of high water table. Plants should not suffer from N deficiency.

**Plant Protection:**

1) **Bud rot** – Same as in coconut
2) **Ganoderma** – Same as in coconut
3) **Band disease**:
   (i) Improve the soil condition by loosening hard soil strata present and providing good drainage.
   (ii) Apply powder mixture of copper sulphate and lime in equal quantities @ 225 g per palm twice a year at the base of the affected palm.

**Stem bleeding**: Same as coconut.

**Benefit: cost ratio**: 1.40 after 6 years; 12.6 after 8-10 years

# CASHEWNUT

*Anacardium occidentale*

**Climatic requirement**:

Cashew is restricted to an altitude below 700 M where temperature does not fall below $20^0$C for prolonged periods. The optimum temperature for growth is $17^0$C to $36^0$C. Cashew is grown in areas with annual rainfall ranging from 600 to 4500 mm. Fruit set in cashew is good if rains are not excessive during flowering (November to February). Dry spell during flowering ensures better harvest.

**Variety**:

So far, the National Research Centre of Cashew (NRCC), Puttur, Karnataka has released about 40 varieties. Out of which NRCC has recommended Jhargram-1, Ullal-3 and BPP-8 for the Northeastern Region.

**Jhargram-1**: It has a medium compact canopy and intensive branching habit. It bears on average 6 nuts per bunch and yields 8.5 kg/tree with small sized nuts (5g). Shelling percentage is 30 and kernel grade is W 320.

**BPP-8:** This variety is superior to all other released varieties from Bapatla. It yields about 14 kg/tree with better nut size (8.2 g) with 29% shelling recovery. The kernel grade is W 210.

**Ullal-3:** It is an early flowering variety with a short duration (November to January), the fruiting period is also short (50 to 60 days). The fruit occurs from January to March. It is a high yielding variety with average production of 14.7 kg raw nut/ tree. The nut size is medium with 7g per nut. Shelling percentage is 30 and kernel grade is W210. The apples bears red colour.

**Soil:**

Cashew is grown on a wide variety of soils like laterite, red soils and coastal sands of Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu and West Bengal. Whatever the nature of topsoil, free drainage and absence of brackish water are considered essential.

**Planting material**:

Cashew is a highly cross-pollinated crop, hence seed propagation is avoided. The most common and successful method of propagation is the use of softwood graft.

**Soft wood grafting**

1. About 45-60 days old seedlings raised in polythene bags are utilized as root stocks.
2. From the selected variety, lateral shoots of current seasons' growth (pencil thickness, 3-5 months old) are selected and procured on the mother plant by clipping the leaf

blades. After 10-15 days these shoots are collected and used as scions.

3. The terminal growth of the rootstock (soft wood portion) at a height of 15 cm from ground level is decapitated and a cleft of 5-6 cm deep is made on the stem.
4. The scion stick is mended into a wedge shape of 5-6 cm long by chopping off the bark and a little portion of wood from two opposite sides.
5. The wedge of the scion is inserted carefully into the cleft of the root stock.
6. Then the graft union is secured firmly with a polythene strip.
7. A white polythene cover is inserted on the graft and it is tied at the bottom to maintain humidity.

**Planting season**:

Planting of softwood grafts is usually done during monsoon (June to August).

**Land Preparation**:

Clearing of wild growth, digging of pits for planting should be done during pre-monsoon season (May to June).

**Spacing**

- A spacing of 7.5 m x 7.5 m (175 plants/ha) for 8 m x 8 m (156 plants/ha) is recommended for cashew in sloppy areas.
- In level plains it is advantageous to plant the graft at 10 m x 5 m spacing (hedge row system) which will accommodate about 200 plants/ha and at the same time leaving adequate interspaces for growing intercrops during the initial years.
- Under high density planting system (HDP) a spacing of 4 m x 4 m is recommended (625 plants/ha) in low fertility soils whereas spacing of 6 m x 4 m (416 plants/ ha) and 5m x 5m (400 plants/ha) are recommended in medium fertile soils.

**Pit size**

- The pits should be open at least 15 to 20 days before planting.
- The pit size of 1m length x 1m breadth should be opened in soils with hard laterite substratum. A pit size 60 cm x 60 cm x 60 cm is sufficient in other soils.

**Filling up of pits**

- The pits should be filled with a mixture of topsoil, compost (5 kg/pit) or poultry manure (2 kg/pit) and rock phosphate 200 g/pit).
- A small drainage channel at the elevation side of the pit can be made to drain the excess rainwater.

**Planting**:

While planting the grafts, the polythene bag has to be removed carefully without disturbing the ball of earth. A portion of soil is scooped out from the center of the filled pit and

grafted plant is placed in such a way that the graft joint remains above the soil level. The base of the plant should be covered with topsoil and pressed gently and a stack should be placed near the graft plant to prevent wind damage. The polythene sheet used during grafting should be removed at planting time to avoid constricted growth at the grafting point.

**Soil and water conservation**:

Terracing is required in sloppy sites where soil erosion and leaching of plant nutrients are generally common. In such cases terracing with catch pits followed by mulching is done.

**Terracing:**

- Terracing of 2 m radius is prepared during May to June in the second year of planting.
- The terraces are done by removing the soil from the elevated side and spreading it to the lower side of the slope.
- Terraces are generally made crescent shaped to retain the washed soil from the upper side along with rain water.

**Catch pit:**

- A catch pit of 200 cm length x 30 cm width x 45 cm depth) across the slope at the upper side of the peripheral end of the terraces is made to conserve rainwater. A channel is made sideways to drain out excess rainwater.

**Mulching:**

- Mulching can be done at the basin of cashew plants either with green leaves or dry leaves soon after planting.
- Live mulches are also utilized to conserve moisture.

**Manure and fertilizer:**

- Application of 10 to 15 kg FYM or compost per plant every year is beneficial.
- The recommended dose of fertilizer by the National Research Centre for Cashew is 750 g N, 125 g $P_2O_5$ and 125 g $K_2O$ per year per plant. It is advisable to use straight fertilizer instead of complex fertilizer.

**The year-wise fertilizer is as follows**

| Year (s) after planting | Urea | Dose (g/plant) | |
|---|---|---|---|
| | | Rock phosphate | Muriate of potash |
| 1st | 330 | 125 | 40 |
| 2nd | 660 | 250 | 80 |
| 3rd | 990 | 375 | 120 |

| | | | |
|---|---|---|---|
| 4th | 1320 | 500 | 160 |
| 5th | 1650 | 625 | 200 |

- The fertilizer is to be applied in two splits. The first split is given during pre-monsoon (May/June) and second part is applied in post monsoon (August/ September).
- Fertilizers are applied in 50 cm circular bands in flat land at a distance of 50 cm, 70 cm, 100 cm and 150 cm away from the trunk of cashew of plant during 1st, 2nd, 3rd and 4th year after planting and onwards respectively and rake the fertilizer into the soil.
- In sloppy areas, the fertilizers are applied in circular trenches of 25 cm width and 15cm depth at the distance mentioned earlier.

**Canopy management**: Training and pruning are essential management practices in cashew.

**Training:**

- Training is done in the initial years
- During 1st and 2nd years after planting flower panicles are removed to encourage vegetative growth and frame formation.
- Stacking is provided to plants to prevent lodging.
- The lower branches are gradually removed with the help of secateur during the initial 4 to 5 years of planting so that the trunk up to 60 to 75 cm remain single stemmed. This operation assists easy cultural operations like pest control and nut collection.
- Branches are evenly spaced by pruning unwanted criss-cross branches.
- The mature plants are de-topped at 3 to 4m height and a semi globular canopy is maintained.

**Pruning:**

- Water sprouts, crown suckers, dead branches/twigs are removed.
- About 60 percent of leader shoots (1 to 2 years old laterals) are to be pruned by pruning back at two third lengths.
- Pruning atleast in 2 to 3 years is necessary depending on the amount of dead wood and age of the plants.

**Intercropping/Mixed cropping:**

- Intercropping or mixed cropping is recommended in cashew orchards during the initial years of the formative stage of cashew.
- Intercrops help to check soil erosion apart from utilizing soil water and solar energy.

**Some of the recommended intercrops are**:

**Pineapple**: Pineapple can be grown for 7 years from planting in between cashew plants in trenches of 1.0 m width and 0.5m depth.

**Black pepper**: Black peppers can be grown by allowing them to trail in the stems and branches of more than 6 years old plants. A net profit of Rs. 14,000.00 per ha can be achieved from black pepper.

**Ginger**: Ginger can be raised in the initial 3 to 4 years of cashew plantations. A net profit of Rs. 40,000 per ha can be obtained from ginger as a mixed crop.

**Turmeric**: Turmeric can also be easily taken up as intercrop in the initial 7 years. **Vegetables**: A wide range of vegetable *viz*., cucurbits, cowpea annual leafy vegetables etc. can be raised.

**Plant Protection**:

Cashew is most commonly attacked by Tea mosquito bug (*Helopeltis antonii)*, cashew stem and root borer.

1) **Tea mosquito bug** (*Helopeltis antonii)*: This insect causes maximum damage to the new flushes, flowers and young fruits by sucking cell sap. If extreme infestation occurs, the leaves show a scorching effect which drastically reduces the yield of the crop. The occurrence and buildup of the insect coincide with the new flushes, flowering and fruit setting after cessation of monsoon. The insect is controlled by spraying insecticide viz., thiamethoxam 25 WG @25g ai/ha. The first spray of thiamethoxam 25 WG @25g ai/ha is to be given at the time of new vegetative flush and subsequent spraying can be done as and when required.
2) **Cashew stem and root borer:** The grub of this insect causes extensive damage to the old plantations. Young plantations are also not spared. The grub makes irregular tunnels inside the trunk and feeds on the bark. Infested plants show falling off of fruss near the base of trunk as these are expelled out by the grub. Unattended old plants are mostly attacked. The mature roots are attacked by the grub of the insect. It is a highflier. Grubs are medium to large in size (5 cm x 15 cm length). Extensive feeding results in death of the plants within a period of 1 to 3 years.

**Harvesting**:

Harvesting of cashew nuts for its kernel starts by March to June. Nut maturity is a varietal character from a short duration to long duration. The nuts are allowed to be matured fully along with the apples. The apple matures slower than the nuts. Mature nuts show brown colour. The ripened apples are yellow, red and yellow reddish in colour. Cashew apples are used for various industrial uses as well as in preparation of pickles and jams. If only nuts are to be used then it is better to allow the nuts to fall naturally. The mature well filled nuts sink in water easily which is used as a selection criterion of mature nuts. As soon as nuts are collected, they should be washed and sun dried as a pre-conditioning measure.

**Processing of cashew nuts**:

Processing of raw cashew nuts consists of conditioning of nuts, shelling, drying, humidifying, peeling, grading and packing of kernels.

**Conditioning:**

Harvested mature cashew nuts are sun dried for two days soon after harvesting to bring the moisture content from 16% or above to 8 to 9%. Then the nuts are packed in gunny bags and stored for further processing.

- Conditioning is required to make the nuts hard and brittle so that the shell can be removed without damaging the kernel inside.
- Conditioning is done in three ways. They are drum roasting, oil bath roasting and steam roasting. Among these, steam roasting is most commonly followed which have the added advantage of utilizing the cashew shell nut liquid (CSNL) for further industrial use.

**Steam roasting:**

The sun-dried cashew nuts are roasted in steam under pressure of 25 to 30 lb/inch for 20 to 30 minutes. Then the nuts are allowed to cool 24 hours before shelling.

**Shelling**

- Shelling requires hand and foot operated mechanical devices in which the roasted nut is held by fingers between two pairs of blades of the shelling machine, in such a way that the kernel never comes into contact with blades.
- Then the splitted nuts become easy to scoop out the kernel, 92 to 95% kernel recovery is possible with the hand and foot operated sheller.

**Drying of kernel**

- Scooped out kernels are then sent to the drier in trays to be dried in the hot chamber at $78^0$ to $80^0$ C for 6 to 8 hours to bring the moisture content in the nuts to 4 to 5%.
- For uniform drying, the trays used for spreading the kernels are changed in position in the chambers.
- Dried kernels in the same trays from the hot chamber are brought to a humidifier room to facilitate easy peeling of seed coat.

**Peeling**

- Peeling of seed coat (testa) is done with the help of sharp knives or bamboo edges.
- 70% of kernels are recovered through peeling operations.

**Grading**

- Grading of peeled kernels is done manually.
- Kernels are graded according to size of wholesome or bits. There are many

commercial grades viz., W180, W210, W240, W320, W450 and W500.

- The large size kernels are graded as W180 (309 to 410/kg) and smallest grades are W500 (1000 to 1100/kg).
- The common grades are WW (White whole), SW (Scorched whole), DW (Dessert whole), SWS (Scorched whole seconds) etc.
- Pieces are also graded as B (Bits), S (Splits), LWP (Large white pieces), BB (Baby bits), SB (Scorched bits), SS (Scorched splits), SSP (Scorched small pieces), SPS (Scorched pieces seconds), DP (Dessert pieces).

**Packing**:

The export trade required packing of kernels in 11.3 kg tin containers which are hermetically sealed by infusing $CO_2$. Moulded Vacuum Packing (MVP) is gaining popularity where nitrogen flushing is done to avoid oxidative rancidity.

**Important address for planting materials-**

1. The Director,

   National Research Centre for Cashew, Puttur – 574 202, Dakshina Kannada, Phone 08251 – 221530 (O), 08251 – 224539 (R)

   E-mail: nrccaju@sancharnet.in

2. Cashew Research Station, Acharyya NG Agricultural University, BAPATLA – 522101

   Guntur District, Andhra Pradesh, Phone No. (08643) 225304

3. Cashew Research Station, Department of Horticulture,

   Orissa University of Agriculture & Technology Bhubaneswar – 751003, Orissa

4. Regional Research Station,

   Bidhan Chandra Krishi Viswa Vidyalaya Jhargram Farm, P. O. Jhargram – 721 507, Midnapore District West Bengal,

   Phone No. (03221) 255593, E-mail : spc@cal.vsnl.net.in

# BER

*Ziziphus mauritiana* Lam.

**Cultivars**: Apple, BAU, Thailand

**Soil:** It can be grown on any type of well-drained soil rich in organic matter.

**Propagation:** Budded plants

**Time of planting:** April to September

**Planting and population:**

Pits of 45 cm x 45 cm x 45 cm size should be dug, refilled after 7-10 days with addition of 5 kg of FYM or 2 kg vermicompost. Spacing of 5 m x 3 m should be adopted, for high density planting it can be reduced to 3 m x 2.5 m distance.

**Manure and Fertilizer:**

10 to 12 kg FYM along with 200 g N, 250 g $P_2O_5$ and 100 g $K_2O$ to be applied from second year onwards. The recommended fertilizer is to be applied in March (after pruning) and October. 25 g Borax is to be applied to each plant during the application of fertilizers.

**Cultural practices:**

**Training and pruning:**

1. The sprouts appearing from the trunk below the bud union should be removed regularly.
2. The young plants should be provided support by bamboo.
3. Branches appearing on the stem up to 40-50 cm of trunk should be removed.
4. Select 4-6 side branches in all directions to have a balanced frame.
5. After harvesting of fruits, branches are to be headed back to 30 cm above the graft union to encourage new shoots.

**Weeding, irrigation and mulching:**

Weeding should be done at least three to four times a year. Hand weeding can be partially eliminated by chemical weedicides like paraquat 1.0 kg/ha. Black polythene (50 micron) can also be used for effective control of weeds, conserving soil moisture and to improve yield and quality of fruits. Watering should be done at the interval of 2 weeks as during flowering and fruiting as water stress during this period causes yield reduction.

**Plant Protection:**

a) **Ber fruit fly:** Use methyl eugenol trap @ 20 number/ha when the fruits attain pea size.

b) **Leaf eating (Chafer) beetle**: Use of light trap for collecting adult beetle, spraying of thiamethoxam 25WG @ 26 g ai/ha

c) **Powdery Mildew:** Dusting with sulphur @ 150-200 g/tree and subsequently 2-3

dusting at an interval of 15-20 days

d) **Alternaria leaf spot and *Cercospora* leaf spot:** Spraying of Chlorothalonil 75 WP @ 2 g/lit of water as soon as the disease appears. Two to three sprays should be given at an interval of 15-20 days.

**Harvesting:**

Harvesting is done when the fruits become yellow in colour during the months of January-February. About 4-5 pickings can be done in a season.

**Yield:**

300-400 q/ha depending upon spacing, variety and cultural practices

# STRAWBERRY

*Fragaria x ananassa* Duch.

**Cultivars**: Chandler, Festival, Sweet Charlie, Early Dawn

**Soil:** Land should be thoroughly prepared by deep ploughing followed by harrowing. Liberal quantities of organic manure should be incorporated in the soil before planting. Runners can be planted on flat beds in the form of hills or in mated rows. In irrigated condition planting should be done on ridges.

**Propagation:** Tissue cultured plants, Runners

**Time of planting:** November

**Spacing:** Plant at a spacing of 45 cm x 45 cm

**Planting:** Planting should be done in a raised bed (15 cm high and 1.8 m wide) mulched with black plastic (30-micron thickness). Crown portion of the plant should be above the soil surface. Straw (4-6 inch thick) can also be used as mulch.

**Manure and Fertilizer:** 5 kg FYM along with 10-7-7 g N-$P_2O_5$-$K_2O$ is to be applied per sqm area. Phosphorus fertilizer should be incorporated before planting while N is to be applied in two splits at 3 weeks after planting and K fertilizer at flowering stage.

**Cultural practices:**

**Irrigation:** Watering should be done at 3-4 days intervals depending on the moisture status of soil. During fruiting frequent irrigation increases the fruit size and yield.

**Plant Protection:**

1) **Red spider mite** and **cutworms:** These are common insect-pests in strawberry. The mite can be controlled by application of spiromesifen 22.90 SC @ 72 g ai/ha. Cut worms can be controlled by application of clothianidin 50 WDG @ 80 g ai/ha or thiamethoxam 25 WG @ 26 g ai/ha.
2) **Red stele:** Caused by *Phytophthora fragaria.* Soil drainage and crop sanitation is to be maintained. Soil application of fosetyle AI 80 WP @ 0.2% in severely infected area.
3) **Root rot:** Drench the affected plants with chlorothalonil 75 WP @ 2 g/lit of water
4) **Leaf spot / Black spot:** Chlorothalonil 75 WP @ 0.2% or COC @ 0.25 % sprays at weekly intervals when the disease appears. Rotation of strawberry with other crops like legume vegetables (beans, peas etc.) reduces the infestation.

**Harvesting:** Fruits ripen during February to April

For the local market fruits should be harvested when fully ripe. For distant markets, fruits should be firm but should be harvested before development of colour.

**Yield:**

200-250 q/ha depending upon spacing, variety and cultural practices

# Dragon fruit

*Hylocereus spp*

**Types and Cultivars of dragon fruit:**

- Alice: Red colour fruit with white colour flesh (*Hylocereus undatus*)
- Bloody Marry, American Beauty, Costa Rican sunset, Dark Star: Red colour fruit with red colour flesh (*Hylocereus costaricensis*)
- Yellow dragon fruit: Yellow colour fruit with white colour flesh (*Hylocereus megalanthus*)

**Soil:**

Dragon fruit can be grown in a wide range of soil but sandy loam soils with high organic matter content and good drainage facility are the best. Soils with 10-30% of sand are preferred for dragon fruit. It prefers slightly acidic soil within a pH range of 5.5 to 6.5.

**Propagation:** By cuttings

**Time of planting:** April to September

**Planting:**

Pits of 60 cm x 60 cm x 60 cm sizes should be dug, refilled after 7-10 days with addition of 5 kg FYM or 2 kg vermicompost. The cured cuttings are planted at a spacing of 2.5 m x 2.5 m. A concrete post (1.8 m height above ground) should be provided as support. The number of cuttings per post varies from 3-4; number of poles per ha: 1600.

**Manure and fertilizer:**

During the first year, Urea, SSP and MOP @ 70:90:40 g/plant should be applied along with 10 kg of FYM in 2 equal splits *i.e.,* at 3$^{rd}$ and 6$^{th}$ month after planting. From 2nd year onwards, 15 kg of FYM along with Urea, SSP and MOP @ 150:150:300 g/plant should be applied at 3 equal splits *i.e.*, April, July-August and December.

**Cultural Practices:**

**Training and pruning:**

The immature vines should be tied with the supporting post loosely to avoid snapping of the matured plant parts. The lateral branches should be pruned when the vines grow towards the trellis and 2-3 main vines should be allowed to grow. Once the vines reach the trellis free branching is allowed. It is recommended to have a round/circular metal frame to maintain the fully grown dragon fruit plant in balance. After harvesting, only 50 main branches with one or two secondary branches are allowed and tertiary and quarterly branches are removed. Once pruned, the pruning cut ends should be treated with fungicide.

**Irrigation:**

Dragon fruits can withstand certain periods of drought, whereas they require significantly more water than other cacti members. However, too much water may result in bacterial and fungal diseases and lack of soil moisture reduces the number of flowers, thereby reducing the yield.

**Weeding:**

Weeding is required in dragon fruit planting sites up to 1 m in diameter around the planting zone

**Plant Protection:**

1) **Stem rot:** Caused by *Xanthomonas campestris*, *Fusarium oxysporium*. Control measures include pruning of infected parts, proper nutrition and Copper compound (Copper oxychloride @ 0.2%) sprays.
2) **Anthracnose:** Caused by *Colletotrichum gloeosporioides*. Fungicidal sprays like chlorothalonil @ 2 g/liter of water would be able to control the disease.

**Harvesting:**

The plant starts bearing fruits after 1-1.5 years of planting. The fruits are harvested in June to October in 5-6 flashes. The mature fruit turns full red or yellow colour after 40-45 days of fruit set. For local markets, the fruits can be harvested 3-4 days after the skin color changes from green to pink/red, while for distant markets it can be harvested one day after colour change.

**Yield:** Average yield is 12-14 tones per hectare from third year onwards

# HI-TECH NURSERIES

Nursery is a place where seedlings, saplings or any other planting materials are raised and sold out for planting in gardens and orchards. The nursery industry is diverse, comprising such varied operations as the production of potted plants, cut flowers, greens, ornamentals, fruit and tree nursery plants. The initial planting material is the basic requirement on which both the quality and quantity of the final crop depends.

**Objectives of nursery production**

- To raise healthy and disease-free planting materials
- To distribute plant materials in masses who have little knowledge about the techniques of raising plants
- To introduce exotic species/cultivars
- Planting of nursery grown plants is the surest method of artificially regenerating poor and barren sites
- Replacement of casualties

**Selection of site for the nursery**:

The selection of site for the nursery should be made after considerable care and thought since location has a great impact on the overall success of the nursery. The land for the nursery should be leveled for most efficient use. Areas that are prone to flooding should be avoided. The soil should have good structure and porosity. Sites with degraded topsoil should be avoided.

**Propagation structures**:

Different types of propagation structures like greenhouse, hot bed, cold frame, lath house, net house and mist chambers, etc. are routinely used under different agroclimatic conditions for different crops.

**Propagation techniques**:

It includes all the steps involved in the propagation/ multiplication of a particular crop/cultivar, from beginning to the end, i.e., it provides a schedule of activities for propagation. Plant multiplication involves either sexual or asexual propagation.

**Containerization**:

Plastic bags of appropriate size, root trainers, earthen pots or trays can be utilized at various stages of plant multiplication. These containers can be shifted to greenhouses for protection against rain, cold or high temperature for quick growth.

**Rooting media/potting mixture**:

Field soil can be used in container mixes (10-30% by volume) but requires the additional step of pasteurization to eliminate disease and weed seeds. Though peat moss can be used as an alternative, it is a non-renewable resource.

**Importance of mother plants**:

Stock or mother plants should receive every care in the way of pruning, manuring and weed control to keep them in good condition over a period of years. The aim should be to keep them as far as possible, in strong vegetative condition. Both the rootstock and the scion determine the performance of a compound horticultural tree. Choice of a scion is based on its quality, yield performance, adaptability and other horticulturally desirable traits. Rootstocks exhibit a great effect on the production efficiency, yield, quality, adaptability, tree vigour and resistance to biotic and abiotic stresses of scion cultivar. The primary function of rootstock is to provide anchorage by growing roots deep into the soil and to regulate the uptake of moisture and nutrients.

**Care of nursery plants**:

Proper care of nursery plants including timely application of manures and fertilizers, irrigation and weed control should be undertaken. Regardless of fertilizer type, whether the source is synthetic or organic in sustainable nursery production, the emphasis is on zero runoff. Organic or synthetic slow-release fertilizers help to cut down levels of nitrates in runoff water. Foliar feeding can be used to supplement soil and liquid fertilization. The two most widely used irrigation systems are overhead and drip and each has certain advantages and disadvantages. Weed control is extremely important in container production, since large quantities of media are lost when big weeds are pulled out of containers.

**Some marketing tips**

Effective marketing is the key to profitability and success of a nursery:

1. Ensure reliable and consistent plant availability
2. Proper labeling & proper displaying
3. Place plant in clean containers/proper location
4. Nurseries must be registered
5. Proper quarantine measures
6. Adding value to the product
7. Market research

# VEGETABLE CROPS

## PROCEDURE FOR 'NURSERY RAISING' OF TRANSPLANTED VEGETABLE CROPS

**VEGETABLE CROPS**:

1. Select a sunny area with well drained friable light soil rich in organic matter.
2. Bring the soil into fine tilth and prepare the bed of 1 m width and of convenient length. Raise it to 10-15 cm above ground level.
3. For an area of 10 $m^2$ in the bed, mix 20 kg sand or silt and 20 kg compost (well decomposed, dried and sieved) thoroughly.
4. To make the soil free from soil-borne disease-causing pathogens (most common disease in the nursery is the 'Damping-off') drench the bed with 0.2% solution of Chlorothalonil or Carboxin so as to saturate the soil up to a depth of 10-15 cm.
5. Keep it covered, immediately after treating, with a polythene sheet or gunny bag or thick paper for 2 days.
6. Uncover the soil and get it loosened and leave it as such for 3 to 4 days
7. Treat the dry seeds with Carboxin@ 2 g/kg seeds against seed-borne pathogens.
8. Apply Clothianidin 50 WDG @ 80 g ai/ha as soil drench in order to protect the seedlings from soil insects.
9. Sow the seeds thinly in U-shaped furrows spaced at 2.5 cm and at a depth of 1- 2 cm (4 times the diameter of the seed). Cover the seeds immediately with a thin layer of sand mixed with well dried and sieved cow dung. The surface should be leveled and formed by a wooden leveler.
10. Water the sown beds using a water can fitted with a fine rose.
11. Cover the beds with a thin layer of straw, banana leaf or dried grass to prevent displacement of seeds. The cover should be removed at the first appearance of sprouts.
12. The seedlings get ready for transplanting when they attain 10-15 cm height or become 30-35 days old. Avoid shading or protection of seedlings; allow maximum sunlight except in case of expected injury due to heavy rain or frost.
13. Harden the seedlings before lifting by gradual reduction of water for about 7 days.
14. Soak the beds 6 hours before lifting to facilitate the maximum retention or roots and plant turgidity.
15. Dip the seedlings in plant protection formulations just before transplanting to avoid attack in the initial stage of establishment.

**Secondary Nursery:**

In case of costly seeds, hardening of seedlings of Cabbage, Cauliflower, Knolkhol, Tomato, Brinjal, Chilli etc. can be done by pricking them to a wider spacing of 5-10 cm either way in a well-prepared secondary nursery when their first pair of true leaves develop. Shade should be provided for at least 5 days after planting.

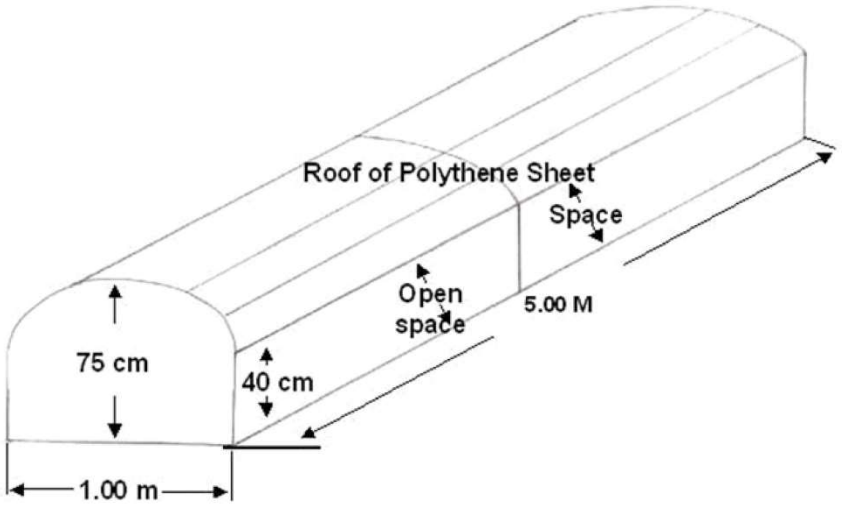
## CULTIVATION OF HYBRID VARIETIES OF VEGETABLES

Hybrid varieties of vegetables are comparatively superior in respect of yield and quality as compared to the traditional varieties. Presently, a number of Govt. organizations and private seed companies have developed some hybrid varieties with high yielding attributes. Moreover, a large amount of hybrid seeds is imported each year by the private companies and sold in the domestic markets. These are widely accepted by the farmers of our country. Every year new hybrid varieties are incorporated into the cultivation stream making the former ones obsolete, and hence, it is not possible to standardize agro-techniques for each and every variety at the University level. It is, therefore, advisable to adopt as such the package of practices of these hybrid varieties recommended by the concerned companies for Assam. However, some hybrid varieties of tomato, cabbage, cauliflower, capsicum and cucumber released by IAHS and HOECHST were tested at AAU and had been found promising for Assam conditions.

**The comprehensive package of practices for various hybrid varieties of vegetables, as per IAHS Company leaflet, is given below:**

| **Vegetable** | **Tomato** | **Cabbage** | **Cauliflower** | **Brinjal** | **Capsicum** | **Cucumber** | **Okra** |
|---|---|---|---|---|---|---|---|
| Varieties | Rupali<br>Vaishali<br>Naveen<br>Mangla<br>Avinash-2<br>Namdhari<br>Suraksha<br>Karnataka | Ganga<br>Yamuna<br>Kaveri<br>Green Express | Swati<br>Himani | Suphal<br>Round-14<br>Long-13 | Bharat | Priya | Vijay<br>Vishal<br>Varsha |
| Sowing & transplanting | Throughout the year except the heavy rainy periods | Throughout the year except the heavy rain periods,<br>Kavery can tolerate very high temp. | June-July.<br>These varieties are heat tolerant | September-November.<br>Long-13 can be grown year round | August-October<br>January-February | March-April | Feb-July |
| Seed rate/ha | 150 g | 300 g | 300 g | 200 g | 375 g | 375 g | 3.5 kg |
| Manure & fertilizer (per hectare) | FYM 360 q<br>N 120 kg<br>$P_2O_5$ 200 kg<br>$K_2O$ 200kg | FYM 250 q<br>N 170 kg<br>$P_2O_5$ 100 kg<br>$K_2O$ 120kg | FYM 300 q<br>N 250 kg<br>$P_2O_5$ 100 kg<br>$K_2O$ 120kg | FYM 250 q<br>N 120 kg<br>$P_2O_5$ 100 kg<br>$K_2O$ 100kg | FYM 360 q<br>N 170 kg<br>$P_2O_5$ 120 kg<br>$K_2O$ 120kg | FYM 250 q<br>N 120 kg<br>$P_2O_5$ 75 kg<br>$K_2O$ 75kg | FYM 150 q<br>N 120 kg<br>$P_2O_5$ 90 kg<br>$K_2O$ 60kg |
| Spacing | 45cmx75cm<br>75cmx75cm<br>60cmx90cm | 45cmx30cm<br>45cmx60cm | 45cmx 30cm<br>45cmx 60cm | 60cm x90cm<br>90cm x90cm | 30cmx60cm<br>45cmx60cm | 120cmx60cm | 30cmx60cm<br>45cmx60cm |
| Duration from sowing to first harvest | 90-120 days | 100-130 days | 100-130 days | 90-110 days | 3.5 months | 70 days | 50-55 days |
| Average weight of edible part | 70-80 g | 1750-3000 g | 700-1200 g | 250-500 g | 150-200 g | 300-500 g | 10-15 g |
| Yield per ha. | 300-400 q | 300-350 q | 120-150 q | 250-350 q | 180-240 q | 100 q | 150 q |

## Details of structure for raising of seedling in nursery




**Breadth: 1 m, Length: 5 m, Height of Post: 40 cm in the side, 75 cm in the middle**

# LAYOUT OF KITCHEN GARDEN

**Objectives of Kitchen Gardening**:

1. To meet the daily requirement of balance diet (85 g fruits, 75-125 g green leafy vegetables, 75 g root or tubers and 100 g of other vegetables)
2. To produce fresh and quality vegetables
3. To utilize the labour of the family members profitably
4. To obtain pleasure, inspiration and a means of recreation

**Principles of Kitchen Gardening:**

1. Select a well-drained sunny area in the backyard near the water source.
2. The size and design of the garden depend on availability of land. However, the garden should preferably be rectangular in shape.
3. Selection of crops is governed by choice of the family, size of the garden and time available to devote in the garden.
4. 200 sq.m area is sufficient for a five-member family to supply 1.5 kg of vegetables per day.
5. Quick growing plants like banana, papaya, lemons etc. should be planted in the northern side of the garden and climbing types of vegetables like cucurbits, dolichos, etc. can be grown near the fence or boundary wall.
6. To ensure a steady and regular supply of vegetables, several sowing of a particular crop at short intervals should be done during the season.
7. Ridges which separate the beds may be utilized for growing root crops like radish, carrot, etc.
8. Early maturing crops should be planted together in continuous beds so that the area can be made available at one for putting late crops.
9. Interspaces of the long duration crops like brinjal, tomato, chillies, etc. may be utilized for quick growing crops like spinach, beet, lettuce, knolkhol, etc.
10. One or two compost pits should be dug in the corner of the garden to dispose of the plant residues which will be reutilized as compost material.

**Recommended Vegetable Cropping Pattern for the Main plots**:

1. Radish + Turnip /Beet (Oct.-Dec.) - Knolkhol (Jan-March) - Bitter gourd (April- July) - Lai + Palak (Aug-Sept.).
2. Late Cabbage (Nov-Feb) - Okra (March-June) - Early Cauliflower (July-Oct.).
3. Tomato (Sept.-Early Dec.) - Late cauliflower (Late Dec. - March) - Okra (April - July).

4. Mid cauliflower (Oct-Jan) - Amaranth (Feb-May) - Okra (June-Sept).
5. Knolkhol (Sept - Nov.) - Palak + French bean (Dec - April) - Bitter gourd (May-Aug).
6. Potato (Oct - Jan) - Cucumber (Feb - June) - Ridge gourd (July - Oct.).
7. Potato (Oct - Jan.) - Bitter gourd (Feb - May) - Okra (June - Sept.).
8. Brinjal (Sept - Jan.) - Snake gourd (Feb - May) - Cowpea (June - Aug.)
9. Onion (Oct - Feb.) - Cowpea (March - May) - Cucumber (June - Sept.)
10. Garlic + Coriander for leaf (Oct - Jan.) - French bean (Feb - April) - Cowpea (May - Sept.).
11. Carrot (Oct - Feb.) - Capsicum (Feb - June) - Brinjal (July - Oct.).
12. Tomato (Oct - Jan.) - Ridge gourd (Feb - May) - Cucumber (June - Sept.)
13. Okra (March - June) - Radish (July - Sept.) - Brinjal (Oct - Jan.).

**Crop Rotation for Fencing or Permanent "Chung"**

1. Bitter gourd (Dec - March) - Cucumber (April - June) - Sponge gourd (July - Nov.)
2. Pumpkin (Sept - Feb.) - Ridge gourd (March - June) - Bitter gourd (July - Oct.).
3. Cucumber (Dec - March) - Bitter gourd (April - July) - Dolichos bean (Aug - Dec).
4. Cowpea (Jan - March) - Ash gourd (April - July) - Dolichos bean (Aug - Dec.).

# CAULIFLOWER

*Brassica oleracea* L. var *botrytis*

**Variety**:

**Early**: Early Kunwari, Pusa Katki and Pusa Deepali.

**Mid**: Improved Japanese, Pusa Synthetic, Pusa Snowball and Main Crop Patna.

**Late**: Snowball-16, Pusa Snowball K-1 and Hissar-1.

**Description**:

**Early Kunwari**: Plant short, bluish green leaf with waxy bloom, small to medium curd, tends to grow loose faster, hemispherical with even surface.

**Pusa Katki**: Plant medium; bluish green leaf with waxy bloom; curd small to medium.

**Pusa Deepali**: Plant medium tall, leaf short erect, waxy, green, curd medium compact, white, self-blanching uniform, well protected by leaves, riceyness is almost absent, maturity 100-120 days.

**Improved Japanese**: Plant tall, erect, leaf bluish green, not incurved, curd large, compact, white, maturity 90-95 days.

**Pusa Synthetic**: Plant erect, leaf Nos. 24-28, varying in colour, curd medium, somewhat creamy white to white compact, maturity 130 days, yields 225 q/ha.

**Pusa Snowball**: Curd medium sized, solid and of attractive snow white colour.

**Snowball-16**: Plant short, 24 to 28 outer leaves, upright grayish green, incurved, curd medium, compact, snow white and self-blanched, maturity 90 days.

**Pusa Snowball K-1**: Plant spreading, outer leaf 24-28 nos., self-blanched, snow white, maturity 90-95 days, resistant to black rot.

**Soil:**

Well drained sandy loam for early and well drained loam to clay loam for mid and late varieties. Optimum pH- 6.0-7.0

**Seed bed preparation and seedling raising:**

Early cauliflower seedlings can be successfully raised under poly tunnels.

Refer to “Procedure for Nursery Raising of Transplanted Vegetable Crops”:

**Field Preparation:**

Land should be prepared to a fine tilth and FYM or compost to be applied. It is advisable to apply slaked lime every 3 years according to the soil test result. Lime should be applied at least 30 days before planting.

**Seed rate:**

400 g/ha for early season crop (53.3 g/bigha)

300 g/ha for mid-season crop (40 g/bigha)

400 g/ha for late season crop (53.3 g/bigha)

8-10 g of seeds should be sown per sq.m.

**Time of sowing:**

1. **Early**: From mid-July to first week of August (Matures by October).
2. **Mid**: From first week of September to last week of October (Matures by Dec - January).
3. **Late**: Up to the first week of November (Matures by Feb - March).

**For North Bank Plain Zone:**

Early – Last week of August

Late Mid – First week of November

Late – Last week of November

**Spacing**: (Row to Row x Plant to Plant):

Early: 45 cm x 45 cm

Mid: 60 cm x 60 cm

Late: 45 cm x 45 cm

**Manures and Fertilizers**:

FYM @ 10 t, N 80 kg, $P_2 0_5$ 60 kg and $K_2 0$ 60 kg/ha (1.3 t FYM, 23.5 kg Urea, 50.4 kg SSP, 13.6 kg MOP/bigha). Half of N and full doses of FYM, $P_2 0_5$ and $K_2 0$ should be applied as basal and the remaining half of N to be top dressed at 30 days after planting (during earthing up). For the kitchen garden, half of N and whole of $P_2 0_5$ and $K_2 0$ may be applied by ring method around the plant at 15 days after planting and the other half of N at 30 days after planting.

Apply either 8 kg of Borax (1.1 kg/bigha) or 6 kg of Boric acid (0.8 kg/bigha) powder per ha along with basal fertilizers or spray 0.2-0.3% Borax (@ 1.6-2.4 kg/800 *l*/ha) against browning in boron deficient soils.

To prevent deficiency of molybdenum, apply Na or $NH_4$-molybdate @ 1-2 kg/ha along with basal fertilizers or irrigation water. Foliar spray of $NH_4$-molybdate 0.01- 0.1% @ 200-300 g/ha is also recommended. Foliar spray with commercial micronutrients formulation may be done.

**For Hill Zone**

(i) Apply boron 3000 ppm (3 g/*l*) as foliar spray 30 days after transplanting @ 650 liter spray solution/ha. Boron content in Borax is 11.3% and the Boric acid 17.5%

(ii) Apply commercial micronutrient formulation in two splits at 30-45 days after transplanting as per recommendation.

**Interculture**:

1. **Irrigation**: A light irrigation immediately after transplanting to be given and subsequent irrigations whenever required. In total five irrigations are sufficient.
2. **Weeding**: First weeding at 20 days and the second at 40 days after transplanting

**Plant Protection**:

**(1) Caterpillars and other leaf eaters**: Spray chlorantraniliprole 18.5 SC @ 1 ml /3 liters of water. Apply emamectin benzoate 5 SG @220 g/ha. Spray flubendiamide 39.35 EC @0.1%.

**(2) Field-cricket, cutworm, red ants and other soil insects**: Apply clothianidin 50 WDG @ 80 g a.i./ha.

**(3) Black rot:** Drench the soil with 100-200 ppm solution (0.1-0.2g/lit) of agrimycin or Streptomycin after transplanting.

**Harvesting**:

Cauliflower is harvested when the curds obtain proper size.

**Yield**:

150-175 q/ha for early and mid and 175-200 q/ha for late crop

**Seed yield**: 25-40 q/ha

## SEED PRODUCTION OF EARLY CAULIFLOWER

**Variety**: Pusa Katki

**Time of Sowing**: Second fortnight of July

**Benefit: Cost Ratio:** 5.16

# SPROUTING BROCCOLI OR BROCCOLI

*Brassica oleracea* var. *italica*

**Variety:**

**Early**: Early Danish Giant, De Cicco, Green Bud, Sparton Early, Coastal and Atlantic.

**Mid**: Green sprouting medium

**Late**: Waltham 29, Green Mountain, Coastal and Atlantic

**Hybrid:** Southern Comet, Premium Crop, Clipper, Laser (extra early and early), Corsair, Cruiser, Emerald, Corona (mid-season) and Late corona, Stiff, Kayak and Green Surf (late)

**Soil:** Soil with high organic matter either through incorporation of FYM or compost or green manuring crops. Broccoli is slightly tolerant to acidic soils. Optimum pH 6 to 6.8.

**Seed bed preparation and seedling raising:**

Refer "Procedure for necessary raising of transplanted vegetable crops"

**Field preparation:** Same as cauliflower

**Seed rate:** 300-400 g/ha (40-53.3 g/bigha)

**Time of sowing:** Same as cauliflower

**Spacing:** 60 cm x 45 cm

**Manures and Fertilizers:**

FYM @ 20 t, N 120 kg, $P_2O_5$ 80 kg and $K_2O$ 60 kg/ha (2.7 t FYM, 35.2 kg Urea, 67.2 kg SSP, 13.6 kg MOP/bigha). Nitrogen should be applied in split doses. Molybdenum and Boron should also be applied as in case of cauliflower.

**Interculture:**

**Irrigation**: Requires more water than cauliflower. Light irrigation at regular intervals should be applied.

**Weeding:** The early-stage hoeing is necessary in order to provide good aeration as well as to make the plot weed-free before irrigation.

**Plant Protection:** Same as in cauliflower

**Harvesting:** Harvesting should be done when the head is compact and green but before the opening of buds. Over matured buds will open and the heads become loose which is unsuitable for marketing. Only the green head should be harvested leaving the whole plant intact to facilitate the growth of axillary head (cull head) which can be harvested as ratoons.

**Yield:** 5 to 15 t/ha, depending upon the variety, time of planting and length of harvesting period.

**Benefit: Cost Ratio:** 5.26

# CABBAGE

*Brassica oleracea* L. var *capitata*

**Variety:**

**Early maturity**: Golden Acre, Pride of India, Pusa Mukta (Sel – 8)

**Late maturity**: Drumhead and Eclipse Drumhead

**Description:**

**Golden Acre**: Plant small, compact with a few outer leaves, short stemmed with small cup shaped leaves, head very uniform, solid and round weighing 1.5 to 2.5 kg, interior clear white, excellent in quality, early maturity (60-70 days), yield 280 q/ha.

**Pride of India:** Characterized by small solid round head weighing 1.0 to 1.5 kg, outer leaves few and slightly cup shaped, early maturity (60-70 days), yield 220 q/ ha.

**Pusa Mukta:** Plant short stalked, medium sized, leaf light green, margin wavy, leaf blade slightly puckered, head slightly flat, maturity 65 days. Average yield is 250 q/ha, resistant to black rot, suitable for salad purpose.

**Drumhead:** Head large, drum shaped, loose, late maturity (80-100 days), yield 450q/ha.

**Soil:** Well drained sandy loam with pH 5.5-6.5

**Seed bed preparation and seedling raising:**

Refer "Procedure for nursery raising of transplanted vegetable crop"

**Field Preparation:** Same as in cauliflower

**Seed Rate:** 400 g/ha for early varieties (53.3 g/bigha)

300 g/ha for late for late varieties (40 g/bigha)

10 g of seeds should be sown per sqm

**Time of Sowing:**

First week of September to last week of November.

**Spacing:** (Row to Row x plant to plant)

**Early maturity**: 45 cm x 45 cm

**Late maturity**: 60 cm x 45 cm

**Manure and Fertilizer:**

FYM @ 10 t, N 120 kg, $P_2 0_5$ 60 kg, $K_2 0$ 60 kg per ha and Borax 8 kg/ha (1.3 t FYM, 35.2 kg Urea, 50.4 kg SSP, 13.6 kg MOP, 1.1 kg Borax/ bigha).

Application method same as in Cauliflower.

**Interculture:**

1. **Irrigation**: Immediately after transplanting, light watering should be given and continued till the seedlings are established and subsequent irrigation should be given whenever required. Availability of water in soil should be as far as practicable, otherwise splitting may occur.
2. **Weeding:** Give two weeding, the first at 20 days and second at 40 days after transplanting.

**Plant Protection:** Same as for Cauliflower

**Yield:** 200-250 q/ha

**Benefit: Cost Ratio**: 3.0

# KNOLKHOL

*Brassica caulorapa* L var. *gongylodes*

**Variety:**

**Early maturity:** White Vienna

**Late maturity:** Purple Vienna

**Description:**

**White Vienna:** Plant dwarf with short stem and leaf, knob globular, light green smooth; flesh creamy white and tender with delicate flavour; maturity 60 days.

**Purple Vienna:** Flesh purplish; other character almost similar to white Vienna; maturity 70 days.

**Soil:** Well drained sandy loam with pH 5.5-6.5

**Seed bed preparation and seedling raising:**

Refer "Procedure for nursery raising of transplanted vegetable crops"

**Field Preparation:** Same as in cauliflower

**Seed Rate:**

900 – 1000 g/ha (120 – 133.3 g/bigha) 10 g of seed should be sown per sq.m.

**Time of sowing:**

First week of September to last week of November

**Spacing:**

30 cm x 25 cm (Row to Row x plant to plant)

**Manure and Fertilizer:**

FYM @ 10 t, N 80 kg, $P_2O_5$ 60 kg, $K_2O$ 60 kg and 8 kg Borax/ha (1.3 t FYM, 23.5 kg Urea, 50.4 kg SSP, 13.6 kg MOP and 1.1 kg Borax/ bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top-dressed at 20 days after transplanting.

**Intercultural operation:** Same as in Cauliflower

**Plant protection:** Same as for Cauliflower

**Harvesting:**

Harvesting should be done when knobs are fully matured before they become tuff, spongy and stringy.

**Yield:** Early maturing variety: 80 q/ha

Late maturing variety: 100 q/ha

**Benefit: Cost ratio**: 7.71

# TOMATO

*Solanum lycopersicum* L.

**Variety:** Punjab Chhuhara, S-12, Punjab Kesri, Pusa Early Dwarf, Sioux, Pusa Ruby, Arka Abha (BWR-1), Arka Alok (BWR-5) and BT-1**.** Late season variety like Kashi Aman and Kashi Adarsh (mid-February transplanting) is recommended for Assam condition

**Kashi Aman:** The fruits of this variety are round and very firm with a pericarp thickness of 0.52-0.57cm. The average fruit weight of this variety ranges from 80-110 g with an average locule number of 3-4. The fruits are attractive red in colour with an average total soluble solid content of 4.6 oBrix at red ripe stage. Average yield 50-60 tonnes/ha. Resistant to ToLCVD.

**Kashi Adarsh:** The fruits of this variety are round and very firm with a pericarp thickness of 6 mm. Average fruit weight ranges from 80-115 g with 3-4 locules. The fruits are attractive red in colour. Variety has an average yield potential of 60 tones/ha. Resistant to tomato leaf curl virus disease.

**Punjab Chhuhara**: Determinate, dwarf with good foliage cover; Prolific bearer, high yielder, fruit medium, pear shaped, pericarp thick; maturity 120 days; suitable for distant transport and processing.

**S-12**: Plant dwarf, bushy, early bearing , fruit medium sized, round, juicy, highly acidic; av. yield 175-280 q/ha; suitable for growing in the plains for fresh marketing (table purpose).

**Punjab Kesri**: Determinate, dwarf, bushy, fruit small, pear shaped, less pulpy; early maturity; yield about 268 q/ha , no fruit cracking, moderate incidence of late blight and fruit borer, susceptible to root-knot nematode, less suitable for processing.

**Pusa Early Dwarf**: Determinate, typical dwarf with compact fruiting, fruit slightly flattish in shape, medium large, uniformly red ribbed, maturity in 55-60 days after transplanting, yield 200-500 q/ha.

**Sioux**: Indeterminate, spreading; fruit round, smooth, medium to large, less seeded, sub-acid in taste, medium late maturity (70-80 days), avg. yield is about 250 q/ha, good for short distance markets and suitable for hilly regions.

**Pusa Ruby**: Indeterminate, spreading, less branched and hardy; fruit flattish round, small to medium, slightly acidic, early maturity (60-65 days), yield about 330 q/ ha, withstands hot and humid climate, good for fresh market and for marking ketchup; tolerant to excess rain.

**Arka Abha** (BWR-1): Semi determinate, fruits oblate, light green shouldered, average fruit weight 75 g, duration 135 days, yield 250 q/ha, resistant to bacterial wilt.

**Arka Alok** (BWR- 5): Determinate; fruits square round, thick fleshed with light green

shouldered, average fruit weight 100 g, duration 125 days, yield 350 q/ha, resistant to bacterial wilt.

**BT-1**: High yielder, tolerant to bacterial wilt

**Kashi Aman:** Attractive red-coloured fruits with 3-4 locules can be harvested in 70-75 days after transplanting. 55-60 g weighing, TSS 4.6 °Brix with an average yield of 395 - 430 q/ha, resistant to Tomato Leaf curl virus. The variety has the added advantage of planting in February for late season crops under Assam condition.

**Kashi Adarsh**: Fruits become harvestable in 70-75 days after transplanting. Average fruit weight ranges from 55-80 g with 3-4 locules. The fruits are attractive red in colour with average yield 380 - 430 q/ha. The variety is resistant to ToLCVD and is ideal for cultivation during main *Rabi* and early *Kharif* season.

**Soil:** Well drained sandy loam rich in organic matter with pH 5.0-7.0

**Nursery bed preparation and seedling raising:**

Refer "Procedure for nursery raising of transplanted vegetable crops".

**Field preparation:**

The land should be prepared to a fine tilth and FYM to be applied at least 15 days ahead of transplanting. Liming should be done earlier to transplanting, to raise the soil pH to optimum level. It is advisable to apply lime @ 10 q/ha in every three years depending upon soil testing.

**Seed Rate**:

Determinate & Semi-determinate varieties: 250 g/ha (33.3 g/bigha) Indeterminate varieties: 300 g/ha (40 g/bigha)

**Time of Sowing:** October – November.

**Spacing:** (Row to row x plant to plant)

60 cm x 45 cm (for both the determinate and semi determinate variety)

75 cm x 30 cm (for indeterminate variety)

**Time of planting for Hill Zone:**

To escape the leaf curl virus planting should be done in October.

**Manure and Fertilizer**:

i) FYM @ 10 t, N 75 kg, $P_20_5$ 60 kg and $K_20$ 60 kg/ha (1.3 t FYM, 22.0 kg Urea, 50.4 kg SSP and 13.6 kg MOP/bigha). Half of N and full doses of FYM, $P_20_5$ and $K_20$ should be applied as basal and the remaining half of N to be top dressed in one or two splits.

ii) Foliar application of Nitrogen in tomatoes is very effective. In that case, 40 kg/ha N should be applied as basal and 20 kg/ha N as foliar spray. The schedule for foliar spray to be followed is given below:

   a) Spray on the 30$^{th}$ day after transplanting by dissolving 9.71 kg urea in 1000 liters

of water for one hectare of land

b) Spray on the 40th day after transplanting by dissolving 14.1 kg urea in 1500 liters of water for one hectare of land

c) Spray on the 50th day after transplanting by dissolving 19.3 kg urea in 2000 liters of water for one hectare of land.

**Interculture**:

1. **Irrigation**: The first irrigation is to be given immediately after transplanting and subsequent irrigations at 10-15 days interval depending on soil condition.
2. **Weeding**: Pre-emergence application of Metolachlor @1 kg ai/ha followed by application of Grubber at 40 DAP is recommended. Alternatively, hoeing is to be done at 20 and 40 DAP.
3. **Growth regulator**: Spray 20 ppm of Gibberellic acid at 30 days after planting.
4. **Intercropping**: Knolkhol can be successfully grown with tomato as intercrop (1 row of tomato: 2 rows of Knolkhol).

**Plant Protection**:

**A. Diseases**

**1. Late blight**: (i) Against late blight, six spraying with copper oxychloride 50 WP @ 2 g commercial formulation /liter at an interval of 12 days.

OR

(ii) Spraying with dimethomorph 50 WP @ 1g commercial formulation per liter followed by copper oxychloride 50 WP @ 2g commercial formulation per liter in alternate application (3 sprays with the dimethomorph & 3 with copper oxychloride) at an interval of 12 days gives very good control if used at the following rates with high volume sprayer.

**Early stage** (1st month): 600 liter of water/ha

**Mid stage** (2nd month): 800 liter of water/ha

**Late stage** (3rd month): 1000 liter of water/ha

Use of sticker Triton (0.5 ml/*l*) will be essential in the spray solution for spraying during rainy weather.

Depending upon weather conditions, particularly in cloudy weather, copper oxychloride should be sprayed as a prophylactic measure. If disease appears, spraying should be done at an interval of 7 to 10 days depending upon weather conditions. While spraying, care should be taken to ensure wetting of the lower sides of the leaves.

(iii). 1% Bordeaux mixture (10 g $CuSO_4$ + 10 g lime + 1 liter water) is also effective in controlling blight in tomatoes.

2. **Wilt:**

**(i) Bacterial wilt:**

- Drench soil with 200 ppm Streptomycin.
- Grow resistant varieties.
- Apply oil cake.
- Apply "Asafoetida – Turmeric powder mixture (1 g Asafoetida + 5 g turmeric powder in 10 liters of water) to drench the soil 3 times i.e., at 15, 30 and 45 days after transplanting.

**(ii) Fungal wilt**: Drench soil with carboxin @ 0.2%

**B. Insect pests:** Apply emamectin benzoate 5 SG @ 220 g/ha, flubendiamide 39.35 EC @48 g ai/ha or 0.3 ml/*l*, chlorantraniliprole 18.5SC @ 40 gai/ha or 0.4 ml/*l*, lamda-cyhalothrin 5EC@ 20 g ai/ha or 1ml/*l*.

**Yield:** 350 – 400 q/ha

**Benefit: Cost ratio:** 6.41

# BRINJAL

*Solanum melongena* L.

**Variety:**

**Long**: Pusa Purple Cluster, Borbengena and BWR-34. Pusa Kranti, Pusa Purple Long

**Round**: Pusa Purple Round, Pusa Bhairav, BWR-12

**Oblong**: BB-7, Pant Samrat

**Description:**

**Pusa Kranti**: Dwarf and spreading growth habit, leaf long, narrow and highly lobbed, green coloured, non-spiny, fruit are 15-20 cm long, attractive dark purple in colour, less seeded, yield about 270 q/ha.

**Pusa Purple Long**: Plant semi-erect and dwarf, in habit; fruit glossy, light purple in colour, 25-30 cm long, smooth and tender; av. yield 275 (q/ha), maturity 100-110 days.

**Pusa Purple Cluster**: Plant tall erect, compact, sturdy with purple pigmentation on stem; leaf purple, non-spiny; fruits born in clusters of 4-8, 10-12 cm long, deep purple colour, av. yield 175 q/ha, maturity 75 days, relatively resistant to bacterial wilt and little leaf disease.

**Pusa Purple Round**: Plant very tall with thick stem of greenish purple colour, leaf highly lobbed with deep green colour; av. weight 137 g with only 6 fruits per plant, resistant to shoot borer and little leaf disease.

**Pusa Bhairav**: Resistant to phomopsis blight.

**BB–7**: Fruit oblong, borne in cluster, purple, yield about 200 q/ha, tolerant to bacterial wilt.

**BWR–34**: Fruit elongated, borne in cluster, purple; yield about 100q/ha, tolerant to bacterial wilt.

**Pant Samrat**: Resistant to fruit and shoot borer and bacterial wilt. (Recommended for bacterial wilt endemic areas)

**Soil:**

Well drained rich sandy loam for early and silt loam to clay loam for late crop. pH 5.5 – 7.0 is ideal.

**Seed bed preparation and seedling raising:**

Refer "Procedure for nursery raising of transplanted vegetable crops".

**Field Preparation:**

The land should be prepared to a fine tilth and FYM to be applied. Clothianidin 50 WDG 80 g ai/ha should be incorporated. It is advisable to apply lime every three years @ 20 q/ha depending upon soil test result. Liming should be done at least 30 days before planting.

**Seed rate:** 200 g/ha (30 g/bigha)

**Time of sowing:**

First week of September to October for winter crops and January to February for spring crop.

**Spacing:**

75 cm x 60 cm (Row to Row and Plant to Plant)

**Manure and fertilizer:**

FYM @ 10 t, N 50 kg, $P_2O_5$ 50 kg and $K_2O$ 50 kg/ha (1.3 t FYM, 14.7 kg Urea, 42.0 kg SSP, 11.3 kg MOP). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed in one or two installments.

**Interculture:**

**Irrigation and weeding:** Same as in tomato

**Brinjal-Okra Cropping Sequence**:

FYM @ 10 t/ha and N-$P_2O_5$-$K_2O$ @ 10-30-15 kg/ha is recommended for 1$^{st}$ crop of brinjal followed by 2$^{nd}$ crop of okra without FYM and with recommended dose of N-$P_2O_5$-$K_2O$.

**Plant protection:**

1. **Fruit and shoot borer**:
   - **a)** Apply emamectin benzoate 5 SG @ 220 g/ha or flubendiamide 39.35 EC @ 0.1% or chlorantraniliprole 18.5 SC @ 40 gai/ha.
   - **b)** Apply lamda-cyhalothrin 5EC @ 20 g ai/ha.
   - **c)** Growing of garlic as intercrop or boarder crop reduces the infestation
2. **Biointensive IPM against shoot and fruit borer**
   - Azadirachtin 1500 ppm @ 2 ml/liter of water
   - *Lecanicillium lecanii* @ 1x $10^8$ spores/ml (5 g/liter of water)
   - Eight releases of *Trichogramma chilonis* (MITS) @ 1,00,000 Nos./ha (13500 Nos./bigha) at weekly interval starting from initiation of flowering
3. **Bacterial wilt**: Soil drenching with 100 ppm of Streptomycin should be done.
4. **Fungal wilt**: Soil drenching with Carboxin @ 0.2% should be done
5. **White blight** (white mould): Spray azoxystrobin 23 SC @ 0.5 g/liter of water

**Yield:** 200 q/ha

# PEA

*Pisum sativum* L.

**Variety:**

**T-163**: Selection from local pea of Bulandshahr (UP). Plant type is medium tall of 100 to 120 cm in height and double-podded variety. Maturity: 100-120 days. Yield: 10-11 q/ha. Other characters: Pods are 7-8 cm long and light green in colour, bear 5-6 seeds per pod. 1000 seed weight 150-200 g. It is susceptible to powdery mildew and Fusarium root rot.

**Boneville:** Plant type: Medium tall and double podded variety (used as vegetables) 100 to 120 cm in height. Maturity: 110-120 days Yield: 10-12 t/ha. Other characters: Seeds are wrinkled and light greenish to white in colour, pods are light green, straight and 8-9 cm in length with 5-6 seeds per pod. It is susceptible to powdery mildew and fusarium root rot.

**HUP – 2**: T-163 x EC 33866. Plant type: Plants are tall, semi spreading and semi leafless, 130-140 cm in height. Maturity: 115-125 days. Yield: 13-15 q/ha. Other Characters: Bears 4-5 seeds per pod. The seeds are white, 1000 seeds weigh 200-250 g. It is resistant to powdery and downy mildew.

**KFPD 1**: Selection from material received from U.S.S.R. Plant type: Plants are dwarf, 50-60 cm in height. Maturity: 100-105 days. Yield: 18-20 q/ha.

**Other characters**: Bears 5-6 seeds per pod. The seeds are white and bold. 1000 seeds weigh 250-300 g. It is susceptible to powdery but escapes the disease because of earliness.

**Soil type**:

Peas can be grown on a variety of soils; well drained light soil is suitable.

**Liming**:

After soil test to bring pH around 6.0, the requisite quantity of lime is to be applied at least 21 days before sowing.

**Time of Sowing**:

The optimum time of sowing is mid-October

**Field Preparation**:

Peas generally require reasonably deeply worked soils. The field is to be ploughed 3 to 4 times to obtain a good tilth.

**Seed rate**:

1. T-163: 50 kg/ha or 7 kg/bigha
2. Boneville: 60 kg/ha or 8 kg/bigha

3. HUP – 2: 65 kg/ha or 8.5 kg/bigha
4. KFPD- 1: 77 kg/ha or 10 kg/bigha

In riverine tracts recommended seed rate 4-6 kg/bigha

**Relay cropping of pea**:

Pea seeds at 25-50% higher seed rate are to be broadcast in the standing crop of rice about 15-20 days before harvest, provided that the soil is in moist condition.

**Seed treatment**: Seed treatment with Carboxin @ 2 g/kg of seed of seed is recommended

**Spacing**: The seeds are to be sown in lines at spacing of 30 cm between rows and 10 cm between plants.

**Fertility Management**: Compost or FYM @ 4-5 t/ha or 6 q/bigha should be applied

| Nutrient requirement | | Name of fertilizer | Nutrient requirement (kg/ha) (Kg/bigha) | |
|---|---|---|---|---|
| **A. Without Rhizobium Culture** | | | | |
| N | 20 | Urea | 45 | 6 |
| $P_2O_5$ | 45 | SSP | 285 | 40 |
| $K_20$ | 0 | MOP | 0 | 0 |
| **B. With Rhizobium Culture** | | | | |
| N | 10 | Urea | 22 | 3 |
| $P_2O_5$ | 46 | SSP | 285 | 40 |
| $K_20$ | 0 | MOP | 0 | 0 |

For Upper Brahmaputra Valley, Lower Brahmaputra Valley and North Bank Plain Zones, 10 kg $K_20$/ha is recommended in addition to normal dose of N-$P_2O_5$-$K_2O$. In North Bank Plains Zone 10 kg Borax/ha is also recommended.

Diammonium phosphate (DAP) @ 100 kg/ha or 13 kg/bigha should be applied in lieu of urea and SSP in non-inoculated crops. N-$P_2O_5$-$K_2O$ may also be supplied in the form of mixed fertilizers.

**Suitable Rhizobium Culture**: *Rhizobium leguminosarum* can be used

**Irrigation**:

If required and available, one irrigation at 40-50 days of sowing may be given.

**Plant Protection**:

**A. Insect Pests**:

**1) Pod borer**: Spray chlorantraniliprole 18.5 SC @ 0.3 ml/liter at reproductive stage

against pod borers (*Etiella zinckenella* and *Helicoverpa armigera*) or apply lamda-cyhalothrin 5EC @ 20 g a.i./ha.

2) **Leaf miner & Aphid:** Apply thiamethoxam 25WG @ 26 g ai/ha or apply Emamectin benzoate 5 SG @ 220 g/ha.

**B. Disease**

1) **Wilt:** Seed treatment with carboxin @ 2 g/kg of seed
2) **Rust:** Foliar spray of Tebuconazole or Propiconazole @ 2 g/liter of water at 10 days interval starting from the appearance of disease
3) **Powdery mildew:** Foliar spray of wettable sulphur @ 0.5 % (2.5 to 3.5 kg in 500-700 ml in 500-700 liter of water) at 10 days interval starting from the appearance of disease.

**Harvesting:**

Harvesting should be done when 75-80% of the pods turn yellow.

**Seed storage:**

For seed storage, seeds should be treated with 3 g/kg seed black pepper powder to protect the seeds from storage pests such as *Callosobruchus* spp. Before treatment the seeds are to be dried to 10-12% moisture content level by sun drying for 10-12 days.

# FRENCH BEAN

*Phaseolus vulgaris* L.

**Variety:** Pusa Parvati, Contender, UPF-203, UPF-191 and Premier

**Description:**

**Contender**: Bush variety, ready for picking in 50 days, pod round, green, very long, curved at the tip, thick, meaty and stringless; very prolific bearer; suitable for most areas except very hot and dry localities; yield 160q green pods/ha.

**Pusa Parvati**: Bush variety; pod attractive, light green in colour, round and meaty; early variety, pods available 5 days earlier than contender; yield 170 q green pod/ha.

**Soil:** Well drained sandy loam with pH 5.5-6.0

**Field preparation:** Land should be prepared to fine tilth

**Seed rate:** 40 kg/ha (5.3 kg/bigha)

**Time of sowing:** October-March

**Seed treatment:** Seeds should be treated with Carboxin @ 3 g/kg seeds

**Spacing:** 45 cm x 30 cm

**Manure and fertilizer:**

FYM @ 20 t, N 30 kg, $P_2O_5$40 kg and $K_2O$ 20 kg/ha (2.6 t FYM, 8.8 kg Urea, 33.6 kg SSP, 4.5 kg MOP and 1.1 kg Borax/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed at flowering.

**Interculture:**

1. **Irrigation**: Irrigation should be given regularly. There should not be moisture stress especially in the early phases of crop growth, during blooming and pod development.
2. **Weeding**: First weeding at 20 days after emergence and subsequent weeding as per necessity

**Plant protection:**

1) **Aphid, Jassid and Beetles**: Spray flubendiamide 39.35EC 0.1%
2) **Anthracnose, Root rot and Wilt**: Treat the seeds with carboxin @ 2-3 g/kg before sowing, Spray azoxystrobin 23 SC @ 0.1% on the crop.
3) **Leaf spot**: Spray the crop with chlorothalonil 75 WP 0.2% (2 g/*l*) twice at 15 days intervals starting at one month after sowing.
4) **Bacterial Blight**: Treat the seeds with streptomycin sulphate @ 2.5 g/kg
5) **Mosaic**: Prophylactic measures should be taken against aphid vector by spraying lambda cyhelothrin 5 EC @ 150- 250 ml/ha.

**Harvesting:**

The pods become ready for harvest in 2-3 weeks after first bloom. Pods should be harvested while they are young and tender.

**Yield:** 80-120 q of green pod/ha

**Seed storage:**

Seeds should be treated with 3 g/kg seed black pepper powder to protect the seeds from storage pests such as *Callosobruchus* spp. Before treatment the seeds are to be dried to 10-12% moisture content level by sun drying for 10-12 days.

# DOLICHOS BEAN

*Dolichos lablab* L.

**Variety:** Pusa Early Prolific, HD-18 and local cultivars

**Hill Zone**: DC-4 and DC-5

**Description:**

**Pusa Early Prolific**: Pole type; pod long, dark green curved, thin in bunches, 4-5 seeded; suitable for early crop, maturity 70-80 days, yield 50-60 q of green pods/ ha, less susceptible to *Cercospora* leaf spot and mosaic, aphid tolerant.

**HD-18**: Pole type, pod dark green, curved, 4-5 seeded, maturity 110-120 days; yield 40-60 q of green pods/ha, tolerant to aphid and mosaic.

**DC-4**: Pod medium broad, flat purplish green in colour, slightly curved. av. yield 39-44 q/ha.

**DC-5:** Pod broad, flat of medium length, green in colour and curved, av. yield 38 q/ha.

**Soil:** Well drained sandy loam rich in organic matter with pH 5.5-6.0

**Field preparation:** Land should be prepared thoroughly to a fine tilth

**Seed rate:** 20-30 kg/ha

**Sowing time:** July-August

**Seed treatment:** Seeds should be treated with carboxin @ 2-3 g/kg seeds

**Spacing:** 1.25 m x 75 cm

**Manure and Fertilizer:**

FYM @ 20 t, N 30 kg, $P_2O_5$ 40 kg and $K_2O$ 20 kg/ha (2.6 t FYM, 8.8 kg Urea, 33.6 kg SSP, 4.5 kg MOP and 1.1 kg Borax/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed at flowering.

**Interculture:**

1. **Irrigation**: As in French bean
2. **Weeding**: Inter cultivation should be done to control weeds until vines spread between rows.

**Plant protection:**

1. **Aphids, Jassids and Beetles**: Spray thiamethoxam 25 WG @ 26 g ai/ha
2. **Yellow mosaic**: Prophylactic measures should be taken against insect vectors

**Harvesting:** Pods should be harvested while they are tender, succulent and have not become fibrous.

**Yield**: 40-50 q of green pods/ha

# SPINACH BEET

*Beta vulgaris* Roxb.var. *bengalensis*

**Variety**: Jobner Green, All Green, S-23 and Pusa Jyoti

**Description**:

**All Green**: Foliage uniformly green, tender without pigmentation, main stem and inflorescence stalk pigmented purple, maturity 40 days, green leaf yield about 125 q/ha; gives about 6-7 cuttings at 15 to 18 days interval, suitable for sowing round the year.

**Pusa Jyoti**: Foliage uniformly green, succulent, thick, broad, tender with higher contents of potash, calcium, sodium, iron and ascorbic acid than Pusa Jyoti, has good regenerative capacity, late bolting habit and gives 6 to 8 cuttings.

**Soil**: Well drained sandy loam, rich in organic matter with pH 6.0-7.0

**Field preparation**: Land should be prepared to fine tilth and FYM to be applied

**Seed rate**: 20 kg/ha (3 kg/bigha)

**Time of sowing**: Second week of September to December

**Seed treatment**: Seeds should be treated with Carboxin @ 2-3g/kg of seed

**Spacing**: Seeds should be directly sown in lines spaced at 20cm and seedlings are thinned out to 5-7 cm within rows of 10-12 days after emergence.

**Manure and Fertilizer**: FYM @ 20 t, N 80 kg and $P_2 0_5$ 60 kg/ha as basal application (2.6 t FYM, 23.5 kg Urea, 50.4 kg SSP/bigha).

**Interculture**:

1. **Irrigation**: First irrigation should be given soon after sowing and subsequently at a 10-12 days interval.
2. **Weeding**: One weeding at 20 days after emergence

**Plant protection**:

**Leaf spot:** Prophylactic measure through seed treatment

**Yield:** 70-100 q green leaf/ha

# RADISH

*Raphanus sativus* L.

**Variety**:

**Early:** Pusa Deshi, Pusa Chetki and Pusa Himani

**Late:** Japanese White, Jaunpuri and Bombay Red

**Description**:

**Japanese White**: Top medium large, leaf deeply cut, root about 20 to 30 cm long cylindrical, skin uniformly white, smooth flesh snow white, crisp, solid, mildly pungent; maturity 50-55 days.

**Pusa Deshi**: Root pure white, 30-35cm long tapering with green end, pungent; maturity 50-55 days; heavy yielder.

**Pusa Chetki**: Root medium large, stumpy, smooth, skin pure white, flesh tender, mildly pungent, weight 300-400 g each, maturity 50-60 days, yield 200-250 g/ ha, suitable for early sowing.

**Pusa Himani** : Semi-stump to taper with short tops, root 30-35cm in length and 10-12 cm in girth with green stem end skin pure white, flesh crisp and sweet flavoured with mid pungency; maturity in 55 days.

**Soil**: Well drained sandy loam rich inorganic matter with pH 5.5-6.8

**Field preparation**: Land should be prepared to a fine tilth and FYM to be applied.

**Seed rate**: 10 kg/ha (1.3 kg/bigha)

**Time of sowing**: August-September (Early varieties) October-November (Late varieties)

**Seed treatment**: Seeds should be treated with carboxin @ 2 g/kg seed

**Spacing**:

Directly sown either on ridges spaced at 45 cm or in flat beds with 20 cm row spacing and seedlings are thinned out to 10cm within rows 10-15 days after emergence.

**Manure and fertilizer**:

FYM @ 20 t, N 50 kg, $P_2 0_5$ 50 kg and $K_2 0$ 100 kg/ha (2.6 t FYM, 14.7 kg Urea, 42.0 kg SSP, 22.7 kg MOP/bigha). Half of N and full doses of FYM, $P_2 0_5$ and $K_2 O$ should be applied as basal and the remaining half of N to be top dressed at 30 days after sowing.

**Interculture**:

1. **Irrigation**: Field should be properly irrigated before ploughing and subsequent irrigations to be given once in every week depending upon soil condition.
2. **Weeding**: One weeding at 20 days after emergence

**Plant protection**:

**Aphid**: Spray thiamethoxam 25 WG @ 26 g ai/ha. lambda cyhalothrin 5 EC @ 150 - 250 ml/ha.

**Yield**: 140-180 q/ha

# CARROT

*Daucus carota* L.

**Variety**: Nantes, Pusa Kesar and Chautney

**Description**:

**Nantes**: Medium long, slim, well shape orange, cylindrical, stump root; good flavour five grained, tender, sweet, self- core, small thin tail, flesh orange scarlet; maturity 110-120 days; does not keep well due to thin skin and fine texture; not suitable for seed production in the plains.

**Pusa Kesar:** Foliage reduced, root red, long, tapering, self- narrow central core, maturity 95-110 days, stays longer in field without bolting, seeds freely in the plains, has higher carotene content.

**Chautney**: Root 11.5-15 cm long, 3-5 cm in diameter with tapering to blunt end; deep orange cortex and core, excellent cultivar for canning and storage.

**Soil:**

Well drained sandy loam rich in organic matter with pH 6.5.22 q lime/ha to be applied to raise the pH from 4.5 to 6.2.

**Field preparation:**

The land should be prepared to a fine tilth and FYM to be applied. Liming is necessary in acid soil.

**Seed rate:** 5.5 – 7.0 kg/ha (0.75- 0.93 kg/bigha)

**Time of sowing:** Beginning of October to November

**Seed treatment:**

Prior to sowing, the seed should be well rubbed to remove the fine hairs. The seeds should be soaked in water for 24 hrs dried under shade and to be treated with Carboxin @ 3 g/kg seeds. Seed treatment with 0.1% Boron in the form of Sodium -borate for 24 hours improves the yield.

**Spacing:**

Seeds should be sown at a depth of 1.5 cm in lines spaced at 30 cm on flat bed and seedlings are to be thinned out to 10 cm within row at 10-15 days after emergence.

**Manure and fertilizer:**

FYM @ 10 t, N 60 kg, $P_2 0_5$ 30 kg and $K_2 0$ 120 kg/ha (1.3 t FYM, 17.6 kg Urea, 25.2 kg SSP, 27.2 kg MOP/bigha). Half of N and full doses of FYM, $P_2 0_5$ and $K_2 0$ should be applied as basal and the remaining half of N to be top dressed at 30 days after sowing.

**Interculture:**

1. **Irrigation**: Field should be properly irrigated before ploughing and subsequent irrigations may be given periodically at 10-15 days interval depending upon soil condition.
2. **Weeding**: First weeding at 20 days and second at 40 days after sowing

**Plant protection:**

1. **Cut worm and leaf blight:** Apply a mixture of 10 ml of Clothianidin 50 WDG @80 g ai/ha and 20 g of Chlorothalonil 75 WP
2. **Nematode:** Apply mustard oil cake on soil @ 300-400 kg/ha, 15 days prior to sowing against root-knot nematode

**Yield:** 200-250 q/ha.

**Benefit: Cost ratio**: 4.93

# A FEW GUIDELINES FOR GROWING CUCURBITS

1. Cucurbits should be preferably sown in raised beds.
2. All cucurbits can be planted in pits of size 60 cm x 60 cm x 45 cm filled with soil, FYM and basal dose of fertilizer @ 40-50 g Urea, 40-50 g SSP, 80-100 g MOP.
3. These crops should be provided with suitable climbing support.
4. In monoecious cucurbits such as cucumber, ridge gourd, sponge gourd, pumpkin, bottle gourd etc. where percentage of male flower is higher than the female flower; the femaleness, fruit-set, fruit size and total yield can be increased by spraying NAA (100 ppm) and Ethrel (25 ppm) at 2 to 4 leaf stage.
5. In dioecious cucurbits, like pointed gourd and spine gourd where male and female flowers are borne in separate plants, fertilization is a problem. In such cucurbits, a male-female ratio of 1:10 should be maintained in the field for proper fruit setting.

# CUCUMBER

*Cucumis sativus* L.

**Variety:** Chinese Green, Pusa Sanyog, Poinsette

**Description:**

**Chinese Green**: Medium late, straight variety, very hardy, prolific, fruit very long (50 cm), slender, deep green skin, white spined, flesh white, firm and crisp.

**Pusa Sanyog**: Early and high yielding hybrid; fruit 28 to 30 cm long, cylindrical, dark green with yellow stripes, crisp flesh, maturity 50 days.

**Poinsette**: Fruits dark green, 20 to 25 cm long; carries resistance to downy mildew, powdery mildew, anthracnose and angular leaf spot

**Seed rate:** 800 g/ha (110 g/bigha)

**Sowing time:** March – April (Climbing summer crop)

November – December (Ground trailing spring crop).

(March sowing reduces fruit fly infestation in the hill zone of Assam)

**Spacing:**

1.5 m x 1.2 m (for ground trailing)

1.2 m x 75 cm (for summer crop)

**Manure and fertilizer:**

FYM @ 25 t, N 50 kg, $P_2O_5$ 45 kg and $K_2O$ 80 kg/ha (3.3 t FYM, 14.7 kg Urea, 37.8 kg SSP, 18.1 kg MOP/bigha). Half of N with full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed at 30 days after emergence.

**Irrigation:** Occasionally in case of summer season crop when there is no rain.

**Weed management:**

Apply 30-micron black polyethylene mulch in beds as total ground cover for effective control of weeds, better yield and quality of cucumber.

**Harvesting:** Fruits should be picked while green and tender.

**Yield:** 50-60 q/ha

# RIDGE GOURD

*Luffa acutangula* L.(Roxb.)

**Variety:** Pusa Nasdar, selected local varieties

**Description:**

**Pusa Nasdar**: Bears 15-20 fruits/vine, fruit ridged, club shaped, light green; flesh yellow with firm texture, good flavour; flowers in about 60 days; maturity 70-75 days.

**AAUJ-1**: Bears 15 to 20 fruits/vine, fruit long ridged, green in colour. The number of days for fruit setting are 60 days and for first picking of 68 days, good as early variety. The average yield is 110 q/ha.

**Soil**: Well drained loamy soils rich in organic matter with pH 6.0-7.0

**Seed rate**: 1.5 kg/ha (200 g/bigha)

**Sowing time**: January-May

**Spacing**: 1.5-2.5m x 60 cm – 1.2m

**Manure and fertilizer**:

FYM @ 10t, N 20 kg, $P_2 0_5$ 30kg and $K_2 0$ 30 kg/ha (1.3 t FYM, 5.9 kg Urea, 25.2 kg SSP, 6.8 kg MOP/bigha). Half of N with full doses of FYM, $P_2 0_5$ and $K_2 0$ should be applied as basal and the remaining half of N to be top dressed at vining.

**Irrigation**: At 8-10 days interval during dry spell

**Xylocopa (*Bhoomora*) rearing for yield enhancement**

Place 1000 / ha (143/ bigha) bamboo node (*jati*) nested with *Xylocopa fenestrate* (Farmers' practice)

**Harvesting**: Fruits should be picked while green soft and tender

**Yield:** 90-130 q/ha

**Elimination of bitterness in fruits**:

Seed treatment with 80 ppm succinic acid followed by 2 sprays, one at five-leaf stage and another at first pistillate flowering stage completely eliminates the bitterness of fruit.

## SPONGE GOURD

*Luffa cylindrica* Roem

**Variety:** Pusa Chikni and selected local varieties.

**Description**:

**Pusa Chikni** : Bears 15-20 fruits/vine, fruit smooth, dark green, more or less cylindrical; flowers in about 45 days; maturity 50-60 days; suitable for both spring summer and rainy season.

(Other agro-techniques are the same as in ridge gourd)

# SNAKE GOURD

*Trichosanthes cucumerina* L.

**Variety:** Long Green, Long White and Extra Long

**Soil:** Well drained medium to rich loamy soil with pH 6.0-7.0

**Seed rate:** 1.5 kg/ha (200 g/bigha)

**Sowing time:** April-June

**Spacing:** 2.0-2.5 m x 0.75-0.90 m (Row to Row x Plant to Plant)

**Manure and fertilizer:** FYM @ 25 t, N 45 kg, $P_2O_5$ 30 kg and $K_2O$ 30 kg/ha (3.3 t FYM, 13.2 kg Urea, 25.2 kg SSP, 6.8 kg MOP/bigha). Half of N and full doses of

FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed when the plants start bearing.

**Irrigation:** At 8-10 days interval during dry spell

**Harvesting:** Fruits should be plucked while tender and half grown

**Yield:** 100 q/ha

# BITTER GOURD

*Momordica charantia* L.

**Variety:**

**Spring season:** Earliest of All, Long Green, Extra Long and Pusa Do Mausami

**Summer season:** Monsoon Monarch and Long Green Monsoon, Coimbatore Long

**Description:**

**Pusa Do Mausami**: Stem green, hairy, leaf broad, deeply lobed, fruit dark green, long (18 cm at edible stage), medium thick, club-shaped with 7-8 continuous ridges; maturity 55 days; suitable for both spring-summer and rainy season.

**Coimbatore Long**: Vines prolific spreading fruits long, whitish green in colour tender, heavy bearing; suitable for the rainy season.

**Soil:** Well drained sandy loam soil rich in organic matter with pH 6.0-7.0

**Seed rate:** 1.5 kg/ha (200 g/bigha)

**Sowing time:**

**Early:** October-November (Ground trailing)

**Mid:** February-March

**Late:** June-July

**Spacing:** 1.5 – 2.5 m x 60 cm – 1.2 m (Row to Row x Plant to Plant)

**Manure and fertilizer:**

FYM @ 10 t, N 40 kg, $P_2O_5$ 30 kg and $K_2O$ 30 kg/ha (1.3 t FYM, 11.7 kg Urea, 25.2 kg SSP, 6.8 kg MOP/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed during flowering and fruiting stages.

**Irrigation:** At 8-10 days interval during dry spell

**Harvesting:** Fruits to be harvested while tender and green

**Yield:** 100-120 q/ha

## ASH GOURD

*Benincasa hispida* (Thumb) Cogn.

**Variety:** Selected local varieties

**Soil:** Well drained soils with pH 6.0-6.5

**Seed rate:** 1.5 kg/ha (200 g/bigha)

**Sowing time:** February-April

**Spacing:** 2.0m x 1.0 m

**Manure and fertilizer:** FYM @ 20-25 t, N 70 kg, $P_2O_5$, 80 kg and $K_2O$ 80 kg/ha (2.7 t FYM, 20.5 kg Urea, 67.2 kg SSP, 18.1 kg MOP/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N be top dressed during flowering and fruiting stage.

**Irrigation:** At 8-10 days interval during dry spell

**Harvesting:** Fruits to be harvested when they are fully ripe, smooth, light and covered with whitish wax

**Yield:** 185-325 q/ha

# BOTTLE GOURD

*Lagenaria siceraria* (Mol.) Standl.

**Variety:** Pusa Summer Prolific Long, Pusa Summer Prolific Round, Pusa Meghdoot and Pusa Manjiri. "Keyari Lao" is grown well in the hill zone of Assam

**Description:**

**Pusa Summer Prolific Long:** Bears 10-15 fruits/plant, fruits are long (40-50 cm), girth medium (20-25 cm), narrow at stalk end and thicken at distal end, skin pale green, yield about 120 q/ha, suitable for spring and summer planting.

**Pusa Summer Prolific Round**: Prolific fruiting, fruit round (15-18 cm in girth), green, suitable for spring and summer planting.

**Pusa Meghdoot**: Hybrid, fruit long, light green, yield about 253 q/ha

**Soil:** Well drained sandy loam soil rich in organic matter with pH 6.0-7.0

**Seed rate:**

**Spring:** 1.5 kg/ha (200 g/bigha)

**Summer:** 1.2 kg/ha (160 g/bigha)

**Sowing time:**

Spring: February – March Summer: June – July

Winter: October – November

**Spacing:**

1.5.-2.0 m x 1.0-1.5 m (spring)

2.0-3.0 m x 1.0-1.5 m (summer)

**Manure and fertilizer:**

FYM @ 20-25 t/ha, N 56 kg, $P_2O_5$ 56 kg and $K_2O$ 112 kg/ha (2.7 t FYM, 16.4 kg Urea, 47.0 kg SSP, 25.4 kg MOP/bigha). Half of N and full dose of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed at the fruit-set.

**Irrigation:** At 8-10 days interval during dry spell

**Harvesting:** Fruits to be harvested while tender

**Yield:** 120 – 250 q/ha

# PUMPKIN

*Cucurbita moschata* Duch ex poir

**Variety:** Arka Suryamukhi, Arka Chandan and selected Local cultivar.

**Description:**

**Arka Suryamukhi**: Bears 8-10 fruits/plant, fruit small (1.0 kg), round with flat ends, skin deep orange, flesh firm, orange-flavored, maturity 100 days, yield about 335 q/ha, highly resistant to fruit fly and rich in Vitamin C, keeping and transport qualities are good.

**Arka Chandan**: Bears 2-3 fruits/plant, fruit medium sized (2-3 kg), flat with depressed polar ends, rind light brown with creamy patches at maturity, flesh thick, firm, sweet, (TSS 8-10%), bright orange with pleasant aroma, maturity 120 days, yield about 335 q/ha, rich in Vitamin A, cooking and keeping qualities are good.

**Soil:** Well drained sandy to moderately heavy soil rich in organic matter with pH 6.0-6.5

**Seed rate:** 1.7 kg/ha (250 g/bigha)

**Sowing time:** January – April (For summer harvest)

Sept. – October (For spring harvest)

**Spacing:** 2.5-3.0 m x 0.9-1.0 m (Spring)

2.5-3.0 m x 1.0-1.5 m (Summer)

**Manure and Fertilizer:**

FYM @ 20-25 t, N 75 kg, $P_2O_5$80 kg, $K_2O$ 80 kg, CaO 30 kg/ha basal application (2.7 t FYM, 22.0 kg Urea, 67.2 kg SSP, 18.1 kg MOP and 4.0 kg CaO/bigha).

**Irrigation:** At 8-10 days interval during dry spell

**Harvesting:**

Fruits are to be harvested at full maturity, when colour changes to yellow or orange to yellow or orange yellow.

**Yield:** 65-75 q/ha (Small varieties)

120-200 q/ha (Large varieties)

# WATER MELON

*Citrullus lanatus* (Thumb.)

**Variety:** New Hampshire Midget, Asahi Yamoto, Pusa Bedana, Sugar Baby and Faizabadi

**Description:**

**New Hampshire Midget**: Fruits small (1.5-2.0 kg), oval, skin bright, green with dark green lacerations, flesh red takes 28-30 days from pollination to ripening.

**Asahi Yamoto**: Fruit medium sized (30-35 cm in diameter) weighing 5-6 kg, rind light green, flesh deep pink (TSS 11-13%), seed small, brown, maturity 95-100 days, quite adaptive to various regions.

**Sugar Baby**: Leaf with deeply cut lobes, fruit slightly oblong, small to medium (20-25 cm in dia.) weighing 3-5 kg, round, skin dark green with faint dark stripes, flesh deep red, very sweet (TSS 11-12%), fine textured, seed small, pale brown with black tip, maturity 85 days.

**Pusa Bedana**: Hybrid, credited for seedlessness

**Soil:** Well drained, sunny, sandy loam soil, rich in organic matter with pH 6.5-7.0.

**Seed rate:** 0.5 kg/ha (66.7 g/bigha)

**Sowing time:**

Early: January – February Late: June – July

**Spacing:** 2.5m x 2.0 m

**Manure and fertilizer:** FYM @ 25t, N 60kg, $P_2O_5$40 kg, $K_2O$ 60 kg/ha basal application (3.3 t FYM, 17.6 kg Urea, 33.6 kg SSP, 13.6 kg MOP/bigha).

**Irrigation:** At 7-10 days interval during dry spell

**Harvesting:**

Fruits are to be harvested when fully ripe and show signs of maturity

(1) Withering of tendrils

(2) Muffled sound when stumped with finger

(3) Colour of ground spot turns yellow

(4) Cracking noise when pressed hard with thumb

**Yield:** 280-465 q/ha

# MUSK MELON

*Cucumis melo* L.

**Variety:** Pusa Sharbati, Hara Madhu, Punjab Sunehri, Durgapur Madhu, Arka Rajhans and Arka Jeet

**Description:**

**Pusa Sharbati**: Vine moderately spreading, leaf 5 lobed, green with light pubescence, petiole medium long, fruit medium in size, round to oval, netted with green stripes on outer skin, bears 3-4 fruits/vine, weight 800 q, flesh firm, thick deep orange with small seed cavity, moderately sweet (TSS 11-12%), yield 100-130 q/ha.

**Hara Madhu**: Vine 3-4m long, vigorous, fruit large globose, slightly tapering at stalk end, weights 1 kg, does not slip from vines at maturity, skin light yellow with ten prominent green strips, flesh crisps, light green, juicy, very sweet (TSS 12-15%), seed cavity small, maturity 100-110 days.

**Punjab Sunehri**: Fruit with thick pale skin, flesh salmon-orange, thick with moderate sweetness (TSS 11-12%), early maturing.

**Durgapur Madhu:** Plant spread medium, fruit oblong, medium sized, weighing 500 to 600 g, rind yellowish green with green stripes smooth, flesh light green with dry texture, very sweet (TSS 13-14%), seed cavity big.

**Arka Rajhans**: Fruit medium large, round to slightly oval weighing 1 to 1.5 kg, rind creamy white with fine netting, flesh thick, white with more sweetness (TSS 12-14%), yield 320 q/ha, highly resistant to powdery mildew and has good transportable quality.

**Arka Jeet**: Fruit flat, small weighing 300-500 gm, skin orange to orange- brown, flesh white very sweet (TSS 15-17%) with high Vitamin C content (41.6 mg/100g) and big seed cavity.

**Soil:** Well drained sandy loam to silty loam rich in organic matter with pH 6.0-6.5

**Seed rate:** 400 g/ha (53.3 g/bigha)

**Sowing time:** January – Mid March

**Spacing:** 1.5-2.0 m x 0.6-1.2 m (Row to Row x Plant to Plant)

**Manure and fertilizer:**

FYM @ 25 t, N 68 kg, $P_2O_5$ 68 kg, $K_2O$ 130 kg/ha basal application (3.3 t FYM, 20.0 kg Urea, 57.1 kg SSP, 29.5 kg MOP/bigha)

**Irrigation:** At 10-15 days interval during dry spell

**Harvesting:** Fruits to be harvested when fully ripe and show signs of maturity as in watermelon

**Yield:** 280-450 q/ha

# CHOW-CHOW/CHAYOTE

(Popularly known as Squash in Assam)

*Sechium edule* (Jack) Swartz.

**Cultivated Types:**

**White types:** Round White, Long White

**Green types:** Pointed Green, Broad Green, and Oval Green

**Soil:** Well drained deep, moist, sandy loam rich in organic matter

**Planting method:**

The crop can be raised by planting whole fruits or tuberous roots directly in the field or first it is planted in a nursery and then transplanted in the main field.

**Raising of nursery:** The fruits and tuberous roots are to be planted in polyethylene bags filled with soil and cow dung mixture (3:1 ratio). The fruit should be buried horizontally in the soil exposing the sprout end. When the sprouts attain a height of 30 cm the plants can be transplanted in the main field.

**Pit size:** 45 cm x 45 cm x 45 cm

**Spacing:** 2-3 m x 1-2 m

**Planting time:**

September – November (for irrigated crop)

January – February (for rained crop)

**Manure and fertilizer:** FYM @ 10-15 kg, Neem Cake 1.5 kg, N 50 g, $P_2O_5$ 20 g, $K_2O$ 30 g are to be applied to each vine each year. An additional application of 50 g N may be required during the rainy season when the vine shows poor growth.

**Interculture:**

Control the weeds during the initial growth of the vines. Weeding may be followed twice or thrice in a year when the vines are allowed to trail over a pandal or trellis.

**Harvesting:**

The fruits are not allowed to become too old and must be picked prior to seed development. Usually, the marketable size of fruits is obtained in about 30 days from flowering.

**Yield:** 200-250 q/ha

# SPINE GOURD

*Momordica dioica* Roxb.

**Variety:** Selected local varieties

**Soil:** Well drained, sandy loam to loamy soil rich in organic matter, with pH 6.0-7.0.

**Land Preparation:**

Deep ploughing is essential as it is a perennial crop. The land should be properly leveled.

**Planting Material:**

Spine gourd should be propagated by vegetative method. For propagation, well developed tubers should be selected from female plants when the crops are at bearing stage.

**Planting Time:** February – March

**Planting Method:**

Tubers are planted in the field in a trench method; 30-35 deep trenches are made and filled with FYM. Large size tubers (80-100 g) should be placed in furrows at a depth of 8-10 cm maintaining a spacing of 1 m x 1 m.

**Manure and Fertilizer:**

FYM @ 20-25 t, N 50 kg, $P_2O_5$ 40 kg, $K_2O$ 50 kg/ha (2.7 t FYM, 14.7 kg Urea, 33.6 kg SSP, 11.3 kg MOP/bigha). Whole of FYM, $P_2O_5$ and $K_2O$ should be applied at vining and the remaining half after 30 days of 1$^{st}$ application.

**Trailing:**

Trail the vines by fixing bamboo or other suitable supports within 15 days after sprouting.

**Irrigation:** As and when necessary, in the dry season

**Harvesting:** Harvest the fruit while tender and slightly green in colour.

**Yield:** 90-100 q/ha

**Benefit: Cost ratio:** 4.1

# POINTED GOURD

*Trichosanthes dioica* Roxb.

**Variety:** Selected local varieties

**Soil:** Well drained sandy loam to loamy soil rich in organic matter with pH 6.0-7.0.

**Land Preparation:** Same as in Spine gourd

**Planting Materials:** Female and male plants are to be identified first in the previous season and then skin and root cutting from female plants should be taken. The cuttings should be dipped in 0.1 % trifloxystrobin 25 WP solution for 10 mins.

**Planting Time:** January – February

**Seed Rate:** 100 cm cuttings @ 2500 nos. /ha

**Spacing:** 2.0 m x 2.0 m

80 cm mid portion of cutting should be buried in soil and 10 cm to be kept exposed on either end.

**Manure and Fertilizer:** FYM @ 22-25 t, N 80 kg, $P_2O_5$ 50 kg, $K_2O$ 50 kg/ha (3.3 t FYM, 23.5 kg Urea, 42 kg SSP, 11.3 kg MOP/bigha) as basal application and 2% Urea and 2% MOP at 60 days interval as foliar spray.

**Irrigation:** As per necessary during dry spell.

**Interculture:** The crop should be kept weed free particularly in the early stages and light earthing up should be done. For getting a good second crop weeding, top dressing of fertilizer and the thinning of the overcrowded population should be done. The crop has to be provided with bedding materials like paddy, straw/paddy husk to protect the fruits from decay and to reduce weed infestation. In light soils and riverbanks, the crop should be trailed on ground whereas trailing on bamboo tops or tree branches is recommended in heavy soils.

**Harvesting:** Fruits should be picked while green and tender

**Yield:**

**1st yr.** Crop: 56-72 q/ha

**2nd yr.** Crop: 93-130 q/ha

**N.B.** Propagation of pointed gourd can also be done by leaf bud cutting. Single leaf from the mature vine along with 2-3 cm stem should be taken and put into a nursery bed or polyethylene bag containing 1 part sand and 1 part loamy soil under shade. Regular light watering should be done. Initiation of new shoots and subsequent rooting take place after 12-15 days. New plantlet gets ready for transplanting after 30-40 days.

# Ivy Gourd / Kunduli

*Coccinea grandis*

Kunduli is a popular warm season cucurbitaceous vegetable. The tender green fruits have unique taste and possess high nutritional & therapeutic qualities. Being semi-perennial, the vine produces fruit almost round the year except in the chilly winter months but the peak period of harvest is June to September.

**Cultivar:**

**Local Sel-1**: Long slender fruits with low acidity

**Local Sel-2**: Fruits are short and plump with linear white specks, light sour in taste

**Soil & climate:**

It tolerates a wide range of soil conditions but prefers a neutral to slightly acidic (pH 6.0 to 6.5), well drained sandy or loamy soil under sunny conditions and can tolerate moist soil. The ideal temperature is 25 – 35 $^0$C.

**Method of propagation:** Tuberous root and vine cutting

**Planting:**

Tuberous roots may be collected from identified mother plants and planted in 30 cm x 30 cm x 30 cm pits. Vine cutting with 5-6 nodes may be planted directly in the main field or those may be rooted in a nursery before final planting. Seed sowing often results in male plants.

**Spacing:** 3.0 m x 2.5-3.0 m (145-175 plants/bigha)

**Manures & Fertilizers**:

5 kg of FYM should be added in each pit. A fertilizer dose of 50-45-80 kg of N-$P_2O_5$-$K_2O$ /ha (85-100 g Urea, 215-260 g SSP, 100-125 g MOP per vine) is to be applied. ½ N and K and a full dose of P should be applied before planting and rest after 60 days.

**Irrigation:**

Light watering may be required after planting and during dry spells, as and when required.

**After care:**

Provision of overhead *pandal* or trellis or bamboo top (*Jeng*) is required for plant growth. The vine should be headed back at 5-6 nodes to encourage branching.

**Harvesting & Yield:**

The fruits are in best taste at tender stage and are harvested as soon as the floral remnants fall off from the fruits. Average yield is 7-10 kg tender fruits per vine.

**Pests & Diseases:**

No serious disease or pests. Fruit damage by squirrels and parrots causes economic loss.

# PLANT PROTECTION FOR CUCURBITS

1. **Fruit fly, *Epilachna* beetle, aphid, red pumpkin beetle and black pumpkin beetle:** For fruit fly use methyl eugenol trap @ 20 trap/ha from fruit setting. Apply emamectin benzoate 5 SG @ 220g/ha and spray lambda cyhalothrin 5 EC @ 150-250 ml/ha.
2. **Cutworm:** Clothianidin 50WDG @80 g ai/ha as soil drench
3. **Mite:** Spray spiromesifen 22.90 SC @ 96 g ai/ha
4. **Powdery mildew:** Spray wettable sulphur @ 0.5%
5. **Downy mildew:** Spray 1% Bordeaux mixture or Zinc @ 0.3%
6. **Fusarium root rot:** Pre-sowing seed treatment with Carboxin @ 3 g/kg of seeds
7. **Anthracnose:** Spray zinc @ 0.2% or chlorothalonil (0.2%)

# OKRA

*Abelmoschus esculentus* (L.) Moench

**Variety:**

Pusa Sawani, Arka Anamika, Parbhani Kranti, Red Wonder (Hills zone)

**Description:**

**Pusa Sawani:** Stem and leaf moderately hairy, top leaves deeply lobed (3-5 lobes) purple, top leaves deeply lobed (3-5 lobes) purple patch at base of yellow petal on both sides, slight purple pigmentation on stem, petiole and leaf base; first fruit is as 8$^{th}$ node, fruit dark green smooth, 5-ridged, about 10-12 cm long at marketable stage; maturity 50 days; suitable for both spring-summer and rainy seasons, was tolerant to YMV at the time of release but its tolerance has since broken down.

**Arka Anamika**: Plant tall (180 cm). Erect, well branched; fruit long (200cm), Spineless lush green and tender, borne in two flushes, duration 120-135 days, Yield 175-250 q/ha; resistant to yellow vein mosaic virus.

**Parbhani Kranti**: High yielder: resistant to yellow vein mosaic virus

**Red Wonder**: Avg. Yield 125.1 q/ha

**Soil:** Well drained sandy loam to clay loam rich in organic matter

**Land Preparation:** Land should be prepared thoroughly and FYM should be applied

**Seed Rate:**

15 kg for spring summer crop (Jan-March) (2 kg/bigha)

8 kg for rainy season crop (May-July) (1.1 kg/bigha)

**Sowing Time**:

Spring summer crop (Jan-March)

Rainy season crop (May-July)

**Spacing:**

45 cm x 20 cm (Spring-summer crop)

60 cm x 45 cm (Rainy season crop)

**Seed Treatment and Method of Sowing:**

Pre-sowing soaking of seeds in water for 24 hrs, enhances germination. Seeds should be directly sown in the pit and to be covered with sand and/or FYM.

For organic cultivation, treatment of seeds with biofertilizers AZB and PSB @ 7.5g each per 100 g of seeds and application of Rock Phosphate @ 313 kg/ha, FYM @ 5 t/ha and Vermicompost @ 1 t/ha during final land preparation has been recommended.

**Manure and Fertilizer:**

FYM @ 10t, N 50 kg, $P_2O_5$ 50 kg and $K_2O$ 50 kg/ha (1.3 t FYM, 14.7 kg Urea, 42 kg SSP, 11.3 kg MOP/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed at 35-40 days after sowing.

**Interculture:**

**Weeding:** One hand weeding at 25-30 days after sowing is recommended for adequate control of weeds.

**Intercropping:** Sow black gram in line between rows of summer season okra (45 cm X 30 cm)

**Plant Protection:**

1. **Fruit and shoot borers and Jassids:** Apply lamda-cyhalothrin 5EC @ 150-250 ml/ha or emamectin benzoate 5 SG @ 220g/ha. The waiting period after the treatment is 3 days.
2. **Cut Worm:** Apply Clothianidin 50 WDG @80 g ai/ha
3. **Yellow Vein Mosaic:** (a) Prophylactic measures should be taken against the insect-vector by spraying systemic insecticide thiamethoxam 25 WG @ 26 g ai/ha or lamda-cyhalothrin 5EC @ 150-250 ml/ha. The first spray should be given within 20 days after emergence of seedlings and altogether 5-6 sprays are required to get a disease-free crop. (b) Grow the crop early in the season so as to escape the incidence of YVM which generally intensifies with the increases of the vector (White Fly) population beyond April (c). To get the highest yield and low incidence of YVM February and March sowing is the best.

**Harvesting:**

It takes 45-50 days for first picking. Fruits should be picked at an interval of 4-5 days. Picking should be done before spraying insecticides.

**Storage of seeds**:

First borne 8-10 fruits from the base of the plant should be retained for quality seed production. The upper fruits may be harvested for consumption purposes.

**Yield**: 150-200 q/ha

**Benefit: Cost ratio:** 3.56

# COWPEA

*Vigna unguiculata* (L.) Walp

**Variety:** Pusa Barsati

**Description:**

**Pusa Barsati**: Plant dwarf, height 60-80 cm; flowers in 35 days pod becomes ready in 45 days; produces 2-3 flushes in about 90 days; pod light green, pendent, 20-25 cm long seed striped, bold; yield 70-75 q/ha; suitable for growing under long day condition.

**Soil**: Well drained sandy loam with pH 5.5-6.0

**Land Preparation**: The land should be ploughed 2-3 timers followed by leveling.

**Seed Rate**: 20-25 kg/ha

**Sowing Time:** March-April

**Seed Treatment**: Dry seed treatment should be done with Carboxin @ 2.0 g/kg seed

**Spacing:** 70 cm x 30 cm

**Manure and Fertilizer:** FYM @ 9 t, N @ 15 kg, $P_2O_5$@ 35 kg and $K_2O$ @ 10 kg/ha basal application (1.2 t FYM, 4.4 kg Urea, 29.4 kg SSP, 2.3 kg MOP/bigha).

**Interculture:**One weeding at 20-25 days after sowing

**Plant Protection**:

**Caterpillar and Aphid:** Spray lamda-cyhalothrin 5EC @ 150-250 ml/ha or emamectin benzoate 5 SG @ 220g/ha.

Three sprays of *Lecanicillium lecanii* $1x10^8$ cfu @ 5 ml/liter of water can be applied to manage aphids (*Aphis craccivora*). First spray should be done at 15-20 days after germination followed by second and third sprays at 15 days interval.

**Harvesting:** Pods are to be picked while green and tender

**Yield:** 50-60q of green pods/ha

## POTATO

*Solanum tuberosum*

**Varieties**:

| Name | Duration (days) | Yield (q/ha) | | Plant characters | Tuber characters | Tolerance to diseases |
|---|---|---|---|---|---|---|
| | | Rainfed | Irrigated | | | |
| Kufri Chandramukhi | 80-100 | 85-100 | 150-160 | Medium tall, erect | Oval, slightly curved, skin white, eyes flat | Leaf roll & virus Y |
| Kufri Jyoti | 110-120 | 85-100 | 150-160 | Tall, erect | Oval, flat, skin white, eyes flat, flesh dull white | Late blight |
| Kufri Megha | 100-120 | 120-150 | 175-200 | Tall, erect | White round oval tubers of medium size, white eyes, Flesh dull white, good keeping quality & no tuber cracking | Late blight resistant |
| Kufri Sindhuri | 110-120 | 100-150 | 180-200 | Medium Tall, Open | Round shape, skin light red, deep eyes, dull white flesh | Moderately resistant to early blight, PLRV |
| Kufri Pukhraj | 60-75 | 145 | 200-250 | Medium, erect | Easy to cook; Texture-waxy texture; Free from after cooking discolouration | Moderately resistant to Late blight & tolerant to viruses |

Potato variety Kufri Megha can be grown late (up to Mid-December) in Upper Brahmaputra Valley Zone.

**Soil Type**:

Well drained sandy loam and loam soils, rich in organic matter are suitable. A pulse crop should preferably be included in the rotation to improve the soil condition.

**Field Preparation**:

Field should be thoroughly ploughed to obtain a good tilth. It should be leveled for uniform distribution of irrigation water or to maintain soil moisture uniformly under rainfed

situations. The furrows should be prepared 50 cm apart.

**Time of Planting**:

The optimum time for planting is mid-October to mid-November. In case of Kufri Sindhuri planting may be extended up to the middle of December.

The optimum planting time for white and red eyed local potatoes is 15-30$^{th}$ October in Assam.

**Method of planting:**

The sprouted tubers should be planted in furrows with sprouts facing upward. Care should be taken to avoid sprout damage handling the tubers.

**Seed Selection**:

Virus free, healthy, medium sized sprouted tubers are to be selected for planting. Ideal size is about 2.5 cm in diameter (25-40 g). Bigger sized tubers may be cut into pieces longitudinally with 2-3 eyes in each piece.

**Seed Sources**:

Certified seeds of the recommended varieties are to be procured from Govt. or other recognized agencies.

**Seed Treatment**:

In case of cut seeds, the pieces are to be dipped in carboxin @ 2 g in 1 liter of water for about 10 minutes. After treatment, the seeds are to be spread thinly and dried under shade for 48 hours or should be covered with moist gunny bags for 2-3 days for tuberization.

**Seed Rate**:

The seed requirement is 22.5-25 q/ha when the size of the tubers are about 2.5 cm in diameter (about 25 g) and planted with an intra row spacing of 15 cm. Intra row spacing is increased with bigger sized tuber.

**Fertility Management**:

Ten tones or 5 truckloads or 20 cart loads of well decomposed FYM should be applied per hectare in the furrows before planting.

| **Nutrient** | **Requirement (kg/ha)** | **Form** | **Fertilizer requirement** | |
|---|---|---|---|---|
| | | | **kg/ha** | **kg/bigha** |
| **Rainfed** | | | | |
| N | 60 | Urea | 133 | 19 |
| $P_2O_5$ | 50 | SSP | 312 | 45 |
| $K_2O$ | 50 | MOP | 83 | 12 |

| | | | | |
|---|---|---|---|---|
| **Irrigated** | | | | |
| N | 60 | Urea | 133 | 19 |
| $P_2O_5$ | 100 | SSP | 624 | 90 |
| $K_2O$ | 100 | MOP | 168 | 24 |

Entire quantity of fertilizers should be applied in furrows as basal application and be covered with a thin layer of soils so that tubers do not come into direct contact with the fertilizers.

The crop booster 'Green Harvest' is recommended @ 25 g/10 liters of water at 30 days after planting.

**Mulching**:

Adoption of mulching under rained situations increases tuber yield. Water hyacinth plant materials are applied to cover the entire field after planting of tubers under flat method. Of course, skin of the tubers may turn green due to exposure to sunlight or shrinkage of mulching materials on drying.

Tubers become unsuitable for consumption on greening, however, quantities may be reduced by applying mulching materials in furrows just after planting of tubers, immediately followed by light soil cover. Such practices also reduce rodent damage of tubers considerably.

**Irrigation**:

The furrow method of irrigation has to be adopted. Three irrigations should be applied, first at 25 days (stolon formation stage), second at 60 days (tuber formation stage) and third at 80 days (tuber development stage) after emergence of sprouts. In case of application of mulching materials in furrows, only two irrigations are to be applied at 25 and 60 days after emergence of sprouts. At the time of application of irrigation, care should be taken not to submerge the ridges completely.

**Weeding and Interculture**:

Earthing up is to be done just before first and second irrigation. Under rainfed conditions, this should be done at stolon and tuber formation stages. One or two interculture operations may be necessary when weed infestation is high.

Apply metribuzine @ 0.75 kg/ha (100 g/bigha) at 10% plant emergence (about 10 DAP) to get optimum weed control.

**Plant Protection:**

**A). Insect Pests**:

In areas where infestation of red ant and other soil insects are common, application of thiamethoxam 25 WG @ 26 g a.i./ha and clothianidin 50 WDG @ 80 g *a.i.*/ha is effective.

Application of mustard oil cake @ 150 kg/ha at the time of earthing up reduces red ant

and white ant infestation to a great extent.

**B). Diseases**:

i). Against late blight, six spraying with copper oxychloride 50 WP @ 2 g commercial formulation /liter at an interval of 12 days or spraying with dimethomorph 50 WP @ 1g commercial formulation per lit followed by copper oxychloride 50 WP @ 2g commercial formulation per lit in alternate application (3 sprays with the dimethomorph & 3 with copper oxychloride) at an interval of 12 days give very good control if used at the following rates with high volume sprayer.

**Early stage** (1st month): 600 liters of water/ha

**Mid stage** (2nd month): 800 liters of water/ha

**Late stage** (3rd month): 1000 liters of water/ha

The first spray should be given 40-45 days after planting (canopy closure stage). Use of sticker Triton (0.5 ml/*l*) will be essential in the spray solution for spraying during rainy weather.

Depending upon weather conditions, particularly in cloudy weather, copper oxychloride should be sprayed as a prophylactic measure. If disease appears, spraying should be done at an interval of 7 to 10 days depending upon weather conditions. While spraying, care should be taken to ensure wetting of the lower sides of the leaves.

**Practices for On-farm storage of seed potatoes:**

- The seed tubers for preservation in on-farm storages should be harvested from fully matured potato crop.
- Among the different tuber grades, small sized (5-15g) tubers can be kept suitably in on-farm stores as compared to big sized tubers (>20g).
- Loading density of 75g/$m^2$ proved beneficial than higher loading density for stored tubers under traditional stores.
- Seed potatoes collected from the main field should be cured properly for 10-15 days in cool place and then treat the healthy tubers with 3% boric acid for 30 min followed by 0.2% copper oxychloride for 20 min. After shade drying, the tubers should be loaded in the bamboo rakes fitted in the store.
- Use 4cm thick layer of shade dried 'Neem' or *Eucalyptus* leaves under and over stored tubers help in controlling potato tuber moth.
- Stored potatoes should be covered with mosquito nets in PTM endemic areas.
- Frequent inspection of the tubers in the store is essential. Remove the rotten tubers periodically.
- Sprout breaking during August is essential in order to minimize over-shrinkage and shriveling of tubers.

**N.B**:

(i) In flood prone areas under low land situation of North Bank Plains Zone cropping system of Rice-Fallow-Potato is recommended.

(ii) Under medium land, medium rainfall, flood free situation, intercropping of potato and pea is recommended for Sonitpur district.

(iii)Intercropping of Pea in between every two rows of potato grown with mulches can be done. Extra fertilizer need not be added for pea.

# SWEET POTATO

*Ipomoea batatas* L.

**Variety:**

**Pusa Red:** average yield 24 t/ha

**Kalmegh**: average yield 30 t/ha

**Dergaon White**: average yield 22 /ha

**Dergaon Red:** average yield 20 t/ha

**Soil and climate**:

Sweet Potato can be grown on a variety of soil having good drainage except clay but it is best suited to fertile sandy loam and deep loam. It requires a warm humid climate with a mean temperature of about 22 ºC. It is sensitive to frost but can withstand drought to a certain extent. Under rain-fed conditions, it requires a fairly well/ distributed rainfall of 175 to 150 annually.

**Preparation of land:**

The land should be ploughed or dug to a depth of 15 to 25 cm and brought to fine tilth ridges of 25-30 cm. Height is made 60 to 75 cm apart and vines are planted on these ridges.

**Planting season:**

The rain-fed crop of sweet potato is generally planted in May-June and a second crop is raised in September-October (to be harvested in 105 days after planting). As an irrigated crop it can also be grown in October-November or even later.

**Planting materials planting:**

a) Propagation of this crop is done by means of vine cuttings. In the main field, cuttings of 20 to 25 cm length are planted on ridges at a distance of 20 to 30 cm between vines. While planting, the central part of the cuttings is buried deep in the soil exposing the two cut ends. About 50,000 to 62,000 cuttings are required to cover a hectare. Care should be taken so that there is sufficient moisture in the soil at the time of planting for the early establishment of the cutting. Since sweet potatoes are susceptible to waterlogging, proper drainage facilities should be provided.

b) Adopt 2 tiers planting of deep bulking type (X-5) in between two rows of shallow bulking type (X-4) at 30 cm x 15 cm spacing.

**Manure and Fertilizer:**

Sweet Potato is a soil-exhausting crop. Therefore, proper manuring should be done for better yield. Cattle manure or compost @ 10 t/ha or 1.5 t/ bigha may be applied at the time of preparation of the main field. Application of 75 kg N, 50 kg $P_2O_5$ and 75 kg $K_2O$ per ha or 10 kg N, 6.5 kg $P_2O_5$ and 10 kg $K_2O$/bigha (22 kg Urea, 42 kg SSP, 17 kg MOP per bigha) may be done in two split doses as tabulated below:

| Sl. No. | Name of Fertilizer | Time of application | |
|---|---|---|---|
| | | At the time of planting | 3 weeks after planting |
| 1. | Urea | 80 kg/ha (10.5 kg/bigha | 80 kg/ha |
| 2. | Super Phosphate | 310 kg/ha (40 kg/bigha) | |
| 3. | Muriate of Potash | 135 kg/ha (16 kg/bigha) | |

**Interculture:**

The crop should be given a weeding and earthing up at about 4 to 5 weeks after planting. The second split dose of fertilizer can also be applied at this time. Disturbing the vines occasionally during their active growth period will help to prevent the development of small, slender undesirable tubers at the nodes.

Spray 1000 ppm CCC at 30 and 45 days after planting. This gives an additional yield of 25% over control.

**Rotation and Mixed Cropping:**

When the crop is raised under rain-fed condition, leguminous green manure crop like *Crotalaria juncea* (sunn hemp) can be grown after the harvesting of the crop and later on incorporated in soil at the time of preparation of land for the next crop of sweet potato. In such cases, use of compost or cattle manure can be eliminated. As a mixed crop, it can be taken along with Colocasia, Amorphophallus, etc.

**Plant Protection:**

1) **Weevil:** Sweet potato weevil is the most serious pest. It damages vines and tubers by tunneling through them. Apply Clothianidin 50WDG @ 80 g ai/ha.
2) **Red ant:** Thiamethoxam 25 WG @ 50 g ai/ha as soil drench

**Harvesting:**

The duration of the crop depends upon the variety grown but generally it gets ready for harvest within 3.5 to 4 months after planting when leaves begin to turn yellow.

**Yield:** 20 to 30 t/ha

**Benefit: Cost ratio**: 3.03, Cost of cultivation is Rs.31, 018.00

# TAPIOCA

*Manihot esculenta* Crantz

Cassava, popularly known as Tapioca in India, is the important tuber crop cultivated in Kerala, part of Tamilnadu, Andhra Pradesh, Karnataka and Assam. It is consumed both as freshly cooked tubers and as processed food products like chips, sago and vermicelli. It forms a component of animal and poultry feeds too. Industries use tapioca for producing starch and glucose.

**Variety:** H-97, H-165, Sree Prakash, Sree Sahya, Sree Harsha, Sree Jaya and Sree Vijaya

**Sri Jaya:** Early maturing variety (6-7 months); Average yield-26 to 30 t/ha; Starch- 24-27%; Cooking quality- excellent.

**Sri Vijaya:** Early maturing variety (6-7 months); Average yield-25 to 28 t/ha; Starch-27-30%; Cooking quality- excellent.

**Soil and climate:**

It can be grown on all types of soils except saline, alkaline and ill- drained soils. It grows best in warm and humid climates with well distributed rainfall (1500 to 2000 mm annually).

**Site selection and preparation of land**:

Tapioca can be cultivated profitably on hill slopes, waste land and lands where normal cultivation is difficult. The land should be ploughed two or three times or dug to a depth of 25 to 30 cm.

**Planting material:**

Tapioca is propagated from cuttings obtained from mature healthy stems having 2-3 cm diameter. Discard the basal 10 cm and the top one third and use the remaining portion, Prepare the cuttings of about 15-20 cm length giving a slanting cut towards lower and or cutting using a hacksaw or knife.

**Spacing:**

Planting is done in a square alignment with spacing of 90 cm x 90 cm, 1646 setts/bigha are required for planting.

**Time and method of planting:**

April-May is the best planting time for Assam. Cuttings are planted vertically (after smoothening the lower portion) and basal 4 to 6 cm is buried inside the soil. Flat, ridge or mound method of planting can be adopted considering the soil type, topography and water table.

**Manure and Fertilizer:**

Cattle manure or compost may be applied @ 12.5 t/ha (1.5t/ bigha) during the preparation of the land. Application of organic is better than spreading the manure in the whole area. Tapioca responds well to 75 kg N, 75 kg $P_2O_5$ and 100 kg $K_2O$ per ha when applied in two split doses as tabulated below:

| Sl. No. | Name of Fertilizer | Time of application | |
|---|---|---|---|
| | | At the time of planting | Two months after planting |
| 1. | Urea | 81 kg/ha (10 kg/bigha) | 81 kg/ha (10 kg/bigha) |
| 2. | Super Phosphate | 235 kg/ha (30 kg/bigha) | 235 kg/ha (30 kg/bigha) |
| 3. | Muriate of Potash | 83 kg/ha (10 kg/bigha) | 83 kg/ha (10 kg/bigha) |

**Interculture:**

Removing the weeds and loosening the soil by light digging or hoeing may be done two to three times up to third months followed by a light earthing up. Excess shoots should be removed retaining only two shoots per plant at 45 days after planting.

**Irrigation:**

Irrigation is not necessary for tapioca when the rainfall is well distributed. Irrigation may be done at the time of planting if there is a long dry period. Depending upon the soil moisture, 3 to 5 irrigations may be provided to overcome the drought period.

**Rotation and mixed cropping**:

Tapioca can be rotated with maize, banana, yams etc. with proper fertilization once in two years.

Intercropping with short duration leguminous crops like groundnut or cowpea has been found to be advantageous and economical.

**Plant protection:**

Tapioca is not affected by any serious pest and disease. The important ones attacking the crop are mentioned below:

**1)** Spiders, mites and scale insects occur during the dry season which feed on leaf sap causing blotching, curling and leaf shedding and can be controlled by spraying spiromesifen 22.9 SC@ 96 g a.i./ha.

**2)** The two important diseases of tapioca are "Cassava mosaic" and "*Cercospora* leaf spot". The mosaic disease is apparently transmitted by the insect vector *Bemisia* sp. (white fly). As a rule, only stem cutting from healthy plants should be used for planting to minimize the spread. The diseased plants should be uprooted and destroyed when the symptoms are visible. Spraying of lambda-cyhalothrin 5 EC @

15 g ai/ha 3 to 4 times at monthly intervals in the first 4 months of the crop controls the vector and thereby checks the spread of the disease.

**3)** Leaf spot disease can be controlled by spraying azoxystrobin 23 SC @ 0.1% (1g/*l*) or chlorothalonil 75 WP @ 0.2% (2g/*l*).

**Harvesting:**

Tapioca becomes ready for harvest at 8 to 10 months after planting. Harvesting for table purposes is to be done after 8 months and for starch manufacturing, after 10 months of planting. Harvesting is done by removing the soil from the base of the plants and pulling out the tubers by holding the basal portion of the stem.

**Storage of Tapioca:**

Freshly harvested least damaged roots are packed with 50% moist sawdust in wooden boxes. Dry or very moist sawdust should not be used as it results in deterioration. Once packed, the boxes can be stored in a thatch-roofed shed or in open covered by a waterproof tarpaulin. By following the above method, cassava roots can be stored for up to eight weeks without any deterioration. However, the normal method for overcoming the damage is to leave the plants in the ground until needed and once harvested these are to be dried for longer storage life.

**Yield**: 25 to 35 t/ha

**Cost benefit ratio:** 1:2.53, Cost of cultivation Rs.21,236.00

**Value addition of tubers:**

1. **Plain white chips:** The harvested tapioca tubers are peeled and the rind is removed completely. Sliced them into thin slices of 2 mm thickness. Dried in the sun over a clean surface for 6-7 days to bring down the moisture content up to 15%. The converted arrowroot biscuit-like chips can be broken easily.
2. **Parboiled dried chips:** The plain chips are parboiled for 4 minutes, cooled immediately by pouring cold water over them and then dried over a clean surface under open sun preferably in a single layer, for 5 to 7 days to bring the moisture level below 15%. Dried parboiled chips are consumed after grinding as semolina or suji or these can be deep oil fried and seasoned with spices /salt. Such oil fried chips can be consumed fresh or preserved in airtight polybags.
3. **Tapioca flour:** Flour can be made from both plain and parboiled chips, by grinding in a hammer type mill. Flour made from plain white chips will have colour and texture just like wheat flour and it can be used for making 'roti' and other snacks. Flour made from parboiled chips has texture and colour similar to suji and it can be used just like Halwa, Ladoo etc. Primarily processed tapioca products (dried chips and flour) should be packed airtight in food grade plastic containers, stored up to six months at room temperature.

# COLOCASIA

*Colocasia esculenta* Schott

**Variety:** Kaka Kachu, White Gaurya, Panchamukhia, Bidhan Chattanya, Ahinia Kachu and Bidhan Jaydeb

**Soil:** The best soil is sandy loam or alluvial with abundant organic matter. The land should be ploughed 2-3 times after applying adequate quantities of organic manure and wood ash.

**Planting material:**

(a) Small corms or setts cut from large corms

(b) Cormels or setts cut from large cormels

**Spacing:** 60 cm from row to row and 45 cm from plant to plant

**Time and method of planting:**

April-June is the best planting time for Assam, Planting is done on well prepared land in pits filled up with burnt earth, ashes and rubbish. When plants grow to about 30 cm height, the soil around is lessened and earthing up is done.

**Manure and Fertilizer:**

FYM or compost should be applied @ 12 t/ha. In addition, 80 kg N, 60 kg $P_2O_5$ and 120 kg $K_2O$ should be applied per ha (1.6 t FYM, 23.5 kg Urea, 50.4 kg SSP, 27.2 kg MOP/bigha).

**Interculture:**

Weeding and earthing up should be done at 35-40 days after planting, i.e. when plants attain a height of about 30 cm. All dead leaves should be plucked off.

**Intercropping:** Okra and green gram can be grown profitably as intercrops.

**Plant Protection:** C

**1)** Colocasia blight is a serious disease which can be controlled by using chlorothalonil 75 WP @ 0.2% (2 g/*l*) or trifloxystrobin 25 WP @ 0.1% (1 g/*l*) at an interval of 14 days. The spraying should be started 1-2 months after planting.

**2)** In the endemic areas of red ant and other soil insects apply thiamethoxam 25 WG @ 50 g ai/ha as soil drench.

**Harvesting**:

Colocasia gets ready for harvest when most of the leaves begin to turn yellow. Generally, it takes 6-7 months after planting depending upon the variety.

**Yield:** 12 to 16 t/ha

**Benefit: Cost ratio:** 2.32 (Cost of cultivation Rs.30, 097)

# SMALLER YAM

*Dioscorea esculenta* Burk

Smaller yams are cultivated for its tubers and utilized as vegetables. Yams are more nutritious than potatoes and are used as wholesome food during periods of scarcity. The tubers of smaller yams are small and born in clusters on each plant unlike other yams which usually produce only one or two large tubers per plant.

**Variety**: Sree Latha, Lotani, Local Moa Aloo

**Soil and climate:**

It requires a loose, deep and well drained fertile soil. It is essentially a tropical plant and needs a tropical climate. It requires fairly distributed rainfall.

**Preparation of land:**

Plough of dig the land up to a depth of 15-20 cm. Prepare mounds at a spacing of 75 cm x 75 cm.

**Planting material:** Select healthy and medium sized tubers weighing 100-150 g

**Method of planting**: Tubers are planted at the center of the mound (one tuber/mound) in an upright position keeping the proximal end of the tuber 5-7 cm below the soil surface.

**Manure and Fertilizer:**

Broadcast 10 t FYM/ha and incorporate into the soil during land preparation. In addition, 30 kg N, 60 kg $P_2O_5$ and 60 kg $K_2O$ should be applied per ha (1.3 t FYM, 8.8 kg Urea, 50.4 kg SSP, 13.6 kg MOP/bigha). The fertilizers should be applied in two split doses, the first dose one week after sprouting and the second a month later.

**Interculture:**

Weeding and earthing up of soil are done along with fertilizer applications. The plants are either staked or the vines are trailed on coir ropes attached to supports. Training of the vine is essential for the economic yield of tubers.

**Plant protection:**

**Yam Scale**: It usually infests the corms both in the field and under storage condition. Avoid planting the tubers infested with scales.

**Harvesting:**

Harvesting of the crop is done within 78 months when the leaves dry up.

**Yield:** 9 to 14 t/ha

**Benefit: Cost ratio:** 2.31, Cost of cultivation Rs. 20,120.00

# GREATER YAM

*Dioscorea alata* L.

Greater yam is cultivated for its tuber which can be utilized as a vegetable.

**Variety:** Kowari Aloo, DA – 48, Sree Roopa, IGDa-2

**Soil and climate:**

It requires a loose, deep and well drained fertile soil. It requires fairly distributed rainfall.

**Preparation of land:**

Plough or dig the land up to a depth of 15-20 cm. The pits (45 cm x 45 cm x 90 cm) are dug out at a spacing of l m x 1m. Fill up ¾ $^{th}$ of the pits with 1-1.5 kg of cattle manure or compost and mix up with topsoil and form a mound over it.

**Planting season:**

Planting is done from March to May

**Planting material:**

Divide the whole tuber into pieces weighing 250-300 g each. Dip the cut pieces in cow dung slurry and allow drying under shade before planting.

**Method of Planting:**

Plant the cut pieces in the prepared pits with mounds keeping buds facing upward and cover these with soil.

**Manure and Fertilizer:**

80 kg N, 60 kg $P_20_5$and 80 kg $K_2O$ per ha (23.5 kg Urea, 50.4 kg SSP, 18.1 kg MOP/bigha).

**Interculture:**

Weeding and earthing up are done along with fertilizer application. The plants are either staked or the vines are trailed on coir rope attached to supports within 15 days after planting.

**Plant protection**: Same as in smaller yam

**Harvesting:** Harvest the crop at 8-9 months after planting

**Yield:** 16 to 24 t/ha

**Benefit: Cost ratio:** 2.39, Cost of cultivation Rs. 27,926.00

# WHITE YAM

*Dioscorea rotundata* Poir.

White yam is an introduction from West Africa and is cultivated for its tuber which is utilized as vegetables.

**Variety:** I-212

**Description:** Plant medium height ranges 5-8 meters, the vine twine to the right and roughly circular spines as well as a whitish bloom are present on the stem. The leaves are simple, cordate and usually pointed at the tip. The leaves are opposite in their arrangement. The tubers more or less are cylindrical in shape. The skin of the tuber is smooth and light brown, while flesh is usually white, sometimes creamy and firm.

**Soil:** Well drained sandy loam soils

**Land preparation**: The land should be ploughed to 15-20 cm depth followed by leveling. Pits of 45 cm x 45 cm x 90 cm are dug out at a spacing of l m x l m. Fill up the pit with 1 : 1 : 1 cow dung or compost, straw or dried leaves and topsoil and form a mound over it.

**Planting materials:** Divide the whole tuber into spices weighing 250-300 g each. Preferably use the head and/or tail or tips and dip them in cowdung slurry or smear in wood ash and dry under shade before planting.

**Planting season:** Planting is done from March to May.

**Method of planting**: Plant the out pieces in the prepared pits with mounds keeping buds facing upwards and cover them with soil, put 3-5 cm mulch over the mounds.

**Trailing:** Put 2-3 m bamboo split poles on each pit and tie 3-4 such poles into one, at top construct a pandal for climbing of the vines.

**Manure and Fertilizer:** Cowdung or compost @ 1-1.5 kg/pit should be incorporated at the time of mound preparation. N-$P_2O_5$-$K_2O$ @ 80-60-80 kg/ha (23.5 kg Urea, 50.4 kg SSP, 18.1 kg MOP/bigha) should be incorporated into the soil at the time of first earthing up of soil (1-1.5 months after their culture).

**Interculture**: Weeding and earthing up are done along with fertilizer application. The plants are allowed to trail on bamboo poles or pandals within 15-20 days after planting.

**Plant protection:** Same as in smaller yam

**Harvesting:** Harvest the crop at 9-10 months after planting

**Yield**: 25 to 50 t/ha

**Benefit: Cost ratio:** 3.16, Cost of cultivation Rs.25, 173.00

# ELEPHANT FOOT YAM

*Amorphophallus paeoniifolius* (Dennst.) Nicholson

Elephant foot yam is cultivated for its underground stem which is used for making vegetable dishes.

**Variety:** Gajendra and local selected varieties

**Soil and climate:**

It needs well drained sandy loam soil. It is both a tropical and sub- tropical crop. It requires a well distributed rainfall with humid and warm weather during vegetative phase and cool and dry weather during the development of the corms.

**Preparation of land:**

Plough or dig the land to fine tilth. Make pits of size 60 cm x 60 cm. Collect the topsoil to a depth of 15-20 cm. Mix the top soil with cow dung or compost (2-2.5 kg per pit) and fill the pit with it.

**Planting season and method of planting:**

Start the cultivation in the month of March to April. It can also be planted up to August but planting later than the middle of August will affect the size and yield of corm.

**Planting Material and Planting:**

Select good corms free from mealy bug infestation. Cut the corms into pieces of 1kg size each with a central bud. Dip the pieces in cowdung slurry. Dry it in shade for 2-3 days. Plant the corn vertically in the prepared pit and cover it with soil.

**Manure and Fertilizer:**

A high fertility in the soil is essential as the crop is a heavy feeder. Potash in the form of wood ash, farm refuse etc. is suitable for it. Paddy husk, dried leaves, etc. are also applied in the absence of cattle manure. It responds well to 80 kg N, 60 kg P2O5 and 100 kg $K_2O$ per ha (23.5 kg Urea, 50.4 kg SSP, 22.7 kg MOP/bigha).

**Interculture:** Weeding and earthing up should be done at 30 and 60 days after planting. Retain only one healthy shoot.

**Plant protection:** Corms are usually attacked by mealy bugs in field and storage conditions. Avoid planting corms infested with mealybugs.

**Harvesting:** Harvest the crop at 9 months after planting when all leaves turn yellow and dry off.

**Yield:** 25 to 40 t/ha

# TREE VEGETABLE

## SAJINA

*Moringa oleifera*

Moringa is popular as a fruit vegetable for its tender green pods as well as mature pods with tough exterior, the leaves can be used as fresh vegetables for their delicious taste and very high nutritional & therapeutic qualities. The tender leaves are used for garnishing dal, sambars, salads, etc. while the dried & powdered older leaves can be stored for a long time under ordinary conditions without loss of nutritional value.

**Soil & climate:**

It tolerates a wide range of soil conditions but prefers a neutral to slightly acidic (pH 6.3 to 7.0), well drained sandy or loamy soil at 25 – 30 $^0$C under sunny situation and can tolerate mild frost but does not stand waterlogged.

**Method of propagation:** Seeds & Hard wood cutting

**Planting:**

One third lengths of 45 cm to 1.5 m long and 10 cm thick cuttings should be buried directly in the pits prepared at 4 m distances. Application of rooting hormone before planting gives better results. Boundary/in field/on bunds/homestead is best suited for planting.

**Manures and fertilizers**:

Lime should be applied on the basis of lime requirement of soil. Application of 5 kg of FYM should be added in each pit. A fertilizer dose of 45-15-30 g of N-$P_2O_5$-$K_2O$ /pit should be applied 3 months after planting. Apply 45 g of N/pit after 6 months when the crop is in bearing.

**After care:**

It is necessary to pinch the terminal bud on the central leader stem when it attains a height of 75 cm. This will promote the growth of many lateral branches and reduce the height of the tree.

**Intercropping**:

Okra, tomato, French bean, cowpea or seasonal flowers can be cultivated as intercrops in young moringa plantations

**Pollarding, Coppicing, Lopping or Pruning**:

An overgrown tree may be cut back to 1-2 m above ground level to induce juvenility. By training and pruning 3-4 times during vegetative phase a strong framework with bushy shape may be obtained to maximize fruit and leaf production. Pruning should be undertaken before the month of August as flowering starts in November-December.

**Plant Protection:**

**A) Pests:**

In Assam, several insect pests are seen, including various bark eating caterpillars, the hairy caterpillar or the green leaf caterpillar. Occurrence of hairy caterpillars on the tree trunks is the main deterrent for its inclusion in the kitchen garden.

**Control:** Use flame torch when the caterpillars settle on the tree trunk or spraying of contact insecticides.

**B) Disease:** Pod rot is turning out to be a serious problem in the southern states but not in Assam.

**Harvesting and yield**:

Plants raised from cuttings give flowers in that very year but 20- 30 fruits can be harvested in the second year and increase to 200- 300 Nos. in 4-5 years, a fully developed tree yields 600-800 pods annually. One hectare of well grown *Moringa oleifera* plantation can fetch net return as high as Rs. 2.0-2.5 lakhs per year in Assam.

# SPICES AND CONDIMENTS

## ONION

*Allium cepa* L.

**Variety:**

Pusa Red, Pusa Ratnar, Pusa White (Round), Pusa white (Flat), N-53, Agrifound Light Red, Punjab Red Round, Pusa Madhuri, Arka Niketan

**Description:**

**Pusa Red**: Plant height 30 cm; bulb medium sized (70-90 g each) flattish round; purplish red, less pungent, maturity 125-140 days after transplanting; 12 bulbs weight about 1 kg; characteristically free from bolting tendency; keeps well in storage; short to intermediate day length type.

**Pusa Ratnar**: Plant height 30 cm; leaf dark green with waxy bloom; bulb large, ovate to flat globular, attractive bronze deep red coloured, less pungent, neck dropping; maturity about 125 days after transplanting; heavy yielder (500 q/ ha); less bolting tendency, keeps better in storage.

**Pusa White (Round):** Bulb white, roundish flat in shape; avg. yield 300 q/ha suitable for dehydration.

**Pusa White (Flat**): Bulb medium to large in size, flattish round in shape, attractively white coloured; maturity 130-150 days; high yielder; good in storage and suitable for dehydration.

**N-53:** Bulb has bright scarlet red colour; maturity 121-140 days; bulb yield 197q/ha.

**Agrifound Light Red**: Bulb globular shaped, skin light red; duration about 110 days from transplanting to harvesting; yield 200 q/ha.

**Punjab Red Round**: Bulb round, neck thin, skin shining red; duration about 120days from transplanting to harvesting; yield about 200 q/ha.

**Pusa Madhavi**: Bulb round, neck thin, skin light red; duration about 125 days from transplanting to harvesting; yield about 220 q/ha.

**Arka Niketan**: High yielding short duration and low bolting variety.

**Soil:**

Well drained sandy loam to silty loan rich in organic matter with pH 5.5-6.5.

**Seed bed preparation and seedling raising:**

Refer “procedures for nursery raising of transplanted vegetable crops”.

**Field preparation**:

The field should be prepared to a fine tilth. Apply FYM or compost during field preparation.

**Seed rate:**

**For transplanting**: 7 kg /ha (935 g/bigha)

**For direct sowing**: 14kg/ha (1870 g/bigha)

**Sowing time:**

Last week of September – mid October

**For Hills Zone**: Transplanting of seedlings should be done in the last week of October (25$^{th}$ October).

**Method of sowing/planting:**

1. **Direct sowing:** Seeds are sown in lines in a well-prepared field and seedlings are thinned out to proper spacing after 6-8 weeks. Direct sowing is preferable in riverbed or "*CHAR*" areas.
2. **Transplanting:** 6-8 weeks old seedlings are planted either in dry or puddled beds. In dry planting, irrigation is provided immediately after transplanting. Shallow planting should be done at 2-3 cm depth.

**Spacing:** 20 cm x 10 cm (Row to Row x Plant to Plant)

**Manure and fertilizer**:

FYM @ 20 t, N 60 kg, $P_2O_5$ 50 kg and $K_2O$ 50 kg/ha (2.6 t FYM, 23.5 kg Urea, 42.0 kg SSP, 11.3 kg MOP/bigha). 40 kg N and full doses of FYM, $P_2O_5$ and $K_2O$ as basal and of the remaining N 10 kg to be top dressed at 30- 40 days after planting followed by foliar spraying of remaining 10 kg N at 60-70 days. For hills zone; N @ 120 kg, $P_2O_5$ 80 kg and $K_2O$ 80 kg/ha is recommended.

It has been recommended that for drip irrigation in *Rabi* Onion, apply 35 ml of water per plant per day along with 260 kg/ha water-soluble fertilizer (19:19:19) in five equal splits at 20-days interval up to 100 days after transplanting and rest 20 kg urea per ha as basal dose yields 12.5-25% yield advantage over the existing with B:C of 3.05.

**Interculture:**

1. **Irrigation**: At 7 days interval and a total of 10-15 irrigations required from transplanting to harvesting. Irrigation at bulb development is of great importance; however, it should be stopped at least 15 days before harvest.
2. **Weeding**: One hand weeding at 40 days after transplanting should be done to control the weeds.

**Plant protection:**

**1. Thrips**: Spray Lambda-cyhalothrin 5EC @ 15 g ai/ha. Apply emamectin benzoate 5 SG @ 10 g ai/ha.

**Harvesting and Curing**:

The crop matures in 3-4 months after planting when 70% of the plant starts drying. Harvesting should be avoided during the rainy period. At least 10-15 days ahead of harvesting de-necking (breaking of stem) should be done for proper drying of the bulb. After lifting the bulbs, they may either be left in the field for curing or removed to provide shade for curing. After curing, sort out the injured, damaged and thick necked bulbs from healthy stock and the thoroughly ripened and well cured ones with thin necks. For storage of onion, bulbs are suspended in bundles on bamboo or ropes. Besides, bulbs can be stored for a considerable period of time on dry sand (5 cm thick) spread over *pacca* floor and room temperature.

**New technology-** Sowing black gram in line between rows of summer season Okra (45 cm x 30 cm) yields higher income

**Yield:** 150 – 200 q/ha

**Benefit: Cost ratio:** 7.92

# GARLIC

*Allium sativum* L.

**Variety:** Selected local varieties, Eknalia, 56-4 and G-1

**Soil:** Well drained sandy loam rich in organic matter with pH 5. 5-7.0

**Field preparation:** As in onion.

**Seed rate:** About 3.5-5.0 q cloves/ha (0.5 – 0.7 q cloves/ha)

**Sowing time**: September – October

**Spacing:** 15 cm x 5-7 cm

**Manure & Fertilizer**:

FYM @ 20 t, N 100 kg, $P_2O_5$ 80 kg and $K_2O$ 60 kg/ha (2.6 t FYM, 29.3 kg Urea, 67.2 kg SSP, 13.6 kg MOP/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be supplied as basal and the remaining half of N to be top dress at 30 days after sowing.

**Interculture:**

1. **Irrigation:** Irrigation should be provided at 7 days interval during early stage, at 15 days interval during maturation and should be stopped at least 15 days before harvesting.
2. **Weeding:** First weeding at 30 days and the second at 60 days after planting.

**Harvesting and curing:**

Garlic is a crop of about 4–5 months. Harvesting of bulbs should be done when the leaves start drying, yellowing or browning and show the signs of drying. The bulb should be cured in 7-10 days.

**Plant protection:** Same as in onion

**Yield:** 60-90 q/ha

**Benefit: Cost ratio**: 4.24

# CHILLI

*Capsicum annuum* L. var. *acuminatum*

**Variety:**

NP 46 A, Pusa Jwala and selected local varieties like Suryamukhi, Krishna and Balijuri

**Description:**

**NP 46 A**: Plant dwarf, dense, spreading, fruit long (about 10.7 cm), thin, green when unripe and bright red when ripe, less seeded, pungent, prolific bearer; medium early; tolerant to thrips; contains 0.5 mg capsaicin per gram of fruit.

**Pusa Jwala**: Plant dwarf, spreading fruit long, thin, usually, curved, red coloured; more suited as green chilli; tolerant to thrips, leaf curl and mosaic viruses; contains 0.43 mg capsaicin per gram of fruit.

**Soil:** Well drained sandy loam rich in organic matter with pH 6. 0.6.5

**Field Preparation:** The field should be prepared to a fine tilth and FYM to be applied.

**Seed Bed Preparation and Seedling raising:** Refer' Procedure for "Nursery raising of transplanted vegetable crops".

**Time of Sowing**: September-October

**Seed Rate**: 700 g/ha (95 g/bigha) 3-4 g of seeds should be sown per 10 sq. m.

**Method of Sowing or Planting:**

1. **Direct Sowing**: Seeds should be sown thinly in lines spaced at 40-45 cm and seedlings are thinned out to proper spacing later on.
2. **Transplanting:** 4-5 weeks old seedlings are to be transplanted in the field.

**Spacing:** 45 cm x 45 cm

**Manure and Fertilizer:**

FYM @ 10t, N 120 kg, $P_2O_5$ 60 kg and $K_2O$ 60 kg/ha (1.3 t FYM, 35.2 kg Urea, 50.4 kg SSP, 13.6 kg MOP/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ should be applied as basal and the remaining half of N to be top dressed at 30-35 days after transplanting.

For direct seeded chilli, N : $P_2O_5$ : $K_2O$ @ 150 : 75 : 75 kg/ha should be applied as a basal dose.

**Plant Protection:**

1. **Fruit rot or Anthracnose disease**: Spray chlorothalonil @ 0.2% (2 g/liter of water) or azoxystrobin 23SC @ 0.1%.(1 ml/liter of water)
2. **Root knot Nematode:** Apply Neem cake or Mustard @ 300-400 kg/ha at least 25 days prior to sowing / transplanting.
3. **Thrips, aphids, fruit borer:** Apply emamectin benzoate 5 SG @ 10 g ai/ha. Apply chlorantraniliprole 18.5 SC @ 30 g ai/ha.
4. Two sprays of fenazaquine 10 EC @ 2.0 ml/l at 10 days interval to control yellow mite of chilli (*Polyphagotarsonemus latus)* (B:C ratio 3.15)

**Yield**: 70-80 q of green chilli/ha

**Benefit: Cost ratio:** 4.24

# BHUT JOLOKIA

*Capsicum chinense*

**Varieties:**

**Bor Bhut**: Fruits are bigger in size with average fruit weight 7g, fruits with dark green colour

**Rani Bhut**: Fruits are of medium size with average fruit weight 5g

**Lota Bhut**: Fruits are slender with average fruit weight 5g. Plants have a tendency to climb

**Soil**:

Well drained sandy loam rich in organic matter having good water holding capacity with pH 6.0-6.5

**Field Preparation:**

The field should be prepared well with ploughing and harrowing. Cross ploughing is advocated to avoid the possibility of unploughed strips.

**Seed Bed Preparation and Seedling Raising**:

**Seed collection:**

(a) Collect mature red ripe fruits from authentic sources. The mother plants should be free of diseases and bearing healthy fruits.

(b) Extract the seeds manually using blades and forceps.

(c) Always use hand gloves and spectacles for such work.

(d) Wash the freshly extracted seeds in clean water and dry under shade.

(e) Before sowing, treat the seeds with 1% potassium nitrate or potassium iodide solution for 3 ha. Alternately, the seeds should be soaked overnight in 0.1% solution of potassium nitrate or potassium iodide. In place of the chemicals, seeds can also be soaked overnight in fresh cow urine diluted 10 times.

(f) The treated seeds should be dried under shade for 12 hours after treatments.

**Seed Bed Preparation**

(a) The nursery bed should be prepared in a well-drained sunny area.

(b) 20 kg sand or silt and 20 kg well decomposed sieved cattle manure or compost per 10 $m^2$ area should be mixed thoroughly.

(c) The bed should be drenched with azoxystrobin 23 SC @ 0.1% + carboxin @ 0.2% @ 3 liter per $m^{2.}$

(d) The bed should be covered with a polyethylene sheet for 2 days

(e) The bed should be uncovered and exposed for 1 more day

**Sowing:**

(a) Sow the germinated seeds thinly in furrows spaced at 2.5 cm.

(b) Cover the seeds with a thin layer of treated mixture of sand and sieved cattle manure.

(c) Water the bed lightly

(d) Place an overhead insect-proof net (40 mesh), 1m high, covering all sides.

(e) Keep another transparent polyethylene sheet ready for placing on the overhead structure to serve as a rain-shelter at necessity.

(f) The seedlings get ready for transplanting in 30-45 days after sowing when they attain 10-15 cm height.

(g) Harden the seedlings before lifting by gradual reduction of water for about a week.

(h) Copiously water the bed 6 hr prior to lifting for minimizing root damage during removal of seedling and maintaining plant turgidity.

**Sowing Time:**

(a) Sept-Nov in the plains for irrigated crops

(b) Jan/Feb for rainfed crops

(c) Jan-March for hills region

**Seed Rate:** 115 g seeds/ha (15 g seeds/bigha)

**Spacing:** 1.0 m x 0.75-1.0 m

**Land Preparation:**

Raised bed (15 cm) of 2.00 m width and convenient length should be prepared keeping 40 cm wide inter-bed channels. The channels should be connected to drainage ditches of deeper level.

Two rows of pits measuring 45 cm × 45 cm × 45 cm should be prepared leaving 50 cm longitudinally on both sides of the beds.

**Transplanting:**

30-45 days old seedlings with 3-4 leaves should be transplanted.

**Manures and Fertilizer:**

FYM @ 1 kg/pit to be applied at final land preparation and mixed well. N-$P_2O_5$-$K_2O$ @12-6-6 g/pit should be applied. Half of nitrogen and full doses of phosphorus and potash should be applied as basal and the remaining half of nitrogen to be top dressed in 2 splits at 30 and 60 days after transplanting.

Each seedling should be dipped in a slurry made from 5g *Azospirillum* and 5g PSB for 1 hr before transplanting in a pit. The foliar application of Multiplex @ 0.2% should be done during the active growth stage.

Application of growth promoters like 0.2% Tricontanol is also recommended for boosting up growth and yield.

**Intercultural Operations:**

Mulching with organic materials or LDPE film can also be practiced for suppression of weeds.

The crop cannot tolerate very intense sunlight. Therefore, appropriate measures should be taken to raise non-competitive shade plants.

Staking with bamboo sticks may be required to provide mechanical support to the plants.

**Insect management**

(a) For controlling insects like aphids, thrips, white fly, leaf and plant hoppers apply imidacloprid 17.8 SL @ 20 g ai/ha or 0.3 ml/*l*. Apply thiamethoxam 25 WG @ 20-25 g a.i./ha.

(b) Apply profenofos 50EC (1 ml/*l*) against mites and lepidopteran insects.

(c) For controlling fruit borer, spray lambda cyhalothrin 5 EC @ 1 ml/*l* at the time of fruit setting followed by another spray after 15-20 days.

(d) In organic culture, spray *Beauveria bassiana* @ 3 ml/*l* against sucking pests. Neem seed kernel extract (NSKE) 5% may also be sprayed @ 3 ml/*l* for repelling insect pests.

**Yield:** 120-150 q/ha

**Benefit: Cost ratio:** 8.7

# CAPSICUM

*Capsicum annuum* L. var. *grossum*

**Variety:** California Wonder, Elephant Trunk, Arka Mohini, Arka Gaurav and Selection-16

(The other cultivation practices are the same as for chilli).

# GINGER

*Zingiber officinale* L.

**Variety:** Rio-de-Janeiro, Nadia, Karkai, Bardwan, Moran, Jorhat and China.

**Soil:** Well drained medium loam.

**Seed Rate:** Seed rhizome with one or two good buds weighing about 5g @ 22q/ha (3.0 q/bigha)

**Planting Time**: March-April

**Spacing:** 30 cm x 10 cm to be planted in a shallow pit.

**Manure and Fertilizer**:

FYM @ 10 t, N 20 kg, $P_2O_5$ 60 kg and $K_2O$ 20 kg/ha (1.3 t FYM, 5.9 kg Urea, 50.4 kg SSP, 4.5 kg MOP/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ to be applied as basal and the remaining half of N to be top dressed at 60 days after planting.

**Interculture**:

1. **Mulching:** First mulching should be done after planting and to be repeated at40 days after planting with suitable mulching material like paddy husk and sawdust.
2. **Irrigation**: At 15 days interval during dry spell
3. **Weeding:** First weeding at 40 days after planting (before second mulching) and to be repeated depending upon intensity of weed growth.
4. **Earthing up**: To be done along with weeding

**Plant Protection:**

1. **Shoot borer and leaf roller:** Apply Chlorantraniliprole 18.5 SC @ 30 g ai/ha
2. **Rhizome (soft) rot:** (a) Drainage system should be improved. (b) Prophylactic measure should be taken through treatment of seed rhizome with ferbam 70WP 0.1% (1 g/*l*) or metalaxyl @ 0.2% before storage or planting. (c) The affected areas should be drenched with 0.3% carboxin. Rhizome treatment with copper oxychloride (COC) @ 3 g/*l* + streptomycin (0.2 g/*l*) for 45 minutes followed by shade drying and planting and two soil drenching with COC @ 3 g/*l* at 60 and 90 days after planting against rhizome rot of ginger and alternatively rhizome treatment with Biofor-pf + 2 soil drenching with copper oxychloride (3 g/*l*) at 60 and 90 days after planting and also for organic management, rhizome treatment with Biofor-pf followed by spraying with Biozine @100 ml /clump at 60, 90 and 120 days after planting against rhizome rot of ginger.
3. **Leaf spot:** Apply 1% Bordeaux mixture or 0.2% chlorothalonil 75 WP

**Harvesting and Curing:**

The crop should be harvested when leaves start yellowing and gradually dry up. Rhizomes should be thoroughly washed in water 2-3 times to remove soil and dirt and then

dried in the sun for a day.

**Yield:** 150-200 q/ha.

**Benefit: Cost ratio:** 5.2

# TURMERIC

*Curcuma longa* Linn.

**Variety:** Shillong Type, Tall clone, CL-24, PTS-38, PCT-13, and VK-145

**Description:**

**Shillong Type**: Plant height 140-180 cm; tiller 2-3/clone; leaf 6-9/tiller leaf shiny green; finger rhizome stout, reddish; mother rhizome smaller and constitutes about 24% of the total crop; maturity 255 days; percentage of dry turmeric to green turmeric is 16; highly resistant to *Collectotrichum* leaf spot and Taphrina leaf spot.

**Tall Clone**: Plant height 160-190 cm; tiller 2-3/clump; leaf 5-8/tiller; finger rhizome stout, reddish yellow; maturity 210-280 days, percentage of dry turmeric to green turmeric is 17; susceptible to Taphrina leaf spot in the later stage.

**CL-24**: Medium duration variety with average curing percentage is 26.35, avg. yield of cured produce is 11.60 t/ha and curcumin content 8.55%. Average fresh rhizome yield is 54 t/ha with good tolerance capacity towards common disease and pests.

**PTC-38**: Medium duration variety with almost 24% curing, avg. cured produce of 12.15 t/ha and curcumin content 5.75%. Average fresh rhizome yield is almost 54 t/ ha with good field tolerance to common pests and disease.

**PCT-13**: Medium duration variety with 17.15% avg. curing and 11.25 t/ha cured produce. Average fresh rhizome yield is 66 t/ha and curcumin content is 4.8%. This variety is also tolerant to common pests and diseases.

**Megha Turmeric-1**: Suitable for planting in hills as well as in the plains, as rainfed and irrigated crop. Suitable for processing, extraction of curcumin and oleoresin. Matures in 300-315 days yielding 25-30 t/ha rhizomes with 6.8-7.0% curcumin content and 16.4-20 % dry matter content. It has high tolerance to leaf blotch and leaf spot disease.

**Soil:** Well drained sandy loam to clay loam rich in organic matter

**Seed Rate:** Mother or finger rhizome @ 25 q/ha (3.3 q/bigha)

**Planting time**: April

**Spacing:** 45 cm x 25 cm (Rhizomes are to be planted in furrows at 10 cm depth).

**Manure and Fertilizer:**

FYM @ 20 t, N 30 kg, $P_2O_5$ 50 kg and $K_2O$ 60 kg/ha (2.6 t FYM, 8.8 kg Urea, 42.0 kg SSP, 13.6 kg MOP/bigha). Half of $K_2O$ and full doses or FYM and $P_2O_5$ should be applied as basal. Half of N and the remaining half of $K_2O$ should be side dressed at first earthing up (3 months after planting) and the remaining half of N to be side dressed at second earthing up (4 months after planting). For hills zone, N @ 90 kg, $P_2O_5$ 50 kg and $K_2O$ 60 kg/ha is recommended.

**Interculture:** As in Ginger

**Plant Protection:**

1. **Mites, Leaf roller and Shoot borer**: Spray Lambda-cyhalothrin 5EC @ 15 g ai/ha or Apply Chlorantraniliprole 18.5 SC @ 30 g ai/ha against leaf roller and shoot borer.
2. **Taphrina and *Collectotrichum* leaf spot**: Apply 1% Bordeaux mixture or Zinc or chlorothalonil 75 WP @ 0.2% (2 g/*l*). Spraying should be done at 15 days interval starting at the first appearance of the disease
3. **Rhizome rot:** Same measure as in Ginger.

**Harvesting and Curing:**

The crop should be harvested when it leaves after yellowing and gradually dry up. Fingers are separated from the rhizome, cleaned and dried for one day.

**Processing**:

The clean rhizomes are boiled to make them soft in water containing alkaline substances like lime, sodium bicarbonate or sodium carbonate at 0.05% - 0.1% concentration. Alkalinity of boiling water helps for developing orange yellow tinge to the core of the turmeric. The boiled turmeric is dried in the sun until it produces a metallic sound. The dried rhizomes are polished by putting the rhizome in a gunny bag and struck against the floor to remove the scales and roots.

The next stage in processing is giving yellow colour externally to the turmeric tubers to make them attractive in the eyes of the buyers. The polished fingers are taken in a wicker basket which is shaken continuously while a prepared emulsion is poured in. After the fingers are uniformly coated with the emulsion they are again dried in the sun.

The composition of the emulsion required for coating 100 kg of polished turmeric is –

| | |
|---|---|
| Alum | 0.04 kg |
| Turmeric Powder | 2.00 kg |
| Castor seed | 0.14 kg. |
| Sodium bisulphate | 0.30 kg |
| Hydrochloric acid | 0.30 ml (Developed by CFTRI, Mysore) |
| Curing Percentage | 14-16% |
| Curcumin Content | 2.5-3.5 % |

**Yield:** 300-350 q rhizome/ha

**Benefit: Cost ratio:** 7.77

# CORIANDER

*Coriandrum sativum* L.

**Variety:**

**Bold seeded:** UD 21, GAUI, CSI and CIMPO 33 (Normally cultivated under irrigated condition).

**Small seeded:** UP 41, Pusa 360 and Local selection (suitable for cultivation under rained condition).

**Soil:** Well drained medium to heavy soil rich in organic matter with pH 6.0-7.0.

**Field preparation:** Field should be thoroughly ploughed and harrowed to obtain a fine seeding bed and FYM to be applied.

**Seed rate**: 8-10 kg/ha (1.1 – 1.3 kg/ha)

**Sowing time**: Mid October-November

**Seed treatment:** For ensuring good germination, seed should be soaked in water for 12-24 hours. Floated seeds should be discarded. Seeds should be treated with Carboxin @ 2 g/kg seed before sowing and rubbed or crushed between palms until the pericarps separate.

**Spacing:** Directly sown in lines spaced at 30 cm and later on thinned to 20 cm within rows at 35-40 days after sowing.

**Manure and Fertilizer:** FYM @10-15 t, N 50 kg, $P_2O_5$50 kg and $K_2O$ 50 kg/ha basal application (2.0 t FYM, 14.7 kg Urea, 42.0 kg SSP, 11.3 kg MOP/bigha).

**Interculture:**

1. **Irrigation:** First irrigation at 30 days after sowing and to be repeated at flowering peak.
2. **Weeding:** Sufficient weeding as per necessary.

**Plant protection**:

1. **Wilt**: Take prophylactic measures through seed treatment.
2. **Powdery mildew**: Apply wettable sulphur @ 2 kg/ha
3. **Stem gall**: Take prophylactic measures by sun drying the seed thoroughly.

**Harvesting**:

The crop matures in 4 months. Stage of harvesting influences seed yield and oil content. Seed should be harvested at a fully ripe stage. Unripe seeds lack the pleasant odour.

**Honeybee pollination:**

For yield increase in coriander, install honeybee (*Apis cerana) colonies* @ 5 Nos. /ha

**Yield**: 45 q of seed/ha

# BLACK CUMIN

*Nigella sativa* L.

**Variety:** Local cultivars

**Soil:** Well drained high sandy loam soil rich in organic matter with pH 6.0-7.0

**Field Preparation:**

Land should be thoroughly prepared by 5-6 ploughing and laddering. FYM should be applied.

**Seed Rate:** 7.5-8.0 kg/ha (1.0 – 1.1 kg/ha)

**Sowing Time:** Mid-October- November

**Seed Treatment**:

Seeds should be soaked in water for 24-36 hours followed by drying in shade. Dry seed treatment should be done with Carboxin @ 2-3 g/kg seed.

**Spacing:**

Seed should be directly sown in lines spaced at 30 cm and seedlings are thinned out to 10 cm within row at 35-40 days after sowing.

**Manure and Fertilizer:**

FYM @ 20 t, N 30 kg, $P_2O_5$ 40 kg and $K_2O$ 40 kg/ha (2.6 t FYM, 8.8 kg Urea, 33.6 kg SSP, 9.1 kg MOP/bigha). Half of N and full doses of FYM, $P_2O_5$ and $K_2O$ to be applied as basal and the remaining half of N should be applied in two equal splits, first at 6-8 weeks after sowing and the second just prior to flowering.

**Interculture:**

1. **Irrigation:** First irrigation at 35-40 days, second at 60 days and the third at 80-85 days after sowing.
2. **Weeding:** First weeding should be done at 35-40 days after sowing followed by another at 60 days after sowing.

**Plant Protection**:

1. **Cut worm and Fruit borer**: Clothianidin 50WDG @80 g ai/ha
2. **Stem rot**: Apply copper oxychloride 50WP or chlorothalonil 75WP @ 0.2% (2 g/*l*) at an interval of 15-20 days.

**Harvesting:**

Transition of plant and fruit colour to yellow indicates the right stage of harvest. The plants should be uprooted or cut at ground level, stacked for 7 days and threshed.

**Yield:** 8-15 q of seed/ha

# CUMIN

*Cuminum cyminum* L.

**Variety:** RS- 1, S-404, MC-43, NP (6)-1, NP (J)-140 and NP (J)-126

**Soil:** Well drained sandy loam rich in organic matter with pH 6.0-7.0.

**Field preparation**: Land should be prepared thoroughly and FYM should be applied

**Seed rate:** 10-15 kg/ha (1.3 – 2.0 kg/ha)

**Sowing time**: February-March

**Seed treatment**: As in Black cumin

**Method of bowing and spacing:** Seed are sown on rows spaced at 50 cm, in finally prepared and irrigated beds. Thinning should be done afterwards to maintain a plant spacing of 10 cm within rows.

**Manure and Fertilizer:** As in Black cumin

**Interculture**:

**Irrigation**: A light irrigation before sowing, another at 7-8 days after sowing (at germination) and at 15-20 days interval thereafter.

**Weeding**: Same as in Black cumin

**Harvesting:** As in Black cumin

**Yield:** 8-10 q/ha seed

# FENNEL

*Foeniculum vulgare* Mill

**Variety:** Selected local varieties and PF-35

**Soil:** Well drained sandy loam rich in organic matter with pH 6.0-7.0.

**Field Preparation:** Land should be prepared thoroughly and FYM should be applied.

**Seed Rate**: 10-12 kg/ha (1.3 – 1.6 kg/bigha)

**Sowing Time**: October-November

**Seed Treatment:** Seed should be treated with Carboxin @ 2 g/kg seed

**Spacing:** Same as in Black cumin

**Manure and Fertilizer:** FYM @ 20 t, N 50 kg and $P_2O_5$ 25 kg/ha (2.6 t FYM, 14.7 kg Urea, 33.6 kg SSP/bigha). Half of N and full doses of FYM and $P_2O_5$ should be applied as basal and the remaining half of N to be top dressed at 40 days after sowing. All total 5-6 irrigations are required depending upon soil and climatic conditions.

**Weeding**: As in Black cumin

**Harvesting:** The crop is ready for harvesting in 4-5 months

**Yield:** 10 q of seed/h

# FENUGREEK

*Trigonella foenum graecum* L.

**Variety:** Pusa Early Bunching, Kasuri and Methi No.47

**Soil:** Well drained sandy loam to clay loam rich in organic matter with PH 6.0-7.0.

**Field preparation:** The land should be prepared to a fine tilth after FYM application

**Seed rate:** 20-25 kg/ha (2.7 – 3.3 kg/bigha)

**Sowing time**: Mid-October-November

**Spacing:** Directly sown in rows spaced at 30 cm and seedlings are thinned out to 10 cm within the rows at 35-40 days after sowing.

**Seed treatment:** Seed should be treated with Carboxin @ 2 g/kg seed

**Manure and Fertilizer:**

$N:P_2O_5:K_2O$ @ 25:25:30 kg/ha (1.3 t FYM, 7.3 kg Urea, 33.6 kg SSP, 6.8 kg MOP/bigha).

**Interculture:**

**Irrigation:**

A light irrigation should be done just after sowing and frequently thereafter; generally, each cutting should be followed by a light irrigation.

**Weeding:**

Weeds must be controlled within 20-25 days after sowing.

**Harvesting:**

The young shoots are nipped off about 3 weeks after sowing. Later on the whole plant is pulled out, bunched and marketed. Sometimes the plants are left in situ to produce seeds after taking 2-3 cuttings.

**Yield:** Leaf yield 70-100 q/ha

**Seed yield:** 6-15 q/ha (Provided no leaf cutting is made)

# MINT

*Mentha arvensis* L.

**Variety:** Japanese Mint and Local varieties

**Soil:** Well drained sandy loam to clay loam soil rich in organic matter with pH 6.5-7.0

**Planting Material:** Propagated by runners or rooted cuttings of parent plant.

**Seed Rate:**

2.5-3.5 q suckers are required to plant a hectare of land. Suckers are planted in furrows 12-15 cm apart.

**Treatment:**

The Stolen should be treated with 0.1% solution of dithane M-45 for 5-10 minutes before planting against root rot.

**Manure and Fertilizer:**

30 t FYM per ha should be applied before planting. Also, application of 150 kg N, 80 kg P and 60 kg K per ha (3.9 t FYM, 44.0 kg Urea, 67.2 kg SSP, 13.6 kg MOP/bigha) is necessary. Nitrogen should be applied in split doses.

**Interculture:**

1. **Irrigation:** It requires occasional irrigation be provided alternate days.
2. **Weeding:** Two hoeing operations for each flush of crops.

**Harvesting:**

It requires special care during harvesting otherwise yield is affected. Harvesting should be done in the morning on a bright sunny day.

**Yield:** Japanese mint yields 248 kg green leaves per ha.

# PLANT PROTECTION (CUMIN, FENNEL, FENUGREEK AND MINT)

1. **Powdery mildew**: Can be controlled by spraying wettable sulphur @ 1 kg/ha in 625 liters of water. The spray should be repeated after 10-15 days. Dusting the crop with 20-25 kg sulphur dust/ha would also control the disease.
2. **Blight:** At the time of flowering the crop should be treated with chlorothalonil 75WP @ 0.2% or Fytolan. Chlorothalonil can be mixed with Wettable sulphur to control both blight and powdery mildew.
3. **Wilt:** Runner or sucker treatment with azoxystrobin 23SC @ 2 g/kg of planting materials.
4. **Termite:** Soil application of clothianidin 50 WDG @ 80 g ai/ha as soil drench at the time of field preparation.
5. **Aphid:** Spraying emamectin benzoate 5SG @ 220 g/ha. Spray should be repeated at 20-30 days intervals according to need.
6. Other pests like stink bug and leaf eating caterpillar are seen feeding on the crop but not that seriously which need control.

# BLACK PEPPER

*Piper nigrum* L.

**Variety:**

Only hermaphrodite varieties should be cultivated

The following varieties are common.

- Panniyur-1 (hybrid variety)
- Karimunda
- Panniyur-5
- Subhakara

**Soil:** Well drained alluvium with high organic matter content

**Propagation:**

Black pepper is propagated from cuttings rather than from seeds. Runners used for cuttings should be of 3 nodes length and can be planted directly near the standard (support) or in polythene sleeves in the nursery filled with 1:3 part well rotten cowdung or compost and virgin soil.

**Time of taking cutting:** March

**Time required for rooting and new shooting**: 2 to 3 months

**Time of planting in the main field**: May/June

**Method of planting**:

Planting in virgin land can be done by providing some kind or standard like some fast growing trees, e.g., fast growing trees, e.g., Modar (*Erythrina indica*) or wooden posts. Coconut or arecanut can also be used as standard. The cuttings should be planted 30 cm away from the support.

**Spacing**: 3 m x 3 m

**Pit Size**: 50 cm x 50 cm x 50 cm

**Manure and Fertilizer:**

Compost @ 9 kg, Urea 225g, SSP 1 kg, MOP 100g and lime 500-1000 g per plant at the following rates.

1st year: ½ of the full dose

2nd year: ½ of the full dose

3rd year: ¾rd of the full dose

4th year onward: Full dose

April is the best time for application.

**Interculture operation:**

Pepper Plant makes rapid growth and the vine should be tied to the support at 30 cm interval. The lower portion up to 90 cm of the vine is to be kept clean and unranked. Encourage the vine to produce lateral fruiting branches and do not allow growing to a height beyond 4m. Mulching near the collar of the vine conserves moisture during the drought period.

Looping of the branches of the standard trees is essential in monsoon to ensure proper fruit-setting.

**Bush pepper:**

Bushpeppers are small sized plants that can be grown in pots and do not need support as like in field grown vines. Cuttings should be taken from plagiotrophs (lateral fruiting branch) of vines in the first week of May for obtaining higher success rate in Karimunda and Panniyur–1 varieties for raising bush pepper. For planting use a pot mixture containing neem cake + silt + decomposed cowdung + vermicompost at 1:2:2:2 ratio for growing Bush Pepper varieties (Panniyur-1 and Karimunda) in a container (18-inch diameter holding 10 kg mixture).

**Plant Protection:**

1. **Pollu beetle**: The grubs feed on tender berries and make them hollow. Novaluron 10 EC @ 75 g ai/ha.
2. **Marginal gall forming thrips**: It attacks the leaves and makes crinkles. Lambda cyhalothrin 5 EC @ 15 g ai/ha. Thiamethoxam 25 WG @ 26 g ai/ha.
3. **Quick wilt**: In monsoon, infection appears 25-30 cm above ground level and the vine dies within 10-12 days. Spray 1% Bordeaux mixture before onset of monsoon on the ground up to 1 m of the vine.

# BETELVINE

*Piper betle* Linn.

**Introduction:**

In Assam three different types of cultivation of betel vines are followed -

(1) Around arecanut or any other trees.

(2) Baroj type and

(3) *Khuti* type.

Of these, the first type is generally followed in most households whereas the later two types are practiced for commercial purposes.

**Cultivar:**

*Assamiya* pan or *Jati* pan, *Khasi* pan, *Garo* pan, *Sanchi* pan, *Bangla* pan, (*Kali Bangla*, *Nua Bangla, Ghanegette* and *Godi Bangla*), *Mitha* pan and *Karbi* pan.

**Soil:**

Well drained fertile clay to sandy loam type of soil is suitable. For a new plantation topsoil transplanted from a nearby plot should be used. Soil pH may be increased up to 6.5 by adding lime at least 20 days before planting the cutting of betelvine.

**Cultivation with Arecanut Support:**

Pits of 60 cm x 60 cm x 30 cm size are dug 60- 90 cm away from the base of areca nuts and filled up with well decomposed FYM and topsoils. Three to four cuttings are generally planted in each pit for each of the arecanut trees. It is extremely important to press the soil firmly around the cuttings. Generally, 60 to 90 cm long cuttings having 6 buds are preferable.

**Baroj Type and *Khuti* Type of Cultivation:**

Baroj are prepared out of bamboo and thatch. These are covered from all the sides with thatch and bamboo support and betelvines are supported to climb on bamboo sticks and in *Khuti* type. The roof is covered with thatch.

**Planting Material:**

The vines are propagated by terminal stem cutting obtained from mature mother vines. In the Baroj system, the spacing between the cuttings is 15 cm from plant to plant and 50 cm from row to row. Approximately 95,000 to 1, 00,000 cuttings are required per hectare for planting. In *Khuti* Type, the row to row and plant to plant distance is 90 cm and approximately 10,000 to 12,000 cuttings are required per hectare.

**Planting Season and Raising of Seedlings:**

Land for planting the betelvine setts should be fully pulverized and soil treatment should be given with Formalin solution (4%) which should be sprinkled at the rate of 3 liters per sqm of soil and covered with a polythene sheet or moist gunny bag for 24 hours. Planting should not be done for 15-20 days following formalin treatment.

Before planting, drench the soil with trifloxystrobin 25% WP @ 0.2% uniformly by means of a rose can. Lines are made for planting and cuttings obtained from disease free garden are treated with a solution consisting of Bordeaux mixture 0.5% and streptocycline 500 ppm for half an hour before planting. In Assam, the cuttings are planted during May to August.

**Manure and Fertilizers:**

| Age | N : $P_2O_5$ : $K_2O$ (kg/ha) |
|---|---|
| 1 - 5 year | 0 : 50 :100 |
| >5 – 10 year | 100 : 50 : 150 |
| >10 year | 200 : 50 : 100 |

For Baroj type cultivation, apply N @ 200 kg/ha/year as mustard oil cake in 4 split doses.

Apply 6 (six) foliar sprays of $ZnSO_4$ (4%) at 60 days intervals to increase the leaf yield. The first spray should start in April.

**Trailing the Vines:**

Trailing of the vines is done by tying the vines at intervals of 15 to 20cm along bamboo sticks loosely with the help of banana fibre, arecanut leaf sheath or any other locally available material.

**Lowering the Vines:**

Under normal cultivation, the vines grow to a height of about 3 m in a year. When they reach this height, it needs to be lowered down. This is achieved by lowering the vines down to the ground level at least twice in a year. The top of the young vine is again winded around the stick for the next season's growth.

**Plant Protection:**

1. **Phytophthora leaf and root rot**: Apply four drenches and eight sprays of Bordeaux mixture @ 1.0% and 0.5%, respectively from June to September Drenching and spraying should be done at monthly and fifteen days intervals.
2. **Bacterial leaf spot**: Give four sprays of Streptomycin (1.0%) along with Bordeaux mixture (0.5%) at 20 days interval after initiation of the disease.
3. **Anthracnose**: Give four sprays of Bordeaux mixture @ 0.5% at 20 days interval after

initiation of the disease.

4. **Biocontrol of *Phytophthora* and basal rot of betelvine**: Apply 500 kg de-oiled mustard oil cake at quarterly interval cultured with *Trichoderma harzianum* at the root region of the vines.

# OYSTER MUSHROOM CULTIVATION

Oyster mushroom (*Pleurotus* spp.) also known as "*Sagariya Samukhia Kathfula*" has more potential in our State because of low-cost technology, direct use of available agro-waste and appropriate climate for its cultivation. Advantage of cultivation of oyster mushroom over button mushroom (*Agaricus* spp.) or paddy straw mushroom (*Volvariella* spp.):

i) Cultivation technology is easier to take up

ii) Most suitable for the climate of Assam

iii) Can be grown for a longer period in a year-7 months

iv) Not exigent in its temperature requirement - 20 to 33ºC

v) Possesses the highest bioconversion ability - 60%

vi) Can be easily sun dried and preserved

**Season:**

It is grown in a temperature range of 20 to 33ºC. The best temperature is around 25ºC. The best months in a year for growing this mushroom at Jorhat are September to March. The remaining five months, *viz*. April to August are not favorable. It may take a month longer to bear mushrooms after opening the beds. Besides, the yield is poor, June is the least favorable month for this mushroom.

**Species of oyster mushroom:**

Seven species, *viz*. *Pleurotus sajor caju, P. citrinopileatus, P. florida, P.cornucopiae, P. sapidus, P. ostreatus* and *P. flabellatus* were successfully grown at Jorhat. For winter, i.e. during December, January and February, *P. florida* is more suitable than others.

**Materials required for oyster mushroom cultivation:**

1. **Substrate**: Rice straw, golden coloured straw of *sali* rice (Ahu rice straw is not suitable) or any other dry organic substrates (Lingo-cellulosic waste materials)
2. **Spawn**: Spawn/seed of mushroom consists of mycelium of fungus grown on grains in polypropylene bags
3. **Cutter/Chopper**: For cutting the substrate into pieces
4. **Container**: Trough or oil drums for soaking of substrate
5. **Boiler**: For substrate sterilization
6. **Polybag**: Poly bag of 40 cm x 60 cm size
7. **Puncher**: For perforating poly bags
8. **Thread**

**Mushroom house:** For Spawn run and cropping room

**Cultivation includes the following process:**

1. Cut the lingo-cellulosic waste materials (rice /wheat straw, mustard husk etc.) into pieces of about two inches.
2. Soak the cut pieces of substrate in clean water for 12 hrs for overnight
3. **Pasteurization**: The substrates can be sterilized by boiling in water at 80-85 $^0$C for 60 minutes. Aluminum vessels or cauldrons can be used for boiling water and the wet straw is immersed in this for 30-45 minutes. After draining out of the excess water the treated substrate should be spread on a clean cement floor or on any clean surface for 15 minutes.
4. **Spawning**: It means seeding of the substrate with spawn

**Poly bag method**:

Get a polythene bag of 40 cm x 60 cm size. This can hold 3 kg wet straw. Punch holes at a distance of 10 cm. Remove spawn from the bottle or polypropylene bag to a clean container. Squeeze it to separate grains. Put a 10 cm layer of pre-sterilized substrate in the perforated poly bag and press it with help of your palm then sprinkle the spawn at the rate of 3% the weight of the wet substrate i.e., 90 g of spawn is required to seed 3 kg of wet straw – as first layer of substrate and spawn. In this way fill the bags to 3/4$^{th}$ capacity with alternate layers of straw and spawn, there will be 5 layers of substrate and 4 layers of spawn. Finally tie the bag and place it in the spawn run room.

**Spawn running:**

Filled bags or cubes are arranged on raised platforms or shelves in a dark room i.e., spawn run room for two weeks. Temperature at 20 – 30 $^0$C and 70-85% RH are good for spawn run. Substrate coverage by the white cottony mycelial growth indicates completion of spawn run. The beds will be taken out by inverting the bags. Such open beds should immediately be transferred to the cropping room.

**Cropping:**

Daily watering to the opened beds is essential. Sprinkling of water to the walls and floor can also be done. Direct sunlight should not be allowed to fall into the cropping room. Ventilation and diffused light are required for fruiting. Small pinheads appear on the beds after 3-5 days of opening and first harvest can be done after 7-8 day. Over matured mushrooms shed spores forming a white coating on the ground. Hence, the mushroom fruit bodies should be plucked or harvested before their edges start curling upwards. Three flushes can be harvested at weekly intervals.

**Storage:**

Use paper bags for packing. They can be kept for a maximum of 7 days in a refrigerator.

# MICROPROPAGATION IN HORTICULTURAL CROPS

A number of plants are vegetatively propagated using rhizomes, bulbs, stem cutting or through conventional techniques, such as grafting, layering, budding etc. These include the majority of fruit crops, ornamental plants etc. However, because of low multiplication rate and progressive build up of pests and pathogens, there is often scarcity of healthy planting material in these crops. Alternatively, an economical method is available for rapid control multiplication, average yield of several important crops and forage trees can be tremendously increased by selecting propagation of already existing elite genotypes. Development of tissue culture techniques has revolutionized clonal propagation for the past 2-3 decades and plant regeneration in vitro has been reported for over 100 species. The following are some of the highlights of micropropagation of some of the horticultural crops which have been undertaken during the last few years.

**1)** The technique of regeneration from the internodes segment of *Citrus reticulata* cv. Khasi mandarin and *Citrus limon* cv. Assam lemon was standardized by culturing them on modified M.S. medium supplemented with 0.25 mg/*l* BAP + 0.5 mg/*l* NAA +0.5 mg/*l* IBA.

**2)** The techniques for regeneration of *khasi* mandarin was standardized by culturing the nucellar tissue on (Murashige and Tucker (MT), 1969) medium supplemented with 500 mg malt extract. Nucellar callus is the ideal for protoplast culture.

**3)** The technique for shoot tip and nodal segment culture was standardized for citron (*C. medica*) on modified MS medium supplemented with 1 mg/*l* BAP + 0.5 mg/*l* kinetin + 0.5 mg/*l* NAA.

**4)** The technique for in-vitro propagation of *Poncirus trifoliata* from the shoot tip of mature plant (8-9 years old) was standardized by culturing on modified MS media with 1 mg/*l* NAA-1+1 mg/*l* kinetin.

**5)** Modified Mutative and Scourged (1962 (MS) media + 0.25 mg/*l* IAA+2 mg/*l* BAP for shoot proliferation and MS basal + 1.5 mg/*l* IAA for rooting was standardized for Heliconia by taking auxiliary and terminal bud.

**6)** Notch media (1969): media supplemented with 0.1 mg/*l* IAA +0.5 mg/ *l* IBA exhibited the immature embryo of cymbidium into protector and protocol in to shoot and root proliferation. In *in-vivo* condition the survival percentage was 76.67%.

# USES OF PLASTICS IN HORTICULTURE

The use of plastics in Horticulture is one of the new technologies, which has made rapid development in the agricultural sector and made a direct contribution to improve crop production in many ways. Plastics are nowadays extensively used as roofing materials in the greenhouse, polyhouse or low tunnel, as mulching materials in the crop field and as lining materials in surface irrigation channels. The major thrust area of plasticulture is in drip and sprinkler irrigation.

The following technologies for the use of plastics in the horticultural sector are recommended for Assam.

**Off season Production of vegetable under Plastic Greenhouse**:

Forcing of vegetables for early as well as off-season markets has been found to be possible under UV-stabilized transplant LDPE-polyhouse cum rain shelter in Assam. The gable Even design polyhouse can be easily built with locally available framing materials like bamboo or wood. The UV stabilized plastic materials of 200-micron thickness should be used as the cladding materials. The durability of this plastic material is 5-6 years. The details of erection cost for 20m x 5m i.e., 100 sqm floor area polyhouse of bamboo frame is given below.

# ESTIMATE FOR CONSTRUCTION OF BAMBOO BASED LOW-COST PLASTIC GREENHOUSE

**General specification:**

1) Size of polyhouse: 20 m X 5 m (100 sqm)
2) Cladding materials: 200-micron HD polyethylene sheet
3) Side cover materials: 40 mesh size insect proof net
4) Structural materials: Bamboo

**B. Structural and cladding materials**

| Sl. No. | Item required | Unit | Rate /unit | GST | Rate with GST (Rs) | Total (Rs.) |
|---|---|---|---|---|---|---|
| 1 | 200-micron UV polyfilm (21m x 7m = 147 sqm) (White) | 1 sqm | Rs. 109.30 /sqm | Rs.19.67/sqm (18% GST) | 128.97 /sqm | 18,959.00 |
| 2 | Insect proof net | 50 sqm | Rs. 77.30/ sqm | Rs. 4.10 (5% GST) | 81.40 | 4,070.00 |
| 3 | Rope | 10 kg | Rs. 120/ kg | Rs. 21.60 (18% GST) | 141.60 | 1,416.00 |
| 4 | Nails | 1 kg | Rs. 100/kg | Rs. 18.00 (18% GST) | 118.00 | 118.00 |
| 5 | Nut and boltu | 35 nos. | Rs. 20/ Each | Rs. 3.60 (18% GST) | 23.60 | 826.00 |
| 6 | GI weir | 2 kg | Rs. 150/ kg | Rs. 27.00 (18% GST) | 177.00 | 354.00 |
| 7 | Bhuluka bamboo (*Bambusa balcooa*) | 15 Nos. | Rs. 300/ number | - | - | 4,500.00 |
| 8 | Jati bamboo (*Bambusa tulda*) | 35 Nos. | Rs. 150/ number | - | - | 5,250.00 |
| 9 | Labour | 40 MD | Rs. 250/ MD | - | - | 10,000.00 |
| 10 | Miscellaneous | L/S | | | | 1,000.00 |
| **Grand Total** | | | | | | 46,493.00 |
| **Say** | | | | | | **46,500.00** |
| (Rupees forty-six thousand five hundred only) | | | | | | |

**Note:** The estimate has been prepared on the basis of the current market price of the materials and wages in Assam condition.

During summer, all sides of the polyhouse can be kept open or nylon nets may be provided in place of it for free passage of air. During winter, all the sides are replaced with

plastic film, which causes an increase in temperature rise of at least 4 -5ºC than the ambient. In fact, this polyhouse acts as a greenhouse during winter and a rain shelter during the rainy season.

The following crop sequence can be adopted for raising as off-season vegetables under polyhouse by the farmers of Assam:

**March to June** : Tomato/Capsicum

**June to August** : Palak

**August to November** : Tomato/Capsicum

**December to February**: Cucumber

**Recommended Varieties:**

**Recommended Varieties for growing under net house**:

**Tomato:** Arka Alok, Arka Abha, Arka Saurabh, Namdhari Suraksha, Yash, BT10, BT1, LE-79, Rocky, All Rounder & Amlik

**Capsicum:** California Wonder, Arka Gaurav, Bharat, Bull Nose, Selection – 16, Elephant Trunk, Swarna F1, Natasa & Mahabharata

**Palak:** All Green, Pusa Jyoti and Pusa Harit

**Cucumber**: Pusa Sanyog, Long Green, Poinsette

# ESTIMATE FOR CONSTRUCTION OF BAMBOO STRUCTURE LOW COST AGRO SHADE NET HOUSE

**Floor Area: 100 sqm (20.00 m x 5.00 m)**

| Sl. No. | Item required | Unit | Rate /unit | GST | Rate with GST | Total (Rs.) |
|---|---|---|---|---|---|---|
| 1. | Shade Net (21m x 6.5m) | 1 sq. m. | Rs. 45.70 /sq. | Rs.2.28/sq.m. (5% GST) | Rs. 48.00 /sq. m. | 6,552.00 |
| 2. | Rope | 5 kg | Rs. 120/ kg | Rs. 21.60 (18% GST) | Rs. 141.60 | 708.00 |
| 3. | Nails | 1 kg | Rs. 100/kg | Rs. 18.00 (18% GST) | Rs. 118.00 | 118.00 |
| 4. | Nut and boltu | 42 nos. | Rs. 25/Each | Rs. 4.50 (18% GST) | Rs. 29.50 | 1,239.00 |
| 5. | GI weir | 2 kg | Rs. 150/ kg | Rs. 27.00 (18% GST) | Rs. 177.00 | 354.00 |
| 6. | Bholuka bamboo (*Bambusa balcooa*) | 15 Nos. | Rs. 300/ number | Rs.2.00/sq.m. (5% GST) | - | 4,500.00 |
| 7. | Jati bamboo (*Bambusa tulda*) | 20 Nos. | Rs. 150/ number | Rs. 21.60 (18% GST) | - | 3,000.00 |
| 8. | Man days | 25 Nos. | Rs. 250/ Nos. | - | | 6,250.00 |
| 9. | Miscellaneous | - | - | - | - | 1,000.00 |
| Total | | | | | | **23,721.00** |
| (Rupees twenty-three thousand seven hundred twenty one only) | | | | | | |

# GROWING ORNAMENTALS UNDER PLASTIC HOUSE

**Chrysanthemum**

**Variety:** Purple Decorative, Gulmohar, Prof. Harris, Red Gold, Red Anemone, Ravi Kiran, Yellow Gold, Sadbhavana, Flirt and AAUCC-2 (Spray); Snowball, Diamond Jubilee, Sonar Bangla, White Spider, Houston, Stanly Glossing, and Dignity (Standard).

- Rooted cutting of the spray variety of chrysanthemum should be planted in the middle of April to get early and profuse flowering.
- Rooted cutting of chrysanthemum should be planted in September to get flowers in December.

**Gladiolus**

- July is the best time for planting gladiolus

**Plastic Mulch:**

Black LDPE-film of 20-micron thickness can suitably be used as mulch for suppression of weeds and promoting growth and development of crops like okra, tomato and banana. Mulching with 25-micron black poly films can be practiced by farmers for higher economic return in pineapple.

# COCONUT-BASED MULTIPLE CROPPING

(An Ideal Household Garden for Assam Conditions)

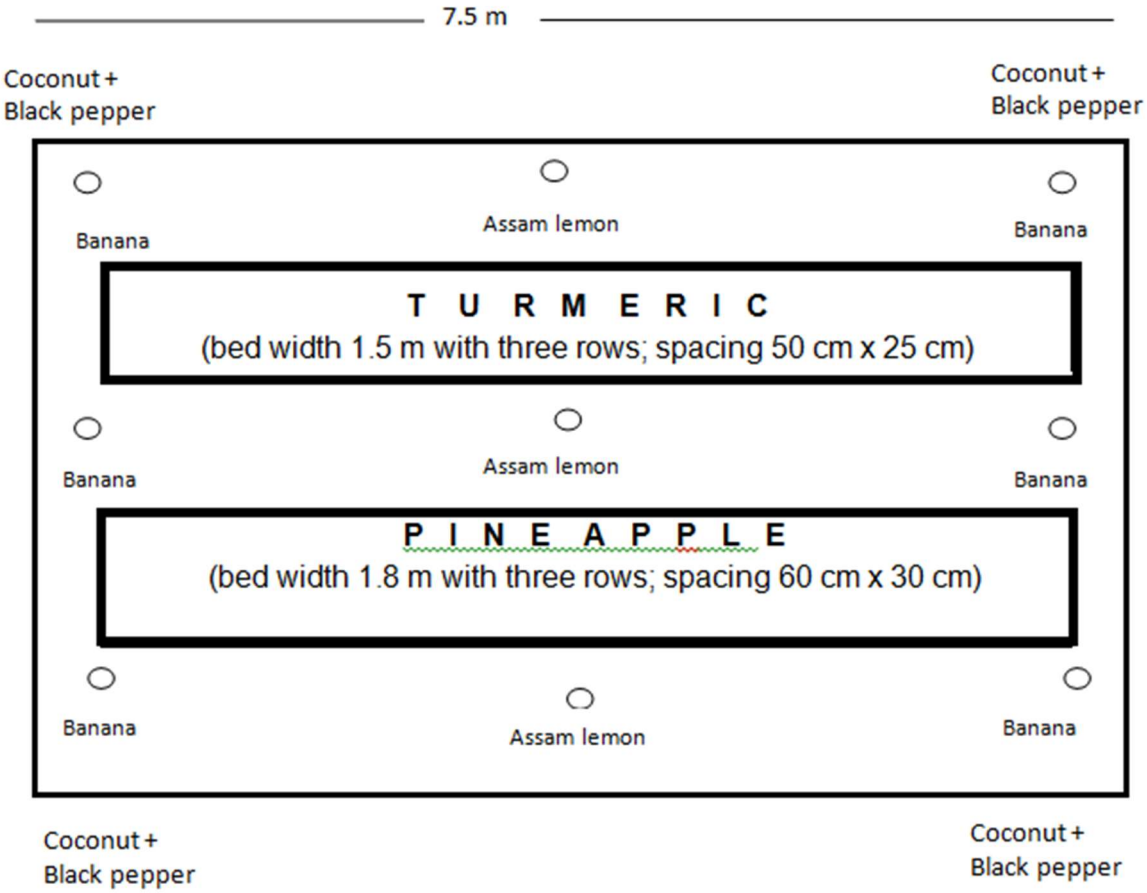
In a state like Assam, where individual land holding is marginal, multiple cropping is the only option for increasing the production and productivity of either field or horticultural crops. Secondly, in Assam unlike field crops, horticulture is confined to household or 'bari' level. As such, for development of horticulture in the state, it is the first and foremost need to develop the household gardens which apart from increasing the production per unit area gives some other advantages such as maximum use of available land, economic use of nutrients from the soil and sunlight from the air. Multiple cropping is also a way to avoid any lean period of production as well as income.

A model household garden with multiple cropping systems required systematic planning with regard to selection of crops, planting, manuring and other management practices. The following points are to be considered while raising a model household garden.

1. **Base Crop:** In multiple cropping systems, one crop is taken as base crop. Coconut can be selected as a base crop because of its tall growing unranked nature. It is particularly suitable for Assam conditions because of its wide adaptability. Wider spacing of the base crop provides more opportunity for raising other crops.
2. **Other Crops:** Locally adapted crops should be selected for growing in between the rows of the base crop. The root system of these crops should be of different depths so that they can draw nutrients from different depths of soil. These crops should have differential height so that they can get their required slight. These crops form their canopy at different heights, for which the system is also termed as "Multistoried cropping should be able to withstand partial shade or shade to some extent. Banana (var. *Chenichampa*), pineapple (var. Kew), lemon (var. Assam Lemon), Ginger (var. Nadia) are found to be suitable for growing in coconut-based gardens in Assam condition. Black pepper (var. Panniyur-I) can suitably be allowed to grow along the stem of the coconut tree.
3. **Planting Method:** The taller plants should be planted nearer to the base crop and shorter ones should be grown gradually away from the base crop. This system of planting is more effective.

# MODEL OF COCONUT-BASED MULTISTORIED CROPPING

## Model – I




**Spacing:**

Coconut to Coconut: 7.5 m x 7.5 m;

Banana to Banana: 2.5 m x 2.5 m;

Assam lemon to Assam lemon: 2.5 m x 2.5 m

Banana to Assam lemon: 2.5 m x 2.5 m

**Nutrient management:**

Apply N 345 g, $P_2O_5$ 200 g, $K_2O$ 525 g, vermicompost 16.4 kg, vermiwash 5 L, biofertilizer (*Azospirillum*) 100 g and *in situ* green manuring in coconut based vertical cropping system with Black pepper, Banana, Assam lemon, Turmeric and Pineapple as intercrops.

# FLOWER

## ROSE

*Rosa* spp.

**Variety:**

**Hybrid Teas:** Super Star, Arjun, Happiness, Rakta Gandha, Avil Sparks, Avon, Blue Moon, C, Christian Dior, Crimson Glory, First Prize, Friendship, Illona, Kiss of Fire, Priyadarshini, Jawahar

**Floribundas**: Queen Elizabeth, Arunima Banjaran, Chandrama, Mohini, Suryakiran, Navsadabahar and Sindoor

**Polyanthas**: Anjali, Nartaki, Pink Showers, Echo, Cameo, Baby Fanreach.

**Ramblers:** American Pillar, Albertine

**Miniatures:** Cricri, Mimi, Baby Masquerade, Bonny, Cinderella, Coralin, Pixie, Rosmarin, Starina, Chandrika, Dark Beauty

**Greenhouse variety:**

First Red, Confetti, Noblesse, Grand Gala**,** Mascara

**Propagating Material**:

Commercially rose is propagated by T- or Shield budding but for root stock preparation one year old cuttings having pencil thickness are used.

**Planting:**

The pit should be dug 75 to 90 cm deep, thoroughly dried and filled with, well rotten FYM at the bottom and good garden soil at the top. New plants may be planted at the beginning or during the rainy season at a distance of 75 to 90 cm from each other depending on type of variety. Soil around the plants should be firmly pressed and watering is done immediately after planting

**Soil Type**: Any well-drained garden soil

**Aftercare:**

In budded roses, the suckers arising from the rootstock should be removed as soon as they emerge, Dead, weak, criss-crossing, diseased or insect-infested branches should be removed or pruned.

**Manure and Fertilizer:**

Immediately after pruning, during the months of October- November, the topsoil around the base of the plant is dug out up to a depth of 10 to 15 cm and kept exposed for 2-3 days, then filled with half a basket of well decomposed FYM and then covered with the excavated soil. The soil compacted around the base and flooded with water. Urea @ 10 g per

plant is to be applied 20 cm away from trunk and mixed carefully before watering. Super phosphate at the same rate may be applied after the flower buds have just begun to emerge since it promotes flower production.

A foliar feeding with 2 parts Urea, 1 part dihydrogen ammonium phosphate,1 part potassium nitrate and 1 part Potassium phosphate @ 3 g per liter of water is an excellent supplement to root feeding. This solution is thoroughly sprayed on both sides of the leaves and stems periodically; insecticides can also be added to the solution if required. Foliar feeding should start 5 weeks after pruning and be given at 10 days interval. Foliar feeding should not be done when the plant is in bloom.

**Irrigation:**

A periodical soaking of soil is done to keep the soil moist but not root wet.

**Plant Protection**:

1) Red scales, which cover the branches and suck cell sap from the plant, are the most serious pests of rose. Spraying milbemectin 1 EC @ 4.5 g ai/ha.
2) Rose chafer beetles which eat away the leaves may be controlled by light traps.
3) Die back, powdery mildew and Black spot are common diseases of rose. Dieback appears after pruning; therefore, fungicidal paint should be applied on the pruned surfaces. Sulphur dusting is an effective remedy for mildew. Black spots of leaves can be controlled by spraying with 0.2% chlorothalonil 75WP as soon as these are noticed

**Harvesting and post-harvest handling:**

Rose flowers are harvested at tight bud stage when the bud shows full colour but the petals have not yet started unfolding. Grading is based on length of stem and size of bud. Roses are packed in corrugated cardboard boxes (100 cm × 32.5 cm × 6.5 cm) in bundles, each bundle containing 20 blooms. Boxes are inner lined with thin polythene and very fine moist tissue paper. Roses are graded according to the length of the stem as follows:

| Length of stem (cm) | Grade |
|---|---|
| Above 70 | White |
| 60-70 | Blue |
| 50-60 | Yellow |
| 40-50 | Red |
| 30-40 | Brown |
| Below 30 | Working grade only for local market |

# BOUGAINVILLEA

*Bougainvillea* spp.

**Variety**:

Mary Palmer, Dr. Homi Bhaba, Crimson, Orange King, Golden Glow, Scarlet Queen, Alok, Million Dollar, Thimma, Dr. Rao, Dr. R.R. Pal, Mahara, Chery Blossom, Double White, Double Pink and L.N. Birla.

**Propagating Material:**

Bougainvillea is propagated by hardwood or semi hardwood cuttings from a matured branch of the past season's growth taken during early or late monsoon (taken during January-February after shedding leaves). Difficult to root varieties are propagated by layering.

**Planting:**

The cuttings are planted in the nursery under shade and care is taken to keep the soil moist by regular sprinkling of water. New shoots emerge from the nodes. About 2-3 baskets of FYM or compost is applied per pit. The rooted cuttings are planted 3 weeks after preparation of the pit. Extra soil is added to the base of the plant to avoid water logging.

**Site and soil:**

Light, well-drained soils are considered ideal for growing bougainvillea. The plant flowers profusely when growing in full sun. Shady, damp waterlogged areas are to be avoided.

**Plant Protection:**

Bougainvillea is usually not affected by any serious insect-pest and disease.

# MUSSAENDA

*Mussaenda philippica* L.

Mussaenda is a beautiful flowering shrub cultivated for their attractive flowers of which the most colourful part is the bracts. The shrub has double, showy leafy sepals and the colour of the sepals may be greenish white, pink and red.

**Cultivation:**

The decorative plant should be grown in pots containing a well drained mixture consisting of equal parts of loam, peat and leaf mould with sand added to ensure good drainage. Deep well-drained loamy soil is ideal for its cultivation.

**Propagation:**

Mussaenda is propagated by cuttings during February to March while all leaves are shedding or before breaking new buds. Some hardwood cuttings of last season shoots with 3-4 nodes are to be taken and inserted in poly bags containing soil, silt and well rotten cow dung at 1:1:1 ratio. For pink and white mussaenda, cuttings are treated with 2000 ppm IBA for better rooting. It can also be propagated by air layering**.**

**Pruning:**

Yearly Pruning of Mussaenda is very essential to maintain a well-shaped canopy of the bush. Generally pruning is done after shedding leaves during January- February. Normally pruning is done in two different ways. In the first kind of pruning the selected branches along with crisscross shoots are pruned which later produce early flowers along with new flush of leaves during March April. In the second kind of pruning the whole branches are cut back to waist height like pruning of Tea bushes. Here flowers appear in terminal branches lately but blooms remain till November-December.

# TUBEROSE

*Polianthes tuberosa* L.

**Variety:**

**Single type:** Calcutta Single, Mexican Single, Shringar (Hyb), Arka Prajwal (Hyb), Rajat Rekha, Arka Nirantara, GK-TC-4, Phule Rajani.

**Double type:** Calcutta Double, Mexican Double, Suvasini (Hyb), Vaibhav (Hyb), Suvarna Rekha.

**Planting:**

Bulbs more than 2.5 cm diameter of tuberose are generally planted 5 cm. deep at a spacing of 30 x 20 cm or 25 x 25 cm. However, for high density planting spacing is maintained as 20 x 20 cm or 20 x 10 cm. Optimum planting time is from March-April.

**Soil and Site:**

It is grown in a wide range of soils. Well-drained sandy and sandy loam soil rich in organic matter with a pH of 5.0 - 7.5 and having ample sunlight is suitable.

**Mulching:**

Mulching of tuberose is to be done with 50 micron black polyethylene sheet for quality cut flowers and year-round production including the lean period (December to February).

**Manure and Fertilizer:**

Application of 2 kg FYM and 60-30-45 g N-$P_2O_5$-$K_2O$ is to be applied per sqm area. Half of N and full doses of $P_2O_5$ and $K_2O$ to be applied at the time of land preparation and the remaining N to be top-dressed in 2 split doses at 35 and 55 days after planting of bulbs. Alternatively, 1 kg FYM + 300 g vermicompost + 40-20-30 g N-$P_2O_5$-$K_2O$ /sq m/year is equally beneficial for the crop.

**Irrigation:**

Watering should be done at weekly intervals during dry spells in the growing season.

**Plant Protection**:

1) **Leaf blight:** Spray difenoconazole (0.1%) or iprodione + azoxystrobin 23SC (0.1%) or azoxystrobin (0.1%) at 7-10 days interval, starting the first spray at the appearance of disease symptom.
2) **Leaf spot/ Blight of tuberose:** Three sprays of azoxystrobin (0.03%) or difenoconazole (0.05%) at 10 days interval starting from first appearance of the disease to manage leaf spot/blight of tuberose (B:C ratio of 3.65 and 3.28 respectively)
3) **Sclerotial wilt:** Dip the selected bulbs in carboxin (0.2%) for 30 minutes before

planting. At the beginning of disease incidence drench soil in and around the infected plants with Chlorothalonil (0.2%) @ 10 liter/ sq. m at monthly intervals for three months. Alternatively, before planting bulbs may be dipped in *Trichoderma viride* (10 g/*l*) followed by soil application of *T. viride* 100 g / sqm mixed with 1 kg FYM at the time of planting.

4) **Aphids:** Spray emamectin benzoate 5SG @ 220 g /ha at 15-20 days interval.

**Intercropping:**

In commercial cultivation of tuberose, certain vegetable crops like pea, spinach beet, French bean and carrot can be taken up as intercrops. However, maximum return can be attained with tuberose - pea combination.

**Ratooning:**

Fresh planting should be done after every 3 years but for quality flower production replanting is done every year. Regular and frequent weeding should be done. Half dose of the recommended fertilizer should be applied during the second year and third year of the ratoon crop.

**Harvesting and post-harvest handling:**

For the short distance market the tuberose spikes are harvested at well-developed bud stage and packaged in PP-100 gauge bags.

For long distance transportation, tuberose spikes are to be wrapped in PP- 100 gauge packaging material before putting in CFB boxes.

A preservative solution containing potassium permanganate (25 ppm) is suitable for extending the vase life of cut tuberose spike. Spikes harvested at well-developed unopened bud stage can be wrapped in PP-100 film and cold stored at 3-4ºC for 3 days, for longer vase life.

For tinting, dip cut ends of tuberose spikes harvested at 2-3 buds open stage in the synthetic food dyes, *viz*., Raspberry Red, Bright Blue and Orange Red @ 8% concentration for 1 hr for uniform tinting of petals.

Boric acid 5% solution treatment helps in enhancing shelf life of loose flowers of tuberose beyond 48 hrs.

**Cost of cultivation**: Rs. 47,100.00

**Benefit: Cost ratio**: 5.96

# CHRYSANTHEMUM

*Dendranthema grandiflora* Tzvelev

*Chrysanthemum morifolium* Ramat.

**Variety:**

**A. Cultivars suitable for pot culture:**

i. **Spray:** Ravi Kiran, Charming, Prof. Harris, Anupam, PC-21, AAUCC-2, Nirod, Yellow Decorative, Basanti, Sadbhavana, Yellow Gold, Aparajita and Yellow Bangla

ii. **Standard:** Snow Ball, Silk Brocade, Sonali Tara, Houston, Alfred Simpson, Kiku Biori, Stanley Gosling, White Spider, Pink Cosa Grande, White Cosa Grande and Gloria Deo

**B. Cultivars suitable for open field:**

i. **Spray:** Purple Decorative, Purple Anemone, Ravi Kiran, Gulmohar, Yellow Decorative, Flirt, Sadbhavana, Yellow Bangla, AAUCC-2 and Basanti

ii. **Standard:** Snow Ball, Diamond Jubilee, Sonar Bangla, White Spider, Houston, Stanly Gossling, Dr. Erabe Cross, Dignity, Heather Gem and Golden Giant

**C. Cultivars suitable for poly house:**

i. **Spray:** Ravi Kiran, Charming, AAUCC-2, Nirod, Basanti, Prof. Harris

ii. **Standard:** Snow Ball, Stanly Gossling, Diamond Jubilee, Dignity, Sonar Bangla, White Spider, Dr. Erabe Cross, Heather Gem, Golden Giant

**Propagation material:**

Annual chrysanthemums are propagated from seeds and perennial chrysanthemums are propagated by the separation of suckers and terminal stem cutting. Planting of suckers is done in the month of February. Terminal stem cuttings of 5-7 cm long are taken during June to September. Lower leaves of the cuttings are removed and the cuttings are treated with rooting hormone (Rootex) before planting in sand or sand + peat moss/vermiculite/soil to promote rooting.

**Planting of rooted cuttings**:

The planting of rooted cuttings for better yield and quality of flower is done from July to September.

**Potting and Repotting**:

The planting materials prepared from suckers in the month of February and from stem cuttings in the month of June to August are potted and repotted 3 to 4 times, each time into bigger sized pots and richer potting media. Newly potted plants should be kept in shade for 3

to 4 days till they are established.

**Aftercare:**

Growing shoots should be pinched off in between the second and third week in order to make the plants bushy. Plants should be watered daily preferably during morning hours. It is necessary to stake the plants to keep them erect.

**Feeding to chrysanthemums:**

Occasional top dressing with SSP @ 3 g per pot especially at final potting helps in growth and flowering of chrysanthemum.

Supplementary feeding with liquid manure is done at 10 days intervals just after light watering. Liquid manure is made in the following way:

Liquid manure is prepared by dissolving 1 kg of fresh cow dung manure and 100 g of mustard oil cake in 10 liters of water. Occasional string is necessary. After 10 days the supernatant liquid is taken out and diluted to attain a straw colour by mixing 1 mug of this liquid with 10 mug of plain water. Feeding with liquid manure should start with the establishment of the plant and continue up to the appearance of the first flower bud.

**Use of Plant growth Regulators**:

Spraying of plants 30 days after final transplanting with $GA_3$ at 40 ppm improves growth and increases the number and size of flowers. However, to induce early flowering, 10 ppm $GA_3$ is recommended which also increases shelf-life in spray cultivars.

Spraying of 5000 ppm CCC increases the flower size in standard cultivars and branch and flower number in spray cultivars, spraying of 10,000 ppm B-9 is better than normal pinching method.

**Plant Protection:**

1) Aphids attack the tender growing points and cause curling of leaves. Leaf miners, which burrow into the leaf. These can be controlled by spraying lambda cyhalothrin 5 EC @ 150-250 ml/ha. Caterpillars eat up buds and young shoots and these should be controlled by spraying chlorantraniliprole 18.5 SC @ 30 g ai/ha.
2) Leaf spot can be controlled by spraying azoxystrobin 23SC @ 1 ml/*l.* Virus infected plants are uprooted and destroyed. Aphids and Thrips are the vectors of viral diseases and must be effectively controlled.

**Harvesting and post harvest handling:**

The correct stage of harvesting depends on the cultivar, marketing and other facilities available to the grower. The decorative type is harvested when petals at the center of the top-most flower are fully developed. Standard type is harvested when outer ray florets cease to elongate. Flowers are cut about 10 cm above the soil and 1/3 of stems are stripped of leaves and placed immediately in water. Cut flowers are graded into several grades depending on stem length, colour and diameter of the flower. The standard chrysanthemums are packed in display

boxes measuring 91 cm x 43 cm x 15 cm size. For spray chrysanthemum, a bundle of 20 stems are packed in cardboard boxes measuring 80 cm x 50 cm x 23 cm.

For local markets, packaging of spray chrysanthemum is to be done in PP-100 gauge polythene to increase shelf- life and maximum floret opening in vase.

**Benefit: Cost ratio:**

**1) For Spray type:**

**(a)** Open field, bed 5.15 (Cost of cultivation Rs. 67,480.00)

**(b)** Pot each 2.13 (Cost of cultivation Rs. 16.00)

**2) For Standard type:**

**(a)** Open field 8.88 (Cost of cultivation Rs. 67,480.00)

**(b)** Pot (each) 3.71 (Cost of cultivation Rs. 17.00)

3) **Planting material generation:** 7.93 (Cost of cultivation Rs. 22,680.00)

# DAHLIA

*Dahlia variabilis* Desf.

**Variety:**

Swami Madhavanadam, Swami Lokeswarananda, Lord Buddha, Ketu, Avalanche, Blood Red, Black Out, Nearest Blue, Bhola Baba, Bhikku's Vivek, Prime Minister, Sri Ramkrishna, Dandapani, Queen Elizabeth, Swami Brahmananda, Bhikku's Mother, Bhikku's Raktajaba, Sarada Devi, Dr. B.P. Pal, Jyotsna, Clarissia, Potgainter.

**Propagating Material:**

Dahlia can be propagated through seeds, tubers and stem cuttings.

**Sowing/Planting:**

Generally, the single and dwarf bedding dahlias are propagated by seeds. Seeds are sown in well-prepared nursery beds or seeds boxes during September- October and the seedlings are transplanted into the permanent beds or pots when they reach 4 to 6 leaves stage. Cuttings are taken from plants raised from tubers in nursery beds from August onwards and planted out in their permanent places in October- November. In case of bedding dahlias, a spacing of 90 cm from row to row and 50-75 cm from plant to plant is given. 60 cm x 60 cm spacing is kept in case of dwarf dahlias.

**Soil and Site:**

Dahlias grow best in a sunny location although they are remarkably tolerant to semi-shade. They do not like much rain and extreme cold or heat.

A good, well-drained sandy loam soil is best suited for dahlia.

**Aftercare:**

When the plants reach 10 to 15 cm height, they are staked by tying 2 or 3 places to bamboo or wooden sticks with a soft-rope. Staking is done to prevent the plant from toppling or lodging over. Earthing up is necessary to give support to its weak and succulent stems.

**Manure and Fertilizer:**

When dahlia is grown on rich soils, additional feeding is not required; but in poor soils a top dressing of 35 g to 50 g/$m^2$ of any complete chemical fertilizer is beneficial. Care should be taken to see that the chemical fertilizer should not come into contact with the base of the plant. Liquid feeding should be done.

**Irrigation:**

Adequate watering with a watering cane should be done throughout the growing season.

**Plant Protection:**

Aphids, wire worms and caterpillars generally suck cell sap or eat up tender portions of stem and leaf. Spraying lambda cyhalothrin 5 EC @ 150-250 ml/ha. Leaf spot, mildew and mosaic virus are common diseases of dahlia. Control measures are the same as in

chrysanthemum.

**Storage of Tuber:**

Bulk quantity of dahlia tubers is to be stored in cold storage at a temperature of 7.7ºC to 10ºC. Small quantity of tubers should be stored in pots covered with sand. Tubers are not allowed to shrivel in any case.

# GLADIOLUS

*Gladiolus grandiflorus* L.

**Variety:**

Red Candiman, White Prosperity, Priscilla, Novalux, Palamtard, American Beauty, Eight Wonder, Friendship, Red Sea, Suryakiran, Gold Beauty, Dhannawanty, Tiger Flame, Marallow, Poppy Tears, Her Majesty, Thunder Horn, Sunayana, George Mazure, Mayur, Vink's Glory, Show Princess, Apple Blossom, Sunny Boy, Lady Killer, Gold Dust, Friendship, Psittacinus Hybrid, Happy End, Melody, Bis Bis, Sylvia, Oscar, Copper King, Rose Spire, Green Woodpecker, Spic and Span, Tropic Seas, Agnirekha, Suchitra, Manmohan, Mukta, Manisha, Manhar, Mohini, Apsara, Shobha, Meera, Nazrana and Poonam

**Propagating Materials**:

Large sized corms having 3-5 cm diameter are used when gladioli are grown for cut flowers. Large corms can be vertically cut into two or three pieces which are then used for propagation. Small and medium size cormels are grown for further corm production in the next season.

**Soil and Site:**

Gladiolus can be grown in a wide range of soils but deep, rich, well pulverized and well drained loam is considered the best soil which should be moisture retentive having medium acid to neutral pH.

**Time of planting:**

The best time of planting in gladiolus is mid-October to mid-November. However, in uplands the gladiolus can be planted in the first part of the September to fetch the early market. Staggered planting at15 days interval from September till January is also profitable for the farmers.

**Aftercare**:

After the corms sprout, the rows should be hilled up about 10-15 cm. Staking is necessary for varieties of standard species when flower spikes start swelling. The soil around the plants should be lightly dug up with a *khurpi* but this should be discontinued when flower spikes start swelling.

**Manure and Fertilizer**:

N:P: K should be applied in the ratio 1: 2:2 @ 56 g/sqm in two equal split doses. One split dose should be thoroughly mixed with the soil before planting of corms and the other at 4 to 6 leaf stage.

**Plant Growth Regulators:**

Soaking corms in $GA_3$ (2500 ppm) has shown the best performance on growth, flowering and corm production of gladiolus. However, Ethrel (2000 ppm) increases the number of cormels at harvest.

For quality spike production of gladiolus, treat corms with 100 ppm $GA_3$.

For healthy cormel production, treat gladiolus corms with Ethrel @ 250 ppm.

**Irrigation:**

Watering should be done at 10-12 days intervals to keep the soil moist.

**Plant Protection:**

1) *Fusarium* corm rot is the most common and serious disease in the field. Bacterial scab also causes corm rot. Pre-sowing treatment against fungal disease included dipping the corms in chlorothalonil 0.3% or carboxin 0.3% (3 g in 1 liter water) for 20 minutes.
2) Thrips and cutworms are serious pests of gladiolus. Application of emamectin benzoate 5SG @ 220 g/ha or flubendiamide 39.35EC @ 0.1*l* is effective against thrips, while spraying of thiamethoxam 25 WG @ 26 g ai/ha effectively controls cutworms.

**Harvesting and Post harvest handling of spikes:**

For the local market, gladiolus spikes are harvested when the 1st pair of florets is fully opened. For distant market flowers are harvested at tight bud stage when 1-5 florets show colour with at least two numbers of clasping leaves. Gladiolus spikes are usually graded based on spike length and number of florets per spike according to the following groups:

| Grade | Spike length (cm) (Minimum) | No. of florets |
|---|---|---|
| Fancy (A) | 107 & above | 16 |
| Special (B) | 96-107 | 14 |
| Standard (C) | 81-96 | 12 |
| Utility (D) | 81 & below | 10 |

The graded spikes are made into bundles of 50-100 spikes and packed in perforated and light proof cardboard boxes.

The spikes are harvested at tight bud stage with 4-5 florets showing colour and pulsed with 20% sucrose for 16 hrs and packed in LDPE-100 or PP-100 gauge before keeping in CFB boxes for better shelf life to the long-distance market. For better postharvest life, gladiolus spikes can be kept in wet cold storage, i.e. with basal ends of stems dipped in water at 3-4°C. The optimum stage of harvesting gladiolus spikes for wet cold storage (3-4°C) is when basal

florets are half-opened.

Gladiolus spikes harvested at tight bud stage can be pulsed with sucrose 20% + Aluminium sulphate 300 ppm, followed by dry refrigerated storage (after packing the spikes in PP bags) for up to seven days.

**Harvesting and Storage of Corms**:

When leaves turn yellow, the corms along with cormels are lifted in the last week of April to second week of May. Corms and cormels are soaked in 0.2% carboxin solution for 15-30 minutes and stored in an airy room on wooden trays in a single layer. The best way to store it is in a refrigerator or cold storage at 4.4$^{o}$C to 10$^{o}$C. During storage, the brown scales covering the corms should not be removed.

**Vase-life:**

Use of a holding solution containing Sodium hypochlorite (50 ppm) and Potassium permanganate (25 ppm) along with Sucrose (4%) extends vase life.

**Cost of cultivation:** Rs. 66,300.00

**Benefit: Cost benefit ratio:** 3.21

# HELICONIA

*Heliconia psittacorum* L.

**Variety:**

Shrimp Heliconia, Red Heliconia, Bihai Yellow Dancer, Bihai Orange Dancer

**Local Type:**

Plant height varies from 90 cm to 120 cm. Inflorescence colour orange yellow with a boat shaped bract and size is 10-19 cm across. Flower yield is 35 number of inflorescence/$m^2$ and rhizome yield is 6145 g/$m^2$.

**Propagating material:** Rhizome with average weight of 40 g

**Soil:**

Heliconia can be grown in a wide range of soils but deep rich well pulverized and well drained loam is considered the best.

**Time of Planting:** January.

**Spacing:** 75 cm x 75 cm for small and medium variety and 100 cm x 100 cm for tall variety

**Manure and Fertilizer**:

4 kg of FYM/$m^2$ and 40-20-20 g N-$P_2O_5$-$K_2O$ /$m^2$ is given in 2 split doses for better growth, yield and quality of flower. The first dose is given at the time of planting and 2$^{nd}$ dose at 45 days after planting.

**Irrigation:**

Watering should be done at weekly intervals during dry weather in the growing season.

**Plant Protection**:

There are no serious insect pests and diseases of Heliconia

# ORCHIDS

Orchids are the most beautiful among all the flowering plants in the world. There are about 22,000 to 35,000 species and 700-800 genera and thus include innumerable varieties. Assam recorded 192 species of native orchid wealth.

From the floricultural point of view orchids are classified into two broad categories, viz. epiphytes and terrestrials. The epiphytes live an independent life as far as their food requirement is concerned and they perch themselves on trees and rocks. On the other hand, the terrestrial types are grown on soil, like ordinary plants.

**Some Important Genera:**

**Epiphytic:** *Dendrobium, Vanda, Rhynchostylis, Coelogyne, Aerides, Bulbophyllum, Phalaenopsis, Vanilla*etc.

**Terrestrial:** *Cymbidium, Paphiopedilum, Pholidota, Thunia, Phaius, Spathoglottis, Arundina* etc.

**Hybrids:** Sonia, Makara, Oncidium. Aranda, Aranthera

**Propagating Material:**

Monopodial epiphytes like Vanda, Rhynchostylis, etc. are propagated by stem cutting or layering. Sympodial orchids, both epiphytes and terrestrials, are propagated by division of pseudobulbs or offshoots.

**Potting of Orchids:**

**Potting material:**

For epiphytic orchids side-perforated earthen pots and for terrestrial orchids, ordinary earthen pots should be used. For epiphytic species, coconut fiber, sawdust, charcoal and brick pieces in equal proportion with moss as covering material should be used. For commercial cultivation coconut husk lock is most suitable.

For terrestrial species, a mixture of loam soils, river sand and coconut fiber (size 3 cm x 3 cm) and peat moss or leaf mould in equal proportion with moss as covering materials should be used.

**Growing media for pseudobulb production:**

**Epiphytic orchid:** Coconut fibre + charcoal in equal proportion are the best growing media for higher pseudobulb production.

**Terrestrial orchid:** Loamy soil + sand + coconut fibre + shredded wood in equal proportion are the best growing media for higher pseudobulb production.

**Growing condition:**

Orchids are grown commercially in low cost (bamboo frame) or medium cost (angle iron) agro shade net houses with 30-50% shade intensity.

**Potting:**

For potting, the selected plants should be carefully examined and decayed roots and dead membrane should be removed. The used pots need to be soaked in water and broken crocks, 2 cm thick layer of decayed moss should be placed. Then the pots should be half filled with the mixture in the form of a hillock in the center of the pot. The plant should be held with one hand and placed over the hillock and with the other hand the pot should be filled up by spreading the roots upward and downward. The mixture should be carefully pressed and a 3 cm layer of moss should be spread over the pot.

**Aftercare:**

The pots of epiphytic orchids should be watered regularly and those of terrestrials at longer intervals. In potted orchids, watering should be done in the evening hour when the soil becomes dry. Beds may be watered at 3-4 days intervals during dry spells. Occasionally emerged weeds should be removed from time to time.

The epiphytic orchids should be held in position by using stakes. Newly potted plants should be kept in semi shade for a few days until new roots start growing. If the basal portion of monopodial orchids become leafless, cut off the portion so that new healthy roots are formed.

Apply biofertilizers *Azospirillum* and Phosphobacterium each @ 2 g per plant in two months interval along with a regular spraying of N-$P_2O_5$-$K_2O$ (20-10-10) @ 0.2% twice a week for better growth and flower production in the *Dendrobium* var. Sonia. Spraying of Mg @ 750 ppm (3.71 g $MgSO_4$/*l*) along with recommended dose of fertilizer (N-$P_2O_5$-$K_2O$ of 19-19-19 @ 1 g/*l* twice a week) or Zinc @ 500 ppm (2.2 g $ZnSO_4$/*l*) along with recommended dose of fertilizer at monthly interval gives better growth and flowering in *Dendrobium* var. Sonia.

Zinc @ 750 ppm (2.2 g $ZnSO_4$/*l*) along with recommended dose of fertilizer is to be sprayed at monthly intervals for better growth and flowering of *Rhyncostylis retusa* planted in bamboo baskets as growing support.

**Plant Protection:**

**A) Disease**: Fungi, viruses and bacteria attack orchids. Growing healthy plants under good hygienic conditions is the best way to prevent diseases.

i) Pythium black rot which infects roots and spreads into the rhizome and pseudobulbs can be checked by spraying 10 ppm copper sulphate solution at weekly intervals.

ii) Anthracnose, which causes leaf spots and soft leaves, can be controlled by copper fungicide spray.

iii) Rust causes reddish brown spots and quickly spreads from plant to plant. This can be controlled by dusting with sulphur or spraying with Propiconazole or Hexaconazole (2 g/*l*).

iv) Bacterial soft rot causes slimy rot of pseudobulbs and stem bases. The affected plants should be destroyed and other healthy plants sprayed with 10 ppm mercuric chloride.

v) For viral diseases, affected plants should be destroyed.

vi) *Cercospora* leaf spot can be controlled by spraying Chlorothalonil 75WP @ 2 g/liter of water.

**B) Insect-Pest**: The following are the chief pests of orchids. The control measures are given against each of them.

| Pests | Control measures |
|---|---|
| Thrips | Thiamethoxam 25 WG @ 26gai/ha 0.3g/*l* |
| Mites | Spiromesifen 22.9 SC @ 96 g a.i/ha |
| Mealy bugs, Leaf hopper | Emamectin benzoate 5 SG @ 220 g/ha |
| Beetle & Aphid | Thiamethoxam 25WG @ 26 g a.i/ha or 0.3 g/*l* |
| Caterpillar | |

**Blooming time:**

Most of the orchids bloom either between February to June or between October to November.

**Harvesting and post-harvest handling**:

Orchid flowers are harvested 3-4 days after opening of flowers. Grading is done based on length of flower spike, flower number, size and arrangement of flower on the spike. Packaging method is different for different species of orchids. Dendrobium is packed in 4 dozen sprays per box. The cut ends of the flower stems are to be covered with wet cotton and wrapped with polythene to maintain humidity. Cymbidium spikes are generally packed 100 flowers per box.

# ANTHURIUM

*Anthurium andreanum* Land

**Varieties:**

**Red:** Tropical, Red Dragon, Ozaki, Mickey Mouse, Hawaii Red, Cherry Red, Sweet Heart, Temptation, Fla Red, Sikkim Red, Tina Red, Fire.

**Pink:** Agnihotri, Abe Pink, Paradise Pink, Lady Jane, Passion, Magic Pink, Nunzia
**Obake:** Red Dragon (red obake), Madonna (cream obake), President (pink obake), Lambada (white obake), Farao (deep orange obake).

**White:** Trinidad, Lima White, Manoa Mist, Meringue White, Mauritius White, Hidden Treasure, Fla Exotic, Acropolis**,** Carnival.

**Cream:** Fantasia.

**Green:** Midori – Green, Pistache.

**Orange:** IASH -2, IASH-1, Sante, Sundet Orange, Nitta, Mauritius Orange, Orangeeth, Fla Orange, Sunburst, Diamond Jubilee.

Varieties like Fire, Calore and Tropical for red colour; Acropolis, Moment for white and Evita Pink for pink colour are recommended for growing in soil less culture under shade net house.

**Climate:**

Anthurium needs conditions of high relative humidity well above 70%. It is grown commercially in low cost (bamboo frame) or medium cost (angle iron) net houses with 75-80% agro shade net roofs. To protect the plants from heavy rains, UV stabilized 200 micron plastic film can be used in combination with agro shade net cloth. The sides of the net house should also be covered with shade net (50% or lower) to improve the microclimate inside it. These nets can be raised for proper ventilation when the temperature rises.

**Planting season:**

Anthuriums can be planted almost round the year except in winter and during heavy rains.

**Planting material/Propagation:**

Anthurium is commercially propagated by separation of suckers produced at the base of the plant. When these suckers grow to 5-6 leaf stages with 2-3 good roots, they can be separated and planted. Suckers should be removed by pulling them out by hand and not by knife or scissors. Tissue cultured plantlets, which are true to type and disease free, can be procured.

To grow anthurium plants from seeds is a lengthy process. Seedlings may take two and half to three years to come from seed to bloom. Mature seeds may be scattered in the growing

media. The seeds germinate immediately and can be transplanted within 4 to 6 months.

**Growing media:**

The growing media for anthurium should be rich in organic matter, slightly acidic, porous, well aerated and well drained. According to the availability, different materials like coir pith, sand, gravel, decomposed organic materials like rice husk, coconut husk, sugarcane bagasse, wood shaving, tree bark, water hyacinth, leaf mould, saw dust etc. can be mixed and used as a growing media. Growing media consisting of 2 parts rice husk/pine bark + 1part soil + 1 part sand + 1 part cow dung + ½ part charcoal produced the best vegetative growth and good flower characteristics under Jorhat conditions.

**Growing media for sucker production:**

FYM +soil+ coconut fibre in equal proportion is the best growing media for sucker production.

**Pot culture of anthurium:**

In small scale planting, anthuriums are generally planted in earthen pots of 25 to 30 cm with two or more holes. Crock pieces are placed at the bottom of the pot above which a 2 cm layer of coarse sand is spread. Over this, brick or charcoal pieces are arranged so that the root ball can be placed easily. The sides of the root ball are covered with pieces of coconut husk and a filler mixture of sand and cow dung is spread over it to fill up the gaps. Initially the pot is filled to about 1/4$^{th}$ to 1/ 3$^{rd}$ and subsequently with increasing growth, fresh medium is added once in about three months. Besides providing good anchorage, this encourages growth of the plant and gives an earthing up effect.

**Planting in beds:**

Large scale commercial cultivation of anthurium is done in beds.

1. The bed should be 1.2 to 1.4 m wide depending on the length and breadth of the greenhouse and distance between posts.
2. The sides of the bed can consist of wood/bricks.
3. There should be a path at least 0.80 cm wide between two beds.
4. Plastic foil (0.1 cm) thick should be placed on the bed to separate the media from the ground.
5. A drainage hose should be placed on the bottom of the bed to drain out the excess water located at the lowest point.
6. The bottom of the bed should slope from the side to the center of the bed (2-3 cm), so that water flows to the drainage hose. The gradient of the slope should not be more than 0.03% (3 cm per 100 m).
7. A sprinkler system, which provides adequate distribution of water, can be installed in the middle of the bed.

8. The height of the growing medium should be at least 20 cm. It can be refilled within 2-3 years to a maximum of 30 cm.
9. A wire should be tied along the bed (fastened to posts placed 4 m apart) to keep the flowers out of the path.
10. Spacing in beds: 40 – 45 cm x 40 – 45 cm depending on the cultivar.

**Aftercare:**

**Application of growth regulators:**

Plant growth regulators play an important role in increasing growth, sucker production, flower yield and quality and in reduction of juvenile phase of anthuriums. Plants sprayed with Maleic hydrazide 1000 ppm at one and three months after planting produced shorter plants with more suckers. Plants sprayed with $GA_3$ (500 and 300 ppm) and BA (200 ppm) showed better vegetative growth and flower characters.

**Pruning of leaves:**

About 4 to 5 leaves are sufficient on a plant. The older leaves should be periodically removed.

**Removal of suckers:**

Suckers produced at the base of the parent plants should be removed at an early stage.

**Manure and fertilizers:**

Fertilizers should be applied in smaller doses at frequent intervals rather than larger doses at longer intervals. For pot cultivation, 5 g of complex fertilizer (N-$P_2O_5$-$K_2O$ of 17-17-17) in 500 ml of water (1%) is sprayed on the foliage once in a month. Foliar application of 0.1% urea at monthly intervals is found to be beneficial. In case of Ca deficiency, lime @ 5 g/plant/month is recommended. Soil drenching of liquid manure consisting of cowdung/urea once in every month is beneficial. A handful of dried sieved cow dung is applied at the base of the plant at monthly intervals. It is advisable to reduce the quantity of nitrogen in flowering plants, to increase the post-harvest life.

**Irrigation:** For Assam conditions, anthuriums require one irrigation/day, either in the morning or evening hours.

**Plant protection:**

**(a) Anthurium blight** (*Xanthomonas campestris pv. dieffenbachiae*): Controlled by spraying plants streptomycin-sulphate or oxytetracycline (200 mg/*l*) at weekly intervals.

**(b) Root rot** (*Phytophthora sp, Rhizoctonia sp, Fusarium sp, Pythium sp*): Controlled by soil drenching with 0.2% chlorothalonil or 0.2% carboxin.

**(c) Aphids and mealybugs:** Controlled by (i) destroying the infested portions (ii) drenching the growing media with thiamethoxam 25 WG @ 26 g ai/ha.

**(d) Snails**: Controlled by (i) hand picking and destruction and using baits like Metaldehyde pellets.

**Harvesting and post-harvest handling:**

Harvesting is done when the spathe is fully opened or when 1/3$^{rd}$ to 2/3$^{rd}$ of the true flowers on the spadix are open. The flower stalk should be cut with a sharp knife, leaving about 3 cm of the stalk on the plant and the basal portion of the flower stalk should be immersed in water as soon as possible to prevent drying out. Cut ends of flowers can also be immersed in 100 ppm BA or 4% sucrose for 30 minutes and then kept in water, to extend the vase life. The pre-cooling temperature for anthurium spathes harvested at fully open stage is 14-15$^{o}$C.

Application of 50 ppm Sodium hypochlorite + 5% sucrose or 300 ppm of Aluminium Sulphate + 5% sucrose is to be used as a holding solution for increased vase life of the spathe.

For the long-distance market of cut anthurium spathes, 1000 ppm sodium hypochlorite may be used as a pre-transit pulsing solution.

# GERBERA

*Gerbera jamesonii* Bolus

**Varieties**:

**Field gerbera:** Red Gem, Orange Green, Yellow Queen, Classic Beauty Popular, Dr. Zakir Hussain, Double Super Giant, Pride of Sikkim, Indukumari, Red Monarch, Avol, HRS-G-OWC,Pride of India, Pink Melody Avon

**Black centered gerbera:** Miracola, Piton, Renee, Tecta, Sonata, Loreto Black centered gerbera varieties like Antibes (red), Batavia (orange), Shimmer (white with pink trans floret), Faith (yellow), Prianha (purplish pink), Winter Queen (white), Cross Road (yellow with red trans floret) and Dream (pink) are recommended for growing under Greenhouse cultivation in Assam.

**Propagating material:**

Gerberas are propagated by suckers separated from the mother clumps.

**Growing condition:**

Black centered gerberas are suitable for growing under a polyhouse. However, for higher production of flowers and their maintenance and also to obtain quality flowers gerbera can be grown under low-cost polyhouse**.**

**Time of planting:** Suckers are planted in the month of Sep-Oct.

**Spacing:**

Gerbera are planted at a spacing of 30 cm between plants and 30 cm between rows, suckers are separated every year when the plant becomes overcrowded and are planted in a separate bed.

**Soil land Site:** A well-drained, sandy loam type of soils best for gerbera.

**Aftercare:**

Regular weeding and stirring of the soil with a *khurpi* is necessary. Dried leaves should be removed to improve the vigour of the plant.

**Manure and Fertilizer:**

FYM 5 kg/$m^2$ to be applied 15 days before planting gerbera suckers.

Soil application of N-$P_2O_5$-$K_2O$ @ 30 g N, 10 g $P_2O_5$ and 20g $K_2$ O per square meter is the best economic level for the agroclimatic conditions of Assam. Half dose of nitrogen and full doses of phosphorus and potassium are to be applied at the time of planting and the remaining half dose of nitrogen is to be applied after 30 days of planting.

Spray manganese sulphate @ 0.8% thrice at 45, 60 and 75 days after planting.

For organic cultivation of gerbera, apply enriched compost @ 10 t/ha at the time of land preparation.

**Irrigation:**

In potted gerbera, watering should be done in the evening hours when the soil becomes dry. Beds may be watered at 3-4 days intervals during dry spells.

**Plant Protection:**

Aphid and mites can be controlled by spraying lambda cyhalothrin @ 150- 250 ml/ha. Emamectin benzoate 5SG @ 220 g/ha. In the monsoon, gerbera is affected by Cercospora leaf spot which can be controlled by Chlorothalonil @ 2 g/liter of water.

Four sprays of pyraclostrobin 20%WG (1g/*l*) or difenoconazole (0. 5 ml/*l*) at ten days interval, first spray at the appearance of disease for the management of leaf blight (*Alternaria alternata*) of gerbera is recommended

**Vase-life:**

A preservative solution of Sucrose (2%) along with Tartaric acid (300 ppm) is suitable for extending vase life.

**Harvesting and post-harvest handling:**

Gerbera flowers are harvested when the second row of disc florets show pollen development. Flowers are graded according to the size of flowers and length of stem. Individual flowers are packed by polythene or netted covers to protect the flower heads. Flower heads are packed in insulated boxes & transported. For the long-distance market, gerbera stems are to be pulsed in Aluminium sulphate1000 ppm +0.1 % Tween-20 solution for 10 minutes, followed by packaging of flower heads in PP sleeves and whole bunch in PP sleeves keeping the tops open.

# ASIATIC LILIUM

*Lilium asiaticum*

**Variety:** Brunello, Navona, Golden Tycoon, Vermeer, Brindisi

**Soil and climate:**

Well drained, very rich in organic matter, pH 6.5-7.5 Temperature 12-18$^0$C (Night), 18-25$^0$C (Day)

**Propagation:**

10-20 cm dia. bulbs and to be planted at a depth of double the diameter of bulbs

**Planting time:** Oct-Nov

**Spacing:** 30 cm x 20 cm

**Manures and fertilizers:**

FYM 2 kg/sq. m, 30-7.5-45 g N-$P_2O_5$-$K_2O$ /sqm N & K should be applied in 2 splits – as basal application & top dressing at 30 days after sprouting of bulbs.

**Intercultural operations:**

Irrigate the crop at weekly intervals after bulbs sprout and at 3-4 days interval on appearance of flower buds.

Apply dry leaf mulching to conserve moisture and regulate soil temperature. Staking is to be provided when flower buds appear.

**Harvesting of flowers:**

Cut stems 3-4 cm above ground level. Harvesting of spikes done when 1-2 florets open for local markets, and for distant markets when lowermost 1- 2 florets show colour (colour breaking stage) but are not open.

**Postharvest handling**:

Pulsing cut spikes in 5% sucrose + silver thiosulphate 2.0 mM for 24 hrs significantly prolongs the vase life. The pre-cooling temperature is 1ºC. For distant markets, pre-cooled cut flowers (harvested when lowermost 1-2 florets show colour but are not opened) can be dry-stored by wrapping in polyethylene film. For distant markets, flowers are packed in fiberboard boxes.

**Tinting of white flowers (Value addition):**

Dip cut stem ends of white cut flowers (cv. Navona) harvested at 2-3 buds open stage in the synthetic food dyes, *viz*., Raspberry Red, Orange Red, Yellow and Green @ 8% concentration for 1 hr for uniform tinting (colouring) of petals.

**Harvesting of bulbs:** After 40-45 days of flowering when foliage turns yellow

**Storage bulbs:** Store bulbs in moist sand (-) 2$^{o}$C.

**Plant protection:**

1. **Gray mould / Leaf blight/Fire blight (*Botrytis elliptica*):** Pre-planting and post-harvest bulb dip in copper fungicide. Spraying of neem oil followed by COC (0.2%), removal & burning of plant debris
2. **Insect pests:** Apply lambda cyhalothrin @ 150-250 ml/ha for aphids, Thrips, White fly, Mites.

# FOLIAGE CUT FILLERS

**Herbaceous Cut filler greens used in Indian floriculture trade:**

*Asparagus sprengeri*, *Nephrolepis cordifolia*, *Cordyline fruticosa*, *Philodendron* xanadu, Dracaena reflexa *var*. angustifolia

**Soil and climate:**

Plants should be planted in soil rich in organic matter, loose, well-drained soil with regular watering

**Land preparation:**

Prepare the soil thoroughly by digging, harrowing, levelling. Remove stubbles and weeds.

**Propagation:**

***Asparagus*:** Division of tuberous roots

***Nephrolepis cordifolia***: Division of rooted runners

***Cordyline fruticosa, Dracaena reflexa***: Terminal & stem cuttings

***Philodendron xanadu***: Division of clumps, stem cuttings

**Planting media:** Add sand 2 kg/sqm, well rotten FYM 5 kg/sqm and mix thoroughly.

**Planting:**

For large scale commercial cultivation of cut filler greens, planting is done under 50% agro shade net in raised beds (1m wide and length according to convenience, 15-20 cm height). 50 cm space between adjacent beds

**Planting time:** March to July

**Spacing:**

Prepare 45 cm x 45 cm pits, plant at a depth of 5-6 cm, soil pressed firmly and apply water immediately

**Manures and Fertilizer:**

5 kg FYM /sqm as basal dose, incorporated into the soil. A second application 5 kg FYM along with 10-10-10 g N-$P_2O_5$-$K_2O$ /sq. m. is to be applied six months after planting, and at every 6 months interval.

**Intercultural operations:**

Irrigate when the top 1-inch soil is dry. Soil should be kept moist but not soggy**.** Overwatering leads to rotting and other diseases.

**Weeding:**

Keep the soil free from weeds throughout the growing season by hand weeding.

**Pruning:**

Prune old plants form dense clumps with long leggy stumps in Philodendron, Dracaena, Cordyline. In Nephrolepis, cut at 5 cm height from base for good growth of new leaves

**Harvesting of foliage:** Harvest leaves at full grown stage

**Pulsing:**

25 ppm BA+ 200 ppm 8-HQC + 10% sucrose for 24 hours increases the vase life of cut greens

**Plant protection:**

Application of lambda cyhalothrin @ 150- 250 ml/ha as prophylactic spray to repel the leaf eating insect-pests. Drench soil at plant bases with 0.1 % carboxin solution to protect from root rot and collar rot.

# SEASONAL FLOWERS

## ANTIRRHINUM

*Antirrhinum majus* L.

**Variety:** Candle Light, Sunset, Sky scraper, Magic Carpet

**Propagating Material**: Seed

**Sowing Time**: September-October

**Method of Sowing**:

Seeds sown in seed pans and watered very carefully as heavy watering will wash away the seeds.

**Stage of Transplanting:**

Transplanted at 4-leaf stage

**Spacing:**

15, 30 and 45 cm for dwarf, medium and tall varieties respectively.

**Blooming Time:**

3 ½ to 4 months after sowing

**Manure and Fertilizer:**

1 kg FYM with 9 : 9 : 12 g N : $P_2O_5$ : $K_2O$ per sqm area is to be applied.

**Aftercare:**

When the plants are 15 cm tall, they are pinched off to encourage side growth.

**Plant Protection**

**Insect Pest:** Aphids

**Disease:** Rust, anthracnose, mold, root rot, crown rot and stem rot

# ASTER

*Callistephus chinensis* Esenback

**Variety:**

Kirkwell, Sunshine, Triumph (dwarf), Giant Comet, Princes, Early Giant, Queen of the Market, Ostrich Plume (tall), Poornima, Kamini, Shashank

**Propagation**: Seed

**Soil:**

Rich loamy soil is best but heavy clay soil can be conditioned with FYM and river soil.

**Sowing Time**:

September-October

**Method of sowing**:

Seeds sown in pans, boxes or raised beds and covered with sieved sand or leaf mould.

**Stage of Transplanting**:

Transplanting at 4-leaf stage

**Spacing:**

15 cm, 30 and 40 cm respectively for dwarf, medium and late branching types.

**Blooming Time:**

Early varieties bloom within 3 ½ to 4 months after sowing and late varieties 5 months after sowing.

**Manure and Fertilizer:**

1 kg FYM with 9 : 9 : 12 g N : $P_2O_5$ : $K_2O$ per sqm area is to be applied. A light dose of liquid manure or a top dressing of complete fertilizers about 10 g per sqm area.

**Aftercare:**

Regular weeding, watering and occasional exposure of the soil with a *khurpi.*

**Plant Protection**

**Insect Pest:** Beetles, aphids and a variety of bugs

**Disease:** Damping off and Aster Yellow

# BALSAM

*Impatiens balsamina* L.

**Variety:** There are single and double varieties.

**Propagation**: Seed

**Soil:** All types of well drained soils in sunny locations.

**Sowing Time:** Last part of April to second week of May

**Method of Sowing:** Seeds are directly sown in permanent beds

**Spacing:** Thinned to 25 cm all around

**Blooming Time:** 2 to 2 ½ months after sowing

**Manure and Fertilizer:**

1 kg FYM with 9 : 9 : 12 g N : $P_2O_5$ : $K_2O$ per sqm area is to be applied.

**Aftercare**:

i) Pinching of shoots at 15 cm height to make the plants bushy.

ii) Lower leaves should be removed when buds appear to increase flower size.

**Plant Protection**

**Insect Pest**: No serious insect pests of balsam

**Disease**: No serious disease of balsam

# CALENDULA

*Calendula officinalis* L.

**Variety:**

Ball Chrysantha, Sunshine, Apricot, Orange King, Cream Beauty, Shaggy etc.

**Propagation**: Seed

**Soil:**

Sandy soil incorporated with organic manure and a small dose of complete fertilizer

**Sowing Time:**

September-October

**Method of Sowing**:

Seeds sown in seed pans

**Stage of Transplanting**:

Transplanted at 4 to 6 leaf stage

**Spacing**:

20-25 cm between plants and rows

**Blooming Time**:

2 ½ to 3 months after sowing

**Manure and Fertilizer:**

1 kg FYM with 9 : 9 : 12 g N : $P_2O_5$ : $K_2O$ per sqm area is to be applied. Liquid manure prepared from fresh cow dung should be applied at flower bud formation until flower opening and then discontinued.

**Aftercare:**

Regular weeding, watering and stirring of the plant with a *khurpi*

**Plant Protection**

**Insect Pest:** White fly at the early growth stage sucks cell sap and acts as a vector for many viral diseases.

**Disease**: Leaf smut, leaf mottling and bud blast

# CARNATION

*Dianthus caryophyllus* L

**Variety:** Marguerite, Chhabaud, Riviera Giant, Margaret, Malaga, Empire, Lipstick,etc.

**Propagation**: Seed (for annuals) and commercially carnation is propagated by cuttings.

**Soil:** Light Soil incorporated with well-decayed leaf mould

**Sowing Time**: October

**Method of sowing**: Seeds sown in seed pans and covered with sieved leaf mould.

**Stage of Transplanting**: Transplanted at 4-leaf stage.

**Spacing:**

**In 20 cm pots:** 3 seedlings per pot.

**In beds:** 30 cm between plants and 45 cm between rows, 15 cm x 10 cm for cutting production.

**Blooming Time**: 3-4 months after transplanting

**Manure and Fertilizer:**

Complete chemical fertilizer @ 38 g per sqm after pinching the tops of shoots and fertilizer should be mixed well at the base of the plants. Alternatively, liquid manure may be applied just before emergence of flower buds.

**After care:**

i) In open beds, the top should be pinched off above the second and third node at least twice before the buds appear to induce side shoots.

ii) Bamboo or wire stakes, about 60 cm. high should be fixed to the soil in the pot to form the triangle.

iii) Calyx splitting can be prevented by tying the calyx with strings or rubber bands just before flower buds open.

**Harvesting and post-harvest handling:**

For distance markets, standards are harvested when outer petals are just unfolding and sprayed when buds show colour (at Paintbrush stage). Harvesting is done by snapping the stem off at a node. Flowers are grouped into bundles of 20 flowers and kept in corrugated cardboard boxes for transportation.

**Plant protection:**

**a). Insect pest:** There are no serious insect pests of carnation.

**b). Disease:** Wilting, stem rot and rust.

**Mass multiplication of carnation by tissue culture (cv. Malaga, Empire, Lipstick)**:

Suitable media for shoot proliferation of carnation is MS media supplemented with NAA 0.5 $mgL^{-1}$+ Kinetin 0.5 mg $L^{-1}$+ GA 0,5 mg $L^{-1}$.

Suitable media for rooting is MS media supplemented with 0.5 mg $L^{-1}$ IBA.

# AFRICAN MARIGOLD

*Tagetes erecta* L.

**Variety:**

Pusa Narangi Gainda, Pusa Basanti Gainda, Gaint Double African Orange, Hajo Local, Golden Glow, Cupid, Pot of Gold, Glitters, Burpee Gold, Guinea Gold, etc.

**Propagating Material**: Seed and Terminal cutting

**Soil:** Almost any type of soil.

**Sowing Time:** October – November

Summer marigold var. Seracole cutting should be planted during July-August for flower production and generation of planting materials.

**Method of sowing**: Seeds sown in seed pans or seed boxes.

**Stage of Transplanting**: Transplanting when seedlings are 5-7 cm in height

**Spacing:**

A spacing of 45 cm x 40 cm has been recommended for seed production of marigold.

**Blooming Time:** 1 ½ to 2 ½ months after sowing

**Manure and Fertilizer:**

1 kg FYM with 9 : 9 : 12 g N : $P_2O_5$ : $K_2O$ per sq.m area

**Aftercare:**

i) Staking in tall varieties.

ii) Regular watering during dry weather.

iii) Drainage of excess water during the rainy season.

**Harvesting and post-harvest handling:**

Flowers are plucked when they have attained full size. Field should be irrigated before plucking. Flowers are mainly used for making garlands. Plucked flowers are loosely packed in bamboo baskets for carrying to the market.

For long distant markets, packaging of marigold loose flowers in plastic crates and bamboo baskets for better shelf life and lower loss in fresh weight.

**Plant protection:**

**a). Insect pest:** There are no serious insect pests in marigold.

**b). Disease:**

**i). Leaf and flower blight:**

1. Low temperature coupled with cloudy weather and continuous drizzling for more than 2 days have a significant role in the epidemiology of leaf and flower blight of both African and French marigold caused by *Alternaria dianthi*. Necessary prophylactic measures should be adopted in anticipation of such weather conditions. Three spraying with chlorothalonil 75WP @ 2 g/*l* at 10 days interval will manage the disease.
2. Routine spraying of chlorothalonil 75WP @ 2 g/*l* at 30, 40 and 50 days after transplanting will effectively protect the African and French marigold crops from the disease.
3. Three sprays of tebuconazole 23EC (0.5 ml/*l*) or difenconazole (0. 5 ml/*1*), at ten days interval starting from the first spray after the appearance of disease, for management of Alternaria blight of marigold

# FRENCH MARIGOLD

*Tagetes patula* L.

**Variety:** Harmony, Rusty Red, Sun Old, Red Brocade, etc.

**Propagating Material**: Seed

**Soil:** Almost any type of soil.

**Sowing Time**: October – November

**Method of sowing:** Seeds sown in seed pans or seed boxes.

**Stage of Transplanting**: Transplanted when seedlings are 5-7 cm in height.

**Spacing:** 30 cm x 30 cm apart and 60 cm for tall varieties.

**Blooming Time:** 1 ½ to 2 ½ months after sowing

**Manure and Fertilizer:** 1 kg FYM with 9 : 9 : 12 g N : $P_2O_5$ : $K_2O$ per sq. m. area

**Aftercare:**

i) Staking in all varieties.

ii) Regular watering during dry weather.

iii) Drainage or excess water during the rainy season.

**Intercropping:** Growing of spinach as intercrop increases yield and benefit cost ratio followed by coriander.

**Plant protection:**

**a). Insect Pest:** There are no serious insect pests in marigold

**b). Disease:**

**i). Leaf and flower blight:**

1. Low temperature coupled with cloudy weather and continuous drizzling for more than 2 days have a significant role in the occurrence of leaf and flower blight of both African and French marigold caused by *Alternaria dianthi*. Necessary prophylactic measures should be adopted in anticipation of such weather conditions. Three spraying with chlorothalonil 75WP @ 2 g/*l* at 10 days interval will manage the disease.
2. Routine spraying of Chlorothalonil 75WP @ 2 g/*l* at 30, 40 and 50 days after transplanting will effectively protect the African and French marigold crops from the disease.
3. Three sprays of tebuconazole 23EC (0.5 ml/*l*) or difenoconazole (0. 5 ml/*1*), at ten days interval starting from the first spray after the appearance of disease, for management of *Alternaria* blight of marigold (B:C 5.73)

# PETUNIA

*Petunia hybrida* Hortorum

**Variety:**

There are 2 strains, viz., tall and dwarf under the sp. Hybrids. The species grandiflora and Nana compacta have double flowers in a great variety of colour.

**Propagating Material**: Seed

**Soil:**

Moist and rich sandy loam and also well drained heavy soil

**Sowing Time**:

October-November for winter blooming March-April for summer blooming

**Method of sowing**:

Seeds sown in seed boxes or in well prepared nursery beds

**Stage of Transplanting**:

Transplanted at 4-leaf stage.

**Spacing:**

20 cm all around in beds.

**Blooming:**

November to January for winter crops and March to May for the summer season.

**Manure and Fertilizer:**

1 kg FYM with 9 : 9 : 12 g N : $P_2O_5$ : $K_2O$ per sqm area is to be applied.

A small dose of complete fertilizer and a little well-rotted cowdung or compost is beneficial.

**Aftercare:**

i) Timely pinching of terminal shoots will encourage side shoots

ii) Faded flowers should be removed immediately to keep the plants in continuous bloom.

**Insect-Pest:** There are no serious insect-pests in petunia.

**Diseases:** There are no serious diseases in petunia.

# PHLOX

*Phlox drummondii* Hooker

**Variety**:

The species *P. drummondii* var. grandiflora has alba, coccinea, violacea and nana compacts strains. The sp. *pilza* has many strains for star phlox.

**Propagating Materials**: Seed

**Soil**: Well manured fibrous loam with good supply of water in the bed.

**Sowing Time:** August-October

**Method of Sowing**: Seeds sown in seed pans of flat boxes.

**Stage of Transplanting**: Transplanted when seedlings are 2 cm in height.

**Spacing**: 25 cm all round.

**Blooming Time**: 3 months after transplanting.

**Manure and Fertilizer**: 1 kg FYM with 9-9-12 g N-$P_2O_5$-$K_2O$ per sqm area

**Aftercare:**

(i) Pinching of central shoots will induce busy growth

ii) The entire bunch should be plucked off after the first blooms start fading in order to encourage side branching and continuous blooming.

**Insect-Pest**: There are no serious insect-pests in phlox

# PORTULACA

*Portulaca grandiflora* Hooker.

**Variety:** Single and Double varieties with orange, white, purple red or pink flowers

**Propagating Materials**: Seed

**Soil:** All types of soils but perform best in poor sandy soil.

**Sowing Time**: March to April

**Method of Sowing**: Seeds sown in seed pans or seed boxes.

**Stage of Transplanting**: Transplanted at 4-leaf stage.

**Spacing:** 15 to 25 cm between plants and 25 cm between rows

**Blooming Time:** 3 months after transplanting, i.e. June and July

**Manure and Fertilizer**:

1 kg FYM with 4.5-4.5-6 g N-$P_2O_5$-$K_2O$ per sqm area is to be applied

**Aftercare**:

Portulacas are very small and succulent and therefore, careful and regular weeding should be done.

**Insect-Pest**:

There are no serious pests in portulaca except scale insects

**Disease**:

There is no serious disease of portulaca

# SALVIA

*Salvia splendens* John Bellenden Ker

**Variety:**

The species *splendens* includes red, white and purple flowered salvia while the sp. *farinacea* and *leucantha* produce blue and deep violet purple flowers.

**Propagating Material**: Seeds and cuttings

**Soil:** All types of well-drained soil

**Sowing Time**:

Seeds are sown from May onwards, while cuttings are made fromApril onwards from the new shoots of old plants

**Method of Sowing**: Seeds are sown thinly in seed boxes

**Stage of Transplanting**: Transplanting is done at the 4-leaf stage

**Spacing**: 20-60 cm apart depending upon the variety

**Blooming Time**:

Salvia blooms continuously for a long duration after about 2 to 2 ½ months of planting

**Manure and Fertilizer**:

1 kg FYM with 9-9-12 g N-P2O5-K2O per sqm area is to be applied. A light dose of organic manure for rich garden soil and a medium dose of complete fertilizer for poorer soils

**Aftercare:**

i) In rich soils, staking is necessary to prevent the blooms from lodging.

ii) Withered spikes should be removed in time.

iii) Liquid feeding or top dressing with FYM is necessary when plants are seen exhausted.

**Insect pest**: Aphid and scale insects

**Disease:** There are no serious diseases in salvia

# SWEET PEA

*Lathyrus odoratus* L.

**Variety:**

The early flowering varieties are Mrs. Herbert Hoover, Princess Blue, Harmony, white Giant, etc.

**Propagating Material**: Seed

**Soil:** Any good garden soil

**Sowing Time**: October-November

**Method of Sowing**: Seeds are directly sown in a prepared trench.

**Spacing**: 15-25 cm all around

**Blooming Time**: 2 ½ to 3 months after sowing

**Manure and Fertilizer**:

About 450 g of complete fertilizer mixture containing a greater proportion of sulphate should be incorporated into the soil to cover an area of 1.11 to 1.48 sqm

**Aftercare**

i) Furrows should be irrigated every second or third day from sowing to keep the soil moist but not too wet.

ii) When vines are about 30 cm high they should be trained over a good support

**Insect-Pest**: Aphids

# ZINNIA

*Zinnia elegans* Nicholar Joseph Jacquin

**Variety:**

Primrose, Scarlet, Candy Cane, Yellow, Orange, Crimson, Liliput Mixed, Giant double strain etc

**Propagating Material**: Seed

**Sowing Time**:

October-November for winter blooming and March-April for summer blooming

**Method of Sowing**: Seeds are sown in nursery beds and seed boxes

**Spacing**: 25-30 cm all round

**Stage of Transplanting**: Transplanting at 4 leaf stage.

**Blooming Time**: 1½ to 2½ months after transplanting.

**Manure and Fertilizer**:

1 kg FYM with 9-9-12 g N-$P_2O_5$-$K_2O$ per sqm area is to be applied

**Aftercare:**

(i) The first flower bud should be pinched off as soon as it is produced to induce side branches.

(ii) In tall varieties, plants should be staked with bamboo sticks.

**Insect-Pest**: Leaf eating caterpillars and aphids

**Disease:** There are no serious diseases of zinnia

# PLANT PROTECTION MEASURES FOR SEASONAL FLOWERS

1. **Aphid, beetles, thrips, leafhoppers, whitefly, caterpillars and scale insects:**

Spray lambda cyhelothrin @ 150- 250 ml/ha or emamectin benzoate 5SG @ 220 g/ha.

2. **Leaf miners:** Spray spraying lambda cyhalothrin @ 150- 250 ml/ha.
3. **Cut worms and red ants:** Soil drenching with thiamethoxam 25 WG @ 26 g ai/ha.
4. **Mites:** Spray spiromesifen 22.9 SC @ 96 g ai/ha.
5. **Powdery mildew and Rust:** Spray trifloxystrobin @ 0.1%, propiconazole or Hexaconazole @ 0.2%.
6. **Anthracnose and Downy mildew:** Spray any copper fungicide, e.g., Bordeaux mixture, chlorothalonil 75 WP @ 0.2%.
7. **Wilt:** Seed treatment with agrosan GN @ 2 g/kg of seeds.
8. **Damping-off:** Soil treatment with carboxin 0.2% solution @ 3 l/sqm area
9. **Leaf Spot:** Spray Bordeaux mixture or azoxystrobin 23SC @ 0.1% or chlorothalonil 75WP @ 0.2% (2g in 1 liter of water).
10. **Viral diseases like aster yellow leaf curl, little leaf, stunting etc.:**

(i) Uproot and destroy affected plants.

(ii) Control the insect vector with insecticides.

# GROWING OF POTTED PLANTS

Now-a-days, the growing of house plants for indoor decoration is gaining much popularity because of rapid urbanization, lack of space around the house as well as their cost of maintenance and transportability. It is possible to grow a variety of attractive decorative and interesting plants within the confines of the house with the help of which the entire indoor environment can be altered completely to give the home a fresh look.

**KINDS OF HOUSEPLANTS:**

**(a) Annuals**: Various seasonal or annual flowering plants can be grown in pots. Annuals are raised from seeds, either sown directly or first in nursery beds, wooden trays or containers and then transplanted into pots when seedlings are at the 3 to 4 leaves stage or one month old. Annuals include Ageratum, Amaranthus, African daisy, Aster, Carnation, Cornflower, Cosmos, Clarkia, Cuphea, Heliotrope, Lupin, Ladys Lace, Marigold, Nasturtium, Nicotiana, Phlox, Pink Dianthus, Poppy, Petunia, Pansy, Sweet William, Snapdragon, Stock, Zinnia, etc.

**(b) Perennials**: Perennial houseplants are either raised by division, cuttings or simply from plantlets that are produced naturally from the mother plant. These include Begonias, Geranium, Cyclamen, Bromeliads, Succulents, Cactus, Coleus, Chrysanthemum, Ferns, Palms, Orchids, Foliage plants and many flowering shrubs and climbers. Perennial plants can be grown in combination in dish gardens and bottle gardens.

**Soil for Potting:**

Soil for potted plants should be light, well drained, rich in organic matter. A potting mixture containing equal parts of rich garden loam soil and coarse sand is suitable for succulents and cacti. In the absence of rich loamy soil, another part of well-rotted organic manure may be added to get better results. A potting mixture containing 2 parts loam, 1 part each of sand and well-rotted manure of leaf mould is best suited for fibrous roots plants like Ferns, Geranium. Begonia, Seasonal flower, etc., For flowering shrubs and foliage plants like palms, Crotons, Hydrangea and Bougainvillea which have deep root systems, a potting mixture containing 3 parts loam, 1 part well-rotted organic manure and1 part sand is suitable.

**Fertilizer:**

A complete fertilizer mixture of N-$P_2O_5$-$K_2O$ (10-10-10) is beneficial for house plants. This should be applied in liquid form (one tablespoonful in 1 liter of water) at monthly intervals during the rapid growing phase of the plants.

**Container**:

House plants can be grown in different kinds of containers such as earthen pots, wooden boxes, etc. The size of the pot should be proportionate to the size of the plants. To facilitate

better drainage, there should be one or more holes at the bottom of the container. The pot should not be glazed or painted because this will block the exchange of gases through the pores of the container.

**Aftercare:**

All indoor plants require care and attention. The plants must be watered often to prevent the plants from wilting. Some plants, for example ferns, shed most of their leaves during a dry spell while in others the lower leaves turn yellow and drop off. On the other hand, over-watering causes the roots to decompose and the soil becomes very acidic and ultimately the plant withers up and dies. The frequency of watering should depend on the weather and season and nature of the soil and plants being grown. Watering should be done either in the morning or evening hours but never during mid-day.

From time to time, leaves should be wiped with a soft sponge or wet cloth to remove the dust particles adhering on the surface, which block the pores and prevent respiration and transpiration. Fungicides and insecticides can be added to the water at proper concentration to control diseases and insects.

Repotting, i.e. changing the potting mixture is essential for perennial house plants. Repotting is done when the soil dries up too quickly or the roots overgrow in the pot. As a general rule, repotting should be done every alternate year with a new pot mixture. However, if old soil is to be reused, organic manure and lime (10 g per pot) should be incorporated in order to reduce the buildup of soil acidity.

# ROOF-TOP GARDENING

The practice of cultivating vegetables, fruits and flowers on the rooftop of buildings is referred to as rooftop farming/gardening. Besides the decorative benefit, roof plantings may provide food, temperature control, recreational opportunities, and in large scale it may even have ecological benefits. They add another dimension of green space without taking up an extensive area of land in densely populated places. Temperatures around the building can be lowered in the summer. A building can be further insulated from the cold in the winter.

**Crops**: Vegetables and Flowers

**Media**: Sand: Cocopeat: Vermicompost: Perlite: Vermiculite (1 : 2 : 2: 0.25 : 0.25)

**Container:** 60 cm length x 40 cm breadth x 30cm height

**Propagation:**

| | | | |
|---|---|---|---|
| **Tuberose:** | Bulbs | **Gerbera:** | Sucker |
| **Cucumber:** | Seeds | **Chrysanthemum:** | Rooted cuttings |
| **Marigold:** | Rooted cuttings | **Broccoli:** | Seedlings |
| **Okra:** | Seeds | **Lettuce:** | Seedlings |

**Time of planting:**

| | | | |
|---|---|---|---|
| **Tuberose:** | February-March | **Gerbera:** | August- September |
| **Cucumber:** | May-June | **Chrysanthemum:** | September-October |
| **Marigold:** | June-July | **Broccoli:** | November-December |
| **Okra:** | June-July | **Lettuce:** | December-January |

**Spacing**:

Planting is done at a spacing of 30 cm x 20 cm for all crops

**Nutrient requirement**:

Fertilizer mixture 19 All should be sprayed @ 2 g/*l* twice a week and Micronutrients @ 2 g/*l* once a week.

**Cultural operation:**

Weeding should be done as and when needed. Irrigation should be provided on a daily basis preferably in the morning hours. To protect the fruits from sunburn, partial shade may be provided by 35% shade net. The media should be refilled as and when needed.

**Yield:**

**Tuberose**: 2.46 spike/bulb
**Cucumber**: 3.35 kg/plant
**Marigold**: 2.56 kg flowers/plant
**Okra**: 324.04 g/plant
**Gerbera**: 40.46 flowers/plant
**Chrysanthemum**:10.49 sprays/plant
**Broccoli**: 472.52 g/plant
**Lettuce**: 397.41 g/plant

**Benefit: Cost ratio**: 3.4

# POST HARVEST AND VALUE ADDITION PREPARATION OF JAM

Jam is prepared by boiling the whole fruit pulp with sugar to a moderately thick consistency. Pectin present in the fruit or added helps to develop the jelly fibre with a good gelatinous set. Acid (0.5-1.0%) is added to invert a part of sugar (40%) to prevent crystallization of sucrose in the finished product in addition to hardening the jelly fibre system. Banana, Guava, Mango, Apple, Pineapple, Apricot, Peach, Berry fruits, Roselles, etc. are widely used for making jam. Jam can be made from practically all varieties of fruits and some varieties of vegetables. Blended jam from various fruits can also be made. The procedure and the amount of ingredients required for the preparation of jam generally have a slight variation according to the fruits. A general procedure for jam preparation is outlined below:

**Fruit preparation:**

Mature fruits are used. Under-ripe or overripe fruits should be discarded. Handling of fruits depends upon the kinds of fruit and the type of produce required. In general, the following steps are involved:

1. Removal of unwanted fruits and parts (under ripe and over ripe fruits, stems, stalks, calyces, strings, leaves, foreign matter and moldy, blemished and defective fruits).
2. Washing and Preparation which may involve quartering, snubbing, cutting, mincing, destining, precooking, sieving, etc.

**Precooking and pulping:** Prepared fruits (e.g., cut pieces of pineapple, guava, etc.) are boiled with a little amount of water to a soft consistency. The fruit is macerated with a ladle and in the case of guava; seeds are separated by passing through a sieve. Fruit pulp can be prepared by a household mixer cum grinder after blanching the fruits for 2-3 minutes.

**Jam boiling:**

Fruit pulp, water, pectin (1%), sugar (67.5%) and acid (0.5%) are boiled to ensure sugar penetration into fruit particles. Partial inversion of sucrose to dextrose and laevulose, destruction of enzyme and yeasts and other physical and chemical changes required to set the jelly fibre and to give the product its recognized characteristics. Excess water can be removed by evaporation.

A short boiling time is important to preserve the colour and natural flavour. Artificial colour can be added with artificial flavour at the last stage of the boiling. Acid (citric acid or lemon juice) should be added at the last stage of jelly fibre formation in liquid form.

**End point:**

In open-pan boiling, the temperature is measured with a thermometer and the end point is usually at 105-108ºC. A shallow metal spoon is also used to ascertain the end point. The

spoon is dipped from time to time in the boiling pan and taken out and held in the open for some time. When the syrup adhering to it forms flakes on cooling, it is presumed that the end point is near. Reading of 65 to 68 per cent total soluble solids (TSS) is also an indication of the end point of jam or jelly.

**Filling and filling temperature:**

The prepared jam should be filled in containers (glass jars) previously cleaned and sterilized in boiling water and dried at 82-85 °C. The filled jars are capped, the head space is sterilized near a flame and the packed containers are then air cooled.

**Recipe for jam preparation:**

Generally, 45 parts by weight of fruit pulp requires 55 parts by weight of sugar and the substrate should be concentrated to 65 to 68 percent total soluble solid (TSS). Depending on the pectin content of fruit, external pectin should be added making the total pectin content about 1.0%. Likewise, according to the PH of the fruit, the total pH level should be maintained at 3.2 by adding citric acid or lemon juice (a pinch). Optimum sugar concentration added should be 67.5 percent which may vary slightly with the kind of fruit, their sweetness or internal sugar concentration, or acidity levels. Flavouring and colouring agents may be added according to necessity.

# PREPARATION OF FRUIT JUICES AND SQUASHES

Fruit juice is a natural juice pressed out of a fruit which remains almost unaltered in its composition during its preparation and preservations. The procedure for the extraction of juice varies according to fruit. In industry, various kinds of machineries like screw press, hydraulic press, basket press, fruit pulper, roller presses, belt presses and centrifugal machines are used. When the fruit contains seeds, it should be separated by cutting and slicing the fruit (Mango, Sapota, Plums, Jackfruit). Small seeded fruit like tomato require a special pressing cum seed separation device (Tomato processing machine). However, citrus fruit which contain bitter principle requires a particular approach where juice are normally extracted in special equipment in order to prevent the extraction of bitter components from their peel and consequent mixing into the juice. Thus, crushing and pressing are not employed in the case of citrus fruits. Generally, citrus fruits are cut into halves and the juice is extracted by holding the cut halves against a revolving rose of burr (reamer) which is conical in shape and ribbed, and is made of stainless steel monel, aluminium or nickel. The reamer tears the juice cells of the fruit.

For the extraction of juice in home scale level or homemade commercial juices, the fruit can be pulped in a mixer cum grinder after peeling, cutting and removing the seeds. The pulp can be pressed with folded muslin cloth by application of pressure. For higher yield of juice in some fruits like banana jackfruit, green mango, *ou-tenga*, etc. the pulp should be briefly boiled and pressed. Application of a small quantity of citric acid and fungal enzymes helps in the higher recovery of juice from the fruits. For extraction of citrus juice, small glass reamers of aluminium and nickel are available at a minimal cost. The extracted juice should be filtered with a filter press or ordinary thick type muslin cloth. Some juices which do not settle satisfactorily during storage and are difficult to filter can be clarified by the addition of fining agents. A fining agent is a kind of coagulating agent which settles and carries with it the finely divided particles responsible for the cloudy appearance. The fining materials most commonly used for fruit juices are egg albumen, casein, bentonite clay and infusorial earth, etc.

**Preservation:** A

After extraction and filtration of the juice, it should be processed for preservation. To retain the natural taste and aroma of a juice, it is necessary to preserve it immediately after extraction. Various methods of preservation are employed with their own merit. The methods generally used are:

1) **Pasteurization:** It is done in fruit juices to kill all microorganisms capable of growing in the juice and causing spoilage. It does not kill the thermophilic bacteria which cannot grow in the acid fruit juices. Heavily carbonated juices can be pasteurized safely at 56ºC for 20 minutes. Most non-carbonated juices must be pasteurized at 80ºC for 15 to

20 minutes. Juices of high acidity may be pasteurized at a lower temperature of 70-72°C for 20 minutes.

2) **Addition of preservatives:** It is usually necessary to add preservatives to fruit juices except for canned juices which are consumed immediately after opening the can. The use of preservatives is essential in concentrated drinks or squashes which after opening the bottle are consumed over a period of several weeks. Two important fruit juice preservatives are: (a) Benzoic acid (benzoates) and (b) Sulphur dioxide (sulphites).

**Sodium benzoate**: The quantity required would depend upon the extent and type of infection to be overcome and the nature of juice, particularly the acidity. For juice of pH 3.5 to 4.0, which is the range of most fruit juices, 0.06 to 0.10 percent should be added in a solution. In less acid juices like ripe grapes, banana, jackfruit, sapota, etc. at least 0.3% is necessary.

**Potassium metabisulphite**: It is used as a source of $SO_2$. Fruit juices can be preserved for more than a year by the addition of 0.1% metabisulphite provided the juice is made from a sound fruit and stored in clean containers at a temperature not above 15°C. For preserving raw citrus juice for a few months for the manufacture of squashes in the off season, generally 700 ppm of $SO_2$ is added for its strong effect in retarding oxidation preventing discolouration and loss of flavour of products. It should not be used in case of naturally coloured juices on account of its bleaching action. It also cannot be used in case of Juice which is stored in tin containers.

Chemical preservatives should never be added in solid form to fruit juices and squashes. They should first be dissolved in a small amount of juice or water and then incorporated.

**Preservation by freezing:**

When stored at 0°C, the temperature ordinarily used in cold storage the fruit juices either become moldy or undergo fermentation. In order to prevent the growth of microorganisms, it is necessary to store them at temperatures below 40°C. Grape, apple and pineapple juices can be held for at least 2 years at temperatures of about 5°C to 8°C without noticeable loss of flavour, aroma or colour when the juices are stored in sealed containers such as lacquered tins or bottles. A juice can be kept in good conditions for a long time at 1°F to 10°F in frozen form while avoiding contact with air. The juice is defrosted before consumption.

**Preservation by sugar:**

All fruit juices may be preserved by the addition of sugar or by increasing the natural sugar content of the juice by concentration. Fruit juices containing 66% or more sugar does not ordinarily ferment. Sugar acts as a preservative by osmosis and not as a true poison for microorganisms.

**Preparation of pineapple juice:**

For pineapple juice, varieties Kew and Giant, Kew are employed in the industry. For home preparation, any variety can be considered. Fully ripe fruits are selected, peeled and cut into pieces. The cut pieces should be homogenized or pulped with a mixer cum grinder and the juice is pressed out with folded muslin cloth. Basket presses may be used; screw presses are also available at lower price.

**Processing of pineapple juice:**

For processing of pineapple juice (pH 3.5 to 4.0) in glass bottles, 30 minutes heating at 85$^{o}$C is adequate to provide complete safety against yeast and mould spoilage and other mesophilic spoilage organisms. In aluminium foil pouches heating 25 min. at 85$^{o}$C is adequate.

Juices from fruits can also be prepared in the same way with a light variation in preparation of the fruit and the mode of extraction of juice.

**Preparation of squash:**

Squashes are sweetened fruit juices containing some pulp. Fruit squashes contain a minimum of 25% by volume of fruit juice and are intended to be drunk after dilution. Squashes also invariably contain added flavour.

**A. Mango Squash Recipe:**

| **Ingredients** | | **To obtain the concentration of** | | | |
|---|---|---|---|---|---|
| | | **25% juice** | **33.5% juice** | **25% juice** | **33.5% juice** |
| | | **45° Brix** | **45 °Brix** | **50 °Brix** | **50 °Brix** |
| | | **0.8% acidity** | **0.8% acidity** | **1.0% acidity** | **1.0% acidity** |
| 1. | Mango pulp | 45 kg | 45 kg | 45 kg | 45 kg |
| 2. | Sugar | 62.60 kg | 45 kg | 80.2 kg | 57.2 kg |
| 3. | Citric acid | 1.2 kg | 650 gm | 1.575 kg | 1.25 kg |
| 4. | Water | 71.8 liter | 44.1 liter | 53.1 liter | 30.6 liter |
| 5. | Preservative (KMS or Benzoic acid) | 110 g | 85 g | 110 g | 85 |

**B. Pineapple Squash Recipe:**

| **Ingredients** | | **To obtain the concentration of** | | | |
|---|---|---|---|---|---|
| | | **25% Juice** | **33.5% Juice** | **25% Juice** | **33.5% Juice** |
| | | **45 °Brix** | **45 °Brix** | **56 °Brix** | **65 °Brix** |
| | | **1.5% acidity** | **1.5% acidity** | **2.0% acidity** | **2.0% acidity** |
| 1. | Pineapple juice | 45 kg | 45 kg. | 45 kg | 45 kg |
| 2. | Sugar | 74.8 kg | 55.25 kg | 110 kg | 81.6 kg |
| 3. | Citric acid | 2.475 kg | 1.8 kg | 3.375 kg | 2.475 liter |
| 4. | Water | 56.5 liter | 32.0 liter | 20.1 liter | 4.7 liter |
| 5. | Flavour | 1.125 kg | 844 q | 1.5 kg | 1.15 kg |
| 6. | Preservative | 110 q | 85 q | 110 q | 85 |

**C. Lime Squash Recipe :**

| **Ingredients** | | **To obtain the concentration of** | | | |
|---|---|---|---|---|---|
| | | **25% Juice** | **33.5 Juice** | **25% Juice** | **33.5% Juice** |
| | | **45 °Brix** | **45 °Brix** | **65 °Brix** | **65 °Brix** |
| | | **1.5% acidity** | **2.0% acidity** | **2.0% acidity** | **2.0% acidity** |
| 1. | Lime Juice | 45 kg | 45 kg | 45 kg | 45 kg |
| 2. | Sugar | 76.5 kg | 56 kg | 112 kg | 83.2 kg |
| 3. | Water | 58.5 liter | 33.75 liter | 22.5 liter | 6.75 liter |
| 4. | Préservative | 110 q | 85 q | 110 q | 85 |

**D. Carambola squashes:**

The following is a recipe for preparation of carambola squash.

**Ingredients:**

Carambola Juice = 1 liter

Sugar = 1500 g

Water = 1 liter

Citric acid = 40 g (for sweet type), 20 g (for sour type)

Potassium metabisulphite (KMS) = ½ tea spoonful

**Preparation:** Extraction of juice is done by the help of a juicer then strained and weighed. Sugar and water should be heated by constant stirring to make the syrup. The syrup should then be strained through a muslin cloth and cooled. Fruit juice should be addedto the syrup. Measured quantities of KMS & citric acid should be added separately to the prepared squash dissolving in a little quantity of water. Pour in sterilized bottles and seal airtight.

**E. Some Other Preparations:**

**1. Preparation ‘‘*Outenga*” (*Dillenia indica)* RTS**

Ripe **“Outenga " fruit** can be used for the preparation of a pleasant ready to serve (RTS) beverage. The best recipe for it is:

| **Recipe** | **Amount of ingredients** |
|---|---|
| *Dillenia* fruits (segments) | 1 kg |
| Water | 3.5 liter |
| Sugar | 350 g |
| Benzoic acid | ½ teaspoonful |
| Pineapple flavor | 2 drops |

**Procedure:**

One kg small washed segments are cooked with 1 liter of water under pressure in a pressure cooker for about 10 minutes and thrown away the excess water. Then the segments are again cooked with 2.5 liter water for about 30 minutes and allowed to cool for 5 minutes after removing the lid. The pieces are then blended in a waring blender and strained through a straining cloth. Measure the liquid which comes to about 3 liters. Then other ingredients are added, mixed, bottled and sealed. This product contains 3.20 mg/100 ml ascorbic acid with a fairly high amount of TSS, reducing, Sugar, colour, flavour and other organoleptic properties. It stores well for two months without any appreciable change in colour and taste.

**2. Recipe for *Bhimkal* Squash:**

| **Recipe** | **Amount of ingredients** |
|---|---|
| 1. Bhimkal juice | 1 liter |
| 2. Sugar | 1000 g |
| 3. Citric acid | 45 g |
| 4. Potassium metabisulphite | 0.1% |
| 5. Orange colour | 2 drops |

**Procedure:**

The pulp, separated from the seeds, is mixed with 45 g citric acid and kept overnight.

Next day the juice is pressed out which gives 65% recovery of the juice. The juice (1 liter) is mixed with boiling syrup containing 100 g sugar. KMS and colour are added to the squash, filled in sterile glass bottles and sealed.

**3. Preparation of tomato squash:** A fine quality squash can be prepared from tomato, the best being from the variety Pusa Ruby at Optimum harvest maturity when 100% colour of the fruit has developed.

The recipe is: (1) Juice extracted from 1 kg of tomato (2) Sugar-500 g (3) Citric acid-1 g. (4) Potassium metabsulphite-1 g. (5) Red colour-0.5 ml.It can be stored for a long time in glass bottles with minimum loss in nutritional and organoleptic quality.

**4. Preparation of *Bhimkal* powder**: A simple dehydrated "Bhimkal" powder can be prepared by the following method. Pulp of ripe 'Bhimkal' fruit is separated from the seeds, supplemented with 20% arrowroot powder and dehydrated in a simple dehydrator at 65ºC for 6 hours. The material is powdered. It has moisture content less than 5% and can be preserved by bagging in polyethylene bags. The powder so prepared has excellent energy value with optimum concentration of minerals, protein and fat. It has got excellent organoleptic quality in respect to test, colour, flavour, texture and eating quality and can be used as baby food.

**5. Preparation of banana chips:**

I) Banana cultivar Kachkol, Manohor, Chenichampa can successfully be dehydrated for preparation of commercial chips using simple dehydrators.

**Method of preparation:** Mature green banana fruits at ¾ full fingers were cleaned, peeled, sliced to a thickness of 3 mm by a slicer and blanched for 2 min. in boiling water (1% NaCI and 0.17 KMS were added to blanching water) and dehydrated at 65ºC for 7 hours to a final moisture content of 5 to 6 percent. Kachkol variety was found to be the best in regard to chip quality, colour and nutrient retention points.

**6. Preparation of weaning food from *Bhimkol*:** A weaning food can be prepared from Bhimkol using filler material like tapioca starch and enrichment of protein by adding green gram powder. Sixty percent of the banana powder was mixed with 40% green gram powder. The formulation developed contains the highest protein (14.14%), energy (371.12 Kcal) with the lowest carbohydrate (76.3%) and fibre content (1.35%). It contains all 18 essential amino acids. It has a protein efficiency ratio (3.03) and food effective ratio (FER) of 0.30.

Organoleptically, colour, flavour, teste and general acceptability was found to be excellent.

It can be stored up to 120 days in metal tin or alluminium foil pouch at room temperature with maximum retention of nutritional quality.

**7. Preparation of carambola chutney:** The principle of preservation of fruits and vegetables in the form of chutney is similar to that for making pickles and involves the use of

sugar, salt, spice or vinegar as preservatives. The method of preparation usually includes a cooking process to hasten the action of the preservatives and develops an agreeable flavour and pleasing odour. Unlike pickles which take several days or weeks for seasoning, chutneys can be used for table purpose soon after preparation.

**Ingredients:**

| | | |
|---|---|---|
| Fruit pieces | - | 1 kg |
| Sugar | - | 800 g |
| Salt | - | 50 g |
| Ginger | - | 50 g |
| Onion | - | 60 g |
| Garlic | - | 15 g |
| Chilli powder | - | 20 g |
| Coriander powder | - | 15 g |
| Cardamom & Cinnamon | - | 5 g |
| Cumin powder | - | 25 g |
| Vinegar | - | 180 ml |

**Preparation:** The fruit should be cut into small pieces and cooked in a pan with salt and sugar. After proper dissolving of salt and sugar, the pan should be removed from heat and cooled for 30 min. The mixture should then be recooked till it becomes thick and sticky. Grinded spices should be put inside the spice bag and allowed to boil along with fruit pieces. Finally, 2-3 fine thread formation by chutney when stretched between the index finger and thumb will indicate the end point. The spice bag should be removed and vinegar be added. The chutney should be allowed to cool and then put into open mouthed sterilized bottles and sealed properly.

This excellent chutney can be stored at least for 6 months at room temperature without much deterioration in nutritional and organoleptic quality.

# PREPARATION OF JELLY

Preparation of jelly is similar to that of jam, except for the use of juice instead of fruit pulp. It is prepared by boiling the fruit with water, expressing the juice and concentrating it to such a consistency that gelatinization takes place on cooling. A perfect jelly is clear, sparkling, transparent and of attractive colour. When removed from the container, it should retain its form and should quiver, not flow.

The raw materials used for jelly making are similar to those used for jam. Pectin, sugar and acid in the mentioned quantity for jam are important ingredients for jelly making also. Pectin and acid are added to those fruit juices which are deficient in these ingredients. The fruit rich in pectin and acid are the acid varieties of apples, lemon, loganberries, limes, grape fruits, sour oranges, damson plums and other sour plums. Ripe melon, carrots, unripe bananas, etc. is low in acid but rich in pectin. Apricots and Strawberries etc. are rich in acid but low in pectin.

**Procedure**: The fruits are first washed. Since, jellies are made from juice; ordinarily peeling is not required for fruit like guavas and apples. In the case of oranges and lemons, the yellow portion of the peel should be removed to get jellies free from excessive bitterness. Fruits are cut into slices so that pectin and acid may be extracted easily. Only a minimum quantity of water should be added to the fruit for a simple extraction of pectin. If necessary, a second or even a third extraction may also be taken and mixed with the first extract. If large quantities of water are used, the jelly will be weak and if too little water is used, the extract will be difficult to clarify. The length of boiling will very according to the variety and the texture of the fruit. The fruit should be heated only long enough to soften sufficiently to permit thorough extraction of juice by pressing and to render it mushy.

The juice is extracted, filtered and boiled with sugar (67.5% optimum, which may vary according to fruit and its sweetness or sordidness), pectin (0.1%) and acid (pH 3.2). Colour, acid and pectin are incorporated just before the end point. Prolonged boiling results in loss of flavour, injury to colour and hydrolysis of pectin; consequently, it is a frequent cause of jelly failure.

The boiling is continued until on cooling the product forms a jelly of the desired consistency. The end point is determined by allowing the liquid to form sheet on a wooden ladle or spoon in sheets, or forming jelly like sheets on its side, the boiling is considered to be completed. If the juice contains the proportions of sugar, acid and pectin, the boiling point of the liquid at the jellying point will normally be about 110ºC.

**Packing:**

Jelly is usually packed at the boiling point or at about 95ºC and sealed hot. Sterilization of jars and lid and hermetic sealing can keep the product free from mould or fermentation.

# PREPARATION OF PICKLES

There are several kinds of pickles; popular among them are sour, sweet, and mustard pickles. Pickling is done in two stages, *viz*., (a) Curing or fermentation (which can be done with dry salting, fermentation in brine, or salting without fermentation) and (b) finishing and packing.

**Oil pickles:** In India, oil pickles which contain some edible oil particularly rape seed or mustard oil is highly popular. Cauliflower, lime and mango pickles are of high demand.

**Cauliflower pickle:** Outer leaves and central stalks of cauliflower are removed. The cauliflower is then cut into pieces, washed, drained and placed in the sun for 2-3 hours to remove some moisture. All the spices (as given in the recipe below) except mustard are taken and ground into fine powder. These are fried in oil. When they turn brown, cauliflower pieces are added and mixed thoroughly. When the pieces become soft, they are allowed to cool. Ground or broken mustard is then added and mixed. The mixture is placed in the sun for 5-7 days. Then 2.2 l of vinegar is added and the mixture is again placed in the sun for 3 more days.

**Recipe:**

| **Ingredients** | **Amount** |
|---|---|
| Prepared cauliflower | 18.0 kg |
| Salt | 1.125 kg |
| Chilli powder | 560 g |
| Mustard seeds | 560 g |
| Rape or Mustard seed oil | 2.250 kg |
| Onion (chopped) | 560 g |
| Green ginger | 560 g |
| Cumin, cloves and Cinnamon | 168 g |
| (Equal quantities) | |

For a sweet pickle, 4.5 kg of sugar should be added along with vinegar. Sugar may be replaced with equal quantities of gur (molasses). The pickle is put in a jar and covered with oil. It will be ready in about a week's time.

**Mango pickle:** Unripe, fully developed, tarty variety mangoes should be taken. Slice them longitudinally and vertically with a knife, discard the stones. Keep the slices in 2-3 percent brine and blanch to prevent blackening. Mix the mango slices with the salt. Place the mixture in a glazed jar and keep it in the sun for 4-5 days till the slices turn pale yellow. Mix with other

ingredients and smear with a little mustard oil. Then pack the pickle in a glass of glazed jars and cover with a thin layer of mustard oil. The pickle will be ready in 2-3 weeks.

**Recipe:**

| Ingredient | Amount |
|---|---|
| Mango slices | 10.0 kg |
| Salt, powdered | 2.5 kg |
| Turmeric powder | 300 g |
| Red chilli powder | 300 g |
| Black pepper | 250 g |
| Mustard oil | 1.5 liter |
| Pasfuran | 250 g |
| Zira | 250 g |
| White mustard seeds | 300 g |

**Lime pickle:** Fully ripe limes are washed thoroughly and given 2 to 4 split each. Salt of good quality ($1/4^{th}$ the quantity of limes) and $3/4^{th}$ of the limes are squeezed to release as much juice as possible into the jar. The juice should cover the contents of the jar. If necessary, a few more limes may be re squeezed and their juice poured into the jar. The jars are placed in the sun for a week. When the limes get softened and their skins turn light brown, the curing is completed. For preparing lime and green chilli pickle, these may be taken in proportions ranging from 8 : 1 to 4 : 1 in weight. The rest of the process is similar to that of lime pickle.

**Preparation of carambola jelly Ingredients:**

| | |
|---|---|
| Carambola juice | 1 liter |
| Citric acid | 5 g |
| Pectin | 5 g |
| Sugar | 500 g |
| KMS | 0.5 g/kg jelly |

**Preparation:** Matured just ripe carambola fruits are cut into small pieces. Citric acid is added and cooked with a little quantity of water for half an hour just to soften the fruit pieces. The fruit juice extract is strained through a muslin bag kept for 6-7 hours in a hanging position. Juice is kept for setting and supernatant juice is tested for pectin. As carambola has lower pectin content, so pectin is added at the rate of 5 g per liter of thejuice. Sugar is added to the juice and put to heat. The fruit juice along with sugar, pectin is boiled briskly and steadily. The end point of boiling is determined by following the drop test in which a drop of concentrated mass is

poured into a glass of water. Settling down of the drop without disintegration denotes the end point. The foam gathered on the top of the jelly should be discarded with the help of a ladle. Then the jelly is poured into a sterilized open-mouthed bottle and kept for 3-4 hours undisturbed. The bottles are sealed with wax and stored.

**Carambola pickle Ingredients:**

| | |
|---|---|
| Carambola | 1 kg |
| Salt | 250 g |
| Turmeric powder | 30 g |
| Fenugreek | 25 g |
| Coriander powder | 30 g |
| White mustard | 50 g |
| Cumin powder | 10 g |
| Acetic acid | 5 ml |
| Oil (mustard) | 500 ml |

**Preparation:** Mature unripe carambola fruits are thoroughly washed and cut lengthwise. Then they are made into smaller pieces. Turmeric powder is mixed with the fruit pieces. The carambola pieces are then placed over banana leaves and sun dried for 2-3 days. The mustard oil is heated and cooled and the rest of the spice mixture is added to it. Then the sun-dried carambola pieces are put into the mixture and the whole mass is thoroughly mixed. The pickles are then packed in polyethylene bags or glass bottles and stored at room temperature.

**Minimal processing of Jackfruit:** Minimally processed RTC tender jackfruit pieces are to be packed in polyethylene bags after treating with 1% KMS solution for 10 minutes for storage up to 4 to 5 days under refrigerated condition.

**Steps for minimal processing is given here under**

Selection of healthy, suitable tender jackfruit

⇩

Brushing and washing with chlorinated water

⇩

Peeling

⇩

Deeping in 5% KMS solution for 1 minute

⇩

Chopping into equal sizes

⇩

Treating with 1% KMS solution for 10 minutes

⇩

Air drying for 30 minutes

⇩

Packaging

# POST HARVEST HANDLING OF FRUITS AND VEGETABLES

## A. Fruits

1. Banana cv. Jahaji, Chenichampa and Monohar can be ripened successfully in 46- 49 hrs. by applying 1500 ppm of ethrel at room temperature in the gas chamber which gives improved eating quality, development of attractive colour and pleasant flavour. However, at higher temperature, no development of pale yellow colour can be obtained in case of cv. Jahaji.
2. For post-harvest storage of pineapple fruits, sawdust storage system should be used to increase shelf life of the fruits by 9 days. Fruit rotting can be controlled by this system significantly. Storing the fruits in polyethylene bags reduces the loss of fruit weight. Application of 6% wax emulsion can increase the shelf-life of Kew pineapple up to 21 days with minimum weight loss and retention of optimum freshness.
3. Both the perforated and non-perforated polyethylene bags, transparent or non-transparent, can be used for packaging Assam lemon fruits to prolong storage life.
4. The Assam lemon fruits should be harvested when the fruits are 120 days old, the skin of the fruits becomes soft and the colour of the fruits changes from dark green to light yellow.
5. Khasi mandarin fruits should be packed in Corrugated Fiber Board boxes (CFB) of 420 mm x 300 mm x 329 mm size (with CFB partitions inside) having 18 numbers of 3 cm (diameter) circular holes (equally distributed on all sides). The shelf life of the fruits can be increased by 12-15 days. The cost per box is Rs 55-60.
6. Two pre harvest sprays during August and September with azoxystrobin 23SC @ 0.1% and *Trichoderma viride* @ concentration of 1 x $10^7$ cfu (Colony Forming Unit) can maintain the quality of *Khasi* mandarin fruits like TSS, Sugar content and ascorbic acid and increase the shelf life of the fruits up to 15 days.
7. Improved Corrugated Fiber Boxes (CFB) of 685 cm length, 380 cm wide and 258 cm height can be used for long distance transportation of pineapple fruits. The cost per box is Rs. 65-70.
8. Fruits and vegetables can be stored in a low-cost cooling structure. The structure should be prepared in an open area with a facility of water supply. The length should be 1.5 – 1.6 m, 1.0 – 1.2 m wide and 0.6 – 0.7 m height. Half of the total height should be under the soil and rest half above the ground. The floor and side walls (2 layered) of the structure should be prepared with bricks. The gap between the two layers should be 0.75 cm and it should be filled up with sand. The sand should always remain wet. Arrangement should be made to cover the structure.

**B. Leafy vegetables**:

Shelf-life of leafy vegetables like spinach beet, coriander, lettuce and *lai saak* can be extended up to 2 days in perforated transparent polyethylene bag (200 gauge), under room temperature and for 6-9 days under refrigerated condition (4±1°C) with maximum retention of ascorbic acid, colour and freshness of the vegetables.

**Cabbage**

Mature Cabbage (Hybrid) can be stored under cold storage conditions (Temperature 5°C to 7°C) up to 50 days by bagging in a gunny bag.

**Storage of Betel vine**:

Harvested leaves should be packed in fresh banana leaves in rolling fashion keeping both ends open.

**C. Tuber crops:**

**Colocasia:**

Storage in perforated (0-3%) polyethylene (300 gauge) bags can prolong the storage life of colocasia with marketable quality up to 75 days for *Ahina Kachu*, 60 days for *Kaka Kachu* and 45 days for *Neel Kachu*.

# BAMBOO

Bamboo is an evergreen or deciduous gregarious plant species grown in homestead, boundary of crop field, on farmlands and other available places on farm holding. It is having advantage over other perennial cash crop as it has low gestation period, fast growth, diversified uses and easier marketability; all ensuring its potential as an excellent agroforestry crop.

**Soil & climate:**

Bamboo succeeds in any type of soil; however, *Bambusa balcooa* prefers heavy textured soils with good drainage and pH of about 5.5, can tolerate 4.5 – 7.5. But *Bambusa tulda* grows best in fertile, medium to heavy soils and prefers a pH in the range of 5-6, tolerating 4.5-6.5. Bamboo grows well at temp $8^0$ to $36^0$ C, annual rainfall 1200-4000 mm, high humidity.

**Altitude:**

Up to 3000 m from sea level. It prefers moist valleys, sheltered depressions and along stream and hill slopes up to 600 -1500m depending upon species.

**Species/varieties:**

Popular species of bamboo are Bhaluka (*Bambusa balcooa*), Jati (*Bambusa tulda*), Kako (*Dendrocalamus hamiltonii*), Kotoha (*Bambusa bambos*), Muli (*Melocanna baccifera*), Cachar bamboo (*Bambusa cacharensis),* Bijuli *(Bambusa pallida)* and Mokal (*Bambusa nutans*).

**Method of propagation:** Seeds, Rhizome, Stem cutting, Tissue culture

**Seeds:**

Seeds are collected from fruiting branches by shaking the culms, in a sheet on four bamboo poles put under the tree. The ripe seeds are mixed with Carboxin (2 g/kg of seed) and dried before sowing. In no case seeds should be collected from the ground as it is infected by insects and fungi.

Seeds should be sown immediately after harvesting. Sowing time varies with time and with the time of seed setting in different species.

Seed should be sown into a well hoed moist bed on fertile soils at a spacing of 30 cm x 10 cm. Beds should be 1 m wide and convenient length and 10 cm raised from the ground. Shade should be provided for better germination and establishment of emerging seedlings.

Seeds generally germinate 2-6 weeks after sowing. Transplanting is done after 12-18 month old seeding.

**Rhizome:**

Bamboo rhizomes of one year old with brown sheaths on the lower nodes of the culm should be selected as planting material. Rhizome/offshoot along with one meteculm length having at least 2 – 3 internodes should be selected from the outer ring. The offshoots should immediately be planted in such a way so that the lower node of the stem is just below the ground. Rhizomes is to be planted during March-August in a pit size of 45 cm x 45 cm x 45 cm at $45^0$ angle inclined towards North; the base should be tempered tightly and top cut end of the offshoot should be covered with cattle manure.

**Culm cutting:**

One year old internode with two nodes having 10-15 cm culm length on both sides of nodes should be selected. A small hole using a sharp knife/chisel should be made in the intermodal region. Boric acid @ 200 g/*l* along with IAA @ 20 mg/*l* should be added with the help of injection syringe through holes.100-150 ml chemical solution is sufficient for treatment of one inter node. The hole should be sealed with cellophane tape. Suitable time for chemical treat is April to September. The treated cuttings should be planted horizontally in the nursery keeping the hole upwards. Spacing between cuttings should be 25 cm and 5-6 cm soil. Mulching with straw is required with intermittent irrigation till sprouting. Culms with shoots are taken out of each bed after emergence of well-established shoots and roots 2.5 -3 months. Individual nodes with sprouts are separated by cutting before planting in the main field.

**Branch cutting:**

This method is applicable in thick-walled bamboo species like Bhaluka , Kako and Kotoha. Select good culms and extract basal lateral branches with root primordia. Cut into 2-3 noded segments and dip in hormone solution. Plant in a sand bed in a mist chamber and seal the exposed cut ends. Transplant rooted and sprouted branch segments in a poly bag. Keep in shade for 6 months before planting in the main field.

**Tissue culture:**

Nodal segments are surface sterilized with 0.1% mercuric chloride for 10 min and cultured on Murashige and Skoog (MS) medium supplemented within ìM 6-benzylaminopurine (BAP), 2.32 ìM kinetin (Kn), and gelled with 0.2% *w*/ *v* gelrite. Eighty-five percent of explants could be established *in vitro* with 90% of this achieving bud break. *In vitro*-formed shoots are being successfully multiplied in MS liquid medium supplemented with 6.6 ìM BAP, 2.32 ìM Kn, 2.5% *v*/*v* coconut water, and 100 mg $l^{"1}$ *myo*-inositol. Subculturing shoots every 3 weeks yields a consistent proliferation rate of 4.11-fold without decline in vigor. Shoot clusters, containing 5 to 8 shoots, are being rooted with 87.5% success in 1/2 MS supplemented with 5.71 ìM indole-3-acetic acid (IAA), 4.9 ìM indole-3-butyric acid (IBA), and 5.37 ìM naphthaleneacetic acid (NAA) within 3 weeks. Plants regenerated in this manner should be acclimatized in the greenhouse and under a shade net with 88% success.

**Land preparation:**

Removal of all vegetation including root stocks and herbs/shrubs followed by ploughing and harrowing should be done.

**Time of planting:** April to August

**Spacing:**

Spacing of bamboo should be 5-8 m depending upon the species and uses. *Bhaluka* and Jati bamboo should be planted at the spacing of 5m x 5m for edible shoot production and 7m x 7m for culm production; however, a wider spacing of 12m x 10m for *Bhaluka* and 10m x 10m for Jati may be suitable for growing intercrops at least for 4-5 years. Normally for '*Muli*' and '*Kako*' spacing requirements is 5-6 m.

**Pit size:** 45cm x 45cm x 45cm

**Planting:**

With the onset of pre monsoon shower, the pit is to be filled with topsoil and one year old seedling should be planted keeping in upright position at an angle of 40$^{o}$ to the ground. Care should be taken so that the roots do not curl during planting in pits. Level the pit with enriched soil and compacted to eliminate all air pockets. Mulch the soil around the plants will help control weeds and keep the soil moist. To avoid drying of the stem, the top is covered with a cake of cattle manure.

**Manures & fertilizer:**

Just prior to planting dry FYM @ 5 kg/plant or vermicompost @ 2.5 kg/plant, 200g Neem cake, 50g Urea, 50g Super Phosphate and 50g Muriate of Potash should be applied in the pit. In subsequent years the application of fertilizer should be increased proportionately.

**Intercultural operation:**

**Soil loosening:**

Soil should be loosened to a depth of 10 – 15 centimeters, and 30 –45 centimeters away from the bamboo clump at least twice a year to improve the growth of shoots and the root system.

**Weeding:**

Regular weeding is necessary to prevent weeds and other vegetation from competing with the young bamboo for sustenance. Weeding should be done at least for the first two years after the rains and end of the wet season. Once the clump gets established there is considerable leaf shedding and this acts as a barrier to the emergence of weeds.

**Mulching:**

Mulching reduces loss of moisture due to evaporation from the planting pits and checks weed growth. In a grown-up bamboo field, fallen bamboo leaves serve as good on-site mulching material. Bamboos have a requirement of silica for growth that can also be

contributed by bamboo leaf mulch.

**Mounding:**

Rhizomes grow laterally under the soil surface and when ready to throw up shoots, begin to grow an upward inclined angle as well. In this period of growth, exposure to sunlight retards and may even stop the growth of rhizomes. Mounding or heaping fresh, loose soil around and over the base of the plant is important as a preventive measure against lodging.

**Pruning and cleaning:**

Regular pruning and cleaning should be carried from the 4$^{th}$ year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to provide sufficient space in the clump for new shoots. Branch pruning also provides sufficient space for the emerging culms to grow upwards quickly without any hindrance. These operations are to be carried out every year during January-February.

**Thinning:**

Thinning the clump is essential from third year onwards to avoid congestion and to ensure proper growth and easy extraction of culms. Weak and deformed culms should not be retained in the culm. An appropriate clump structure should be maintained through thinning as well as through extraction or retention of shoots during January- February.

**Intercropping:**

Intercrops such as pineapple, banana, ginger and turmeric can be grown up to 4-5 years; however, due to profuse canopy of bamboo, inter crops cannot be grown thereafter.

**Harvesting:**

**For edible shoots:**

For edible shoots tender sprouts are to be harvested within 3 weeks of emergence when they are about 30 to 40 cm in length. Ensure that not more than 60% of the sprouts are removed in one season. Soon after extraction the tender sprouts are to be taken for processing as drying of the sprout is detrimental for further processing.

**For poles:**

Harvesting of bamboo culms every year will induce the emergence of new shoots and ensure regular and healthy culm production. Harvesting of bamboo for commercial purposes can begin from the third year of establishing a plantation. However, the clump will mature and yield culms of full physical dimensions only after the fourth year. The best time of the year to harvest culm is in the post monsoon season extending through the winter. The age of the culm is an important factor in the use to which it is meant for.

For nonstructural applications and those that do not require their peak physical and mechanical properties, 2-3 year old culms from a mature clump may be harvested. For most purposes however culms should be harvested when they are 4 years old.

Culms that are more than 5 years old begin to turn brittle and weak and then die. As

norm culms over 5 years should not be retained in a commercial plantation.

**Yield:**

After 7 years of plantation, the harvestable yield of *Bhaluka* is 600 to 700 nos./ ha/year whereas for *Jati* it is around 1110 nos./ha/year.

**Plant protection:**

**Major pests:** Weevils, Shoot borers and termites

**Control:** Plants should be protected by using clothianidin 50 WDG @ 125 g ai/ha as soil drench against termite or thiamethoxam 25WG @ 26 g ai/ha.at 6-10 ml per liter. Besides, treating the culms with 3% boric acid/borax mixture (1 : 2) may give effective protection.

**Rat:** Rat damages the shoots of bamboo while sprouting.

**Control:** To control, rats should be destroyed along with the nests. Apply bromadiolone 00.25% CB or bromadiolone 00.005% RB

**Animals:** Clumps managed for edible shoots need protection from porcupines, wild pigs and household animals.

**Control:** This can cheaply be provided by encircling the clump with fishing net as a barrier.

**Diseases:** Blight and Fusarium wilt

**Control:** Drenching the soil of affected clumps with a fungicide (e.g. chlorothalonil 75WP @ 0.2%) before the onset of rain. Wilting and death of young shoots caused by *Oregma bambusae* can be controlled by the application of azoxystrobin 23SC @ 0.1%.

**B:C ratio:** *Bambusa balcooa*: 4.99 and

*Bambus tulda*: 5.47

# TEA

*Camellia sinensis*

**Soil & Climatic Requirement**

**Soil**

- Soil : Deep & friable, high land
- Depth : 90 cm or more
- Texture : Sandy loam to silty loam
- pH : 4.5-5.5

**Climate**

- Hot and humid
- Temperature: 21-30°C, lower threshold : 13°C
- Rainfall : 1200 mm or more, well distributed

**Planting Material**

- Planting materials selected are judged on their locality wise performance.
- Clones and seeds ratio of planting materials 60:40
- Single planting material should not be more than 10 percent of area
- Minimum 5 to 6 clones should be selected
- Some recommended planting materials

**Clone:** $TV_1$, $TV_{17}$, $TV_{20}$, $TV_{21}$, $TV_{22}$, $TV_{23}$, $TV_{25}$, $TV_{26}$, $TV_{27}$, $TV_{28}$, $TV_{29}$,$S_3A_3$, $P_{126}$, Teen Ali 17/1/54

**Seed stocks:** TS 462, TS 463, TS 464, TS 506, TS 520

**Nursery Selection of site**

- High & well drained land, free from surrounding jungle, bamboo bari
- Avoid Southern and South – Western aspects in hills/ *tillahs*
- Sandy Loam soil with pH 4.5-5.0
- Nematode count < 6/10 g of soil
- Nearby water source for irrigation
- Nearer to residence for better supervision
- Negotiable road

**Vegetative propagation Layout of beds**

- Orientation: East – West direction in plain area and as per contours in the hilly areas.
- Bed size 1.2 m width of convenient length

- Drain size 30 cm width and 45 cm depth between two beds
- North – open over – head shade for poly sleeves nursery
- Low level shade for callusing nursery
- Low height bamboo lathe frame in bed edges to hold poly sleeves

**Sleeve preparation**

- Sleeves of size 15-17.5 cm lay flat width and 25 cm long of 150-gauge thick polythene.
- Soil mixture : Virgin topsoil with SSP @ 500 g/$m^3$
- Prepare sleeves at least six months ahead of planting cuttings

**Preparation and planting of cuttings**

- Vegetative period – mid April to early June and mid-September to mid-October.
- Collect unbranched 5-6 months old banjhi shoots from mother bushes preferably in morning hours
- Discard top succulent and basal hard woody portion of shoots
- Prepare single leaf cutting of 3 cm length
- Plant cuttings in the callusing beds at a spacing of 5 cm×5 cm in fish – scale method
- Transfer the callused cuttings to polythene sleeves after callusing and root initiation
- Irrigate the beds as and when necessary. Follow hand weeding and recommended practices against pests and diseases
- Segregate plants into various size groups
- Nursery plants are ready for transplanting to the main field within 9-12 months after hardening.

**Seed propagation**

- Procure seeds from TRA approved seed growers during November – December.
- Carry out sinker floater test; floaters to be rejected
- Place the sinker seeds in a germination pit (2 m x 2 m x 1 m size) for cracking.
- Selection of site and type of soil are same as of vegetative nursery
- Bed size : 120 cm width and of convenient length
- Grow *Crotalaria anagyroides* in between every two beds in raised *bheti* for shade.
- No overhead shade required
- Plant cracked seeds with eye downward at 20cm x 20cm by covering the seed only
- Mulch the beds with leaves of green crops, grass or thatch, hay etc.
- Remove the mulch after sprouting

- Water the beds as and when necessary
- Follow hand weeding and recommended practices against pests and diseases

**Drainage**

- Dig drain prior to planting
- Dig field drains of 30 cm width and 105 cm depth at 30-40m spacing in sandy soil and 15-20 m spacing in heavy soil.
- Collector and main drains should be 120 cm and 150 cm depth, respectively
- Drains should be of trapezoidal shape
- In sloppy land, graded contour drains with proper vertical interval are constructed
- Dig half the depth of field drains in the first year and then deepened it gradually within three years
- Ensure better fall in outfalls

**Planting**

- Ideal plant for planting Age: 9-12 month

  Leaf number: 12-16 numbers Height: 40-45 cm

  Collar thickness: 0.5-0.8 cm
- Spacing minimum of 60 cm in between plants and 100 cm in between rows
- Plant in single hedge in plains and along the contour in hilly areas
- Planting time : October – November in non-droughty area
- Pit size : 30 cm diameter and 45 cm deep circular pits
- Mix 1-2 kg compost, 30 g SSP, 30 g Rock Phosphate with the top excavated soil and fill the pits.
- Plant tea in pits by keeping soil level of sleeve in same level of ground
- Ram the soil properly without breaking the *bheti*
- Apply oxyfluorfen @ 500 ml/200 liters water as pre – emergent weedicide.
- Plant shade trees and sow green manuring crops (*Crotalaria anagyroides*) at recommended spacing

**Shade**

- Plant temporary shade trees at 5-6 m apart e.g. *Indigofera teysmannii, Melia azedarach, Leucaena leucocephala*
- Plant permanent shade trees at 10-12 m apart e.g. *Albizia lucida, Albizia odoratissima, Derris robusta, Albizzia lebbek,* etc.
- Shade tree pit : 90 cm deep and 60 cm wide

- Mix 5-6 kg well decomposed cattle manure 0.5 kg SSP, 1 kg slaked lime / Dolomite and 0.5 kg wood ash in a pit mixture.
- Protect the seedlings by bamboo basket

**Bringing up of Young Tea**

- Debudding in nursery one week before planting
- Centering at 15-22 cm from ground level leaving below at least 3 laterals.
- Thumb break the single stemmers/ plants with less than three laterals below 22 cm from ground level
- Centering below 10cm from ground level affects frame formation.
- Centre/Thumb break at least after one flush in April for autumn planted bushes
- Centre/Thumb break in July – Aug in spring planted bushes during the banjhi phase
- Tip at 55-60 from ground level and continue plucking
- Leave UP for the next year and pluck to janam
- First Frame Formation Prune after 22-26 months of planting at 35-40 from ground level
- Recentre wherever necessary
- Remove criss – cross branches, weak shoots, *banjhi* shoots only
- Tip at 60 cm ground level for the next year and continue plucking
- Leave UP for next year
- Final Formation prune at 40-45cm from ground level
- Follow judicious KCO
- Frame Formation should be done either after starch – test or at the end of January

**Pruning**

- Time : Light pruning – 1$^{st}$ to 15$^{th}$ December Skiffing – 15$^{th}$ December to 15$^{th}$ January
- Pruning cycle : 3 or 4 year pruning cycle

i) 3 year pruning cycle: Light prune (LP) – Level-off skiff (LOS) - Deep skiff (DS) – Light prune (LP) (LP-LOS-DS-LP) or

Light prune – Unprune - Unprune - Light prune (LP-UP-UP-LP)

ii) 4 year pruning cycle: Light prune (LP) – Medium skiff (MS) - Deep skiff (DS) – Light skiff (LS) - Light Prune (LP) (LP-MS-DS-LS-LP) or

Light prune – Unprune - Deep skiff – Unprune - Light prune (LP-UP-DS-UP- LP)

- Height of pruning

i) LP – Prune at 4-5 cm above the previous pruning mark

ii) DS – Skiff at 10-14 cm above the last LP mark

iii) MS – Skiff at 15-17 cm above the last LP mark

iv) LS – Skiff at 20-22 cm above the last tipping mark

v) LOS – Level off skiff

vi) UP – Level the plucking table by hand

**Pest Management in Tea Mite pests**

- Maintain proper shade and check weed growth
- Improve drainage condition, maintain soil pH and supply manures in time.
- Check entry of animals into the tea sections
- Pluck first in uninfested area and then move to infested area
- Spray propargite 57EC @ 2.5 ml/ 2 liters of water, profenofos 50EC @ 2 ml/ liter of water, spiromesifen @ 1 ml/liter of water, fenpyroximate 5 SC @ 1 ml/liter of water, Micronized sulphur formulations (Sulfex @ 1:100 & Microsul @ 1:200), Neem formulations (*Azadirachtin* 5%), etc. with high volume sprayer etc.
- Spray tebufenpyrad 20 WP @ 200 g *a.i*/ha against tea red spider mite, *Olygonychus coffeae*

**Chewing pests (Looper, Red slug and Bunch caterpillar)**

- Soil stirring and collection of chrysalids.
- Hand collection of bunches and looper caterpillar
- Light trapping of moths
- Spray Neem formulations (Azadirachtin 5%) or emamectin benzoate 5 SG @ 10 g a.i./ha
- Allow birds to visit the plantation

**Sucking pests (Tea mosquito bug, Tea thrips, Tea jassids)**

- Thin out shade trees in heavy shaded areas
- Follow hard plucking
- Prune or deep skiff the infested section at the end of the year
- Spray bifenthrin 8SC @ 40 g a.i./ha, thiamethoxam 25 WG @ 40 g/ 200 liters with high volume sprayer or Clothianidin 5 WDG @ 60 g a.i./ha against.

**Tea mosquito bug**

- Spray at 7-15 days interval depending on severity and period of attack after planting
- Spraying is to be done 3 days after plucking
- Follow barrier spraying

- Follow trapping by leaving a few bushes unplucked and then spray these bushes with pesticide.

**Termites**

- Destroy termite hills and queens and drench the hill with bifenthrin 2.5 EC @ 0.05 % g *a.i.*/ha.
- Remove earth runs and fork the soil around collar region before application of pesticides
- Avoid mulching with rice-straw
- Soil drenching with clothianidin 50 WDG @ 250 g/ha (125 g *a.i.*/ha or 0.5 g/liter of water) is effective against termite in tea.

**Cockchafer grub**

- Remove the mulch material or *jabra* from the collar of the plants
- Loosen the surface soil around the collar of the damaged plants
- Never allow entry of fresh cowdung in the field

**Manuring in Young Tea (0-5 year plants)**

- Apply YTD mixture, 10-5-10 or 10-5-15 N-$P_2O_5$-$K_2O$
- Apply at proper dose, proper time and in proper way
- Manuring near the collar of plants should be avoided
- The schedule is as follows-

| Age | Qty of YTD in g/plant | No of splits | Interval between application | Method of application |
|---|---|---|---|---|
| 0 | 10 | 2 | 8 | Ring |
| +1 | 15 | 4 | 8 | Ring |
| +2 | 20 | 4 | 8 | Ring |
| +3 | 30 | 3 | 10 | Ring |
| +4 | 525 | 3 | 10 | Broadcast |
| +5 | 550 | 3 | 10 | Broadcast |

**Manuring in Mature Tea**

- Apply N-$P_2O_5$-$K_2O$ depending on the yielding ability of the sections
- Dose N – 90 – 135 kg/ha, $P_2O_5$ – 20-50 kg/ha and $K_2O$ – 90-130 kg/ha
- For the plants producing Made Tea above average production of 2000 KMTH,

application of N (Nitrogen) is to be increased @ 5 kg N/100 kg of made tea.

- Dose of K (Potash) is increased in soils having low K content.
- Apply on weed free moist soil beginning with March – April
- Apply in 2-3 splits depending yielding ability
- Nitrogen and Potash is to be splitted, Phosphorus in single dose
- The proportion of ratio should be fixed depending on pruning or yielding ability
- Collar of plants should be unmanured.
- Avoid rainy and hot days for application.
- Apply fertilizers in broadcast method ensuring uniform spread in the area

**Tipping and Plucking**

- Keep allowance of new growth depending on prune or skiff LP: 20 cm

  DS : 10 cm or 2 leaf MS: 5 cm or 1 leaf

  LS/LOS/UP: At the same level
- Pluck at the tipping level
- Pluck to 'janam'
- Type of plucking
- Plucking round: 6-9 days depending on the growth of shoots.
- Step – up plucking : Raise plucking by leaving a leaf over the plucking table in end August
- Follow step-up plucking in denuded plants

**Green Leaf Handling**

- Pluckers should not be allowed to keep the leaves in hand for longer time
- Unload the plucking basket/ bag whenever it is full
- Don't allow to press the leaves in the basket
- Keep the leaves in carrying baskets/ bags loosely in shade
- Don't store leaves in garden for longer period
- Don't allow worker to sit on the plucked leaves while transporting to factory

**Intercropping in Tea**

- Existing arecanut plantation can be used
- Plant tea leaving a circle of 120 cm around palm
- Arecanut can be used as standard for Black pepper/ Betelvine
- Young tea sections can be interplanted with chilli, tomato, french bean, brinjal, cowpea,

etc. in between open rows.

- Possible intercrop: Orange, Chachi plants, Indian Gooseberry (Var. Baranasi and Francis) etc.
- Arahar for initial years for new plantation
- Plants *Kaji Nemu* near the fencing surrounding the plantation

# AGROFORESTRY SYSTEMS

Agroforestry is a multiple land use system and symbiosis of tree growing, crop production and livestock. Such systems provide livelihood security for rural people along with their basic needs of food, fuel, fodder, fiber and fertilizer. Agroforestry systems are practiced in two ways by integrating the farm crops with the forestry or by integrating forest trees into the farming system.

The different types of Agroforestry systems along with their components being practiced are:

1. AGRI-SILVICULTURE (Trees + Crops/trees + Trees)
2. SILVI-PASTORL SYSTEM (Trees + Pasture + Animals)
3. AGRI-HORTICULTURAL SYSTEM (Crops + Fruit trees)
4. HORTI-SILVI-PASTORAL SYSTEM (Fruit trees + Trees + Pasture + Animals)
5. AGRI-HORTI-SILVICULTURE (Crops + Fruit trees + Multipurpose trees)
6. AGRI-SILVI-PASTORAL SYSTEM (Crops + Trees + Pasture + Animals)
7. HOMESTEAD AGROFORESTRY (Multiple combination of various components)
8. AGRI-PISCI-SILVICULTURAL SYSTEM (Crops + Fish + Trees)
9. SILVI-APICULTURE (Trees + Honeybees)
10. PISCI-SILVICULTURE (Fish + Trees)

**Different components of agroforestry systems**

1. Tree species Subabul (*Leucaena leucocephala),* Bamboo (*Dendrocalamus strictus*), Siris (*Albizia lebbeck)*, Neem (*Azadirachta indica)*, Sissoo (*Dalbergia sissoo)*, Modar (*Erythrina spp.*), Kanchan (*Bauhinia variegata)*, Khoir (*Acacia catechu*), Kadam (*Anthocephalus cadamba*).
2. Fruits: Anola (*Terminalia oficinalis*), Ber (*Ziziphus spp.*), Citrus (*Citrus spp.*), Mango (*Mangifera indica*), Guava (*Psidium guajava*), Jackfruit (*Artocarpus heterophyllus*), Mulberry (*Morus alba*).
3. Short duration crops: Wheat, paddy, mustard, lentil, pea, soyabean, gram, ground nut, ginger, turmeric, chillies, tomato, coriander, fenugreek, French bean, green gram etc.

**Management practices:**

Trees and crop systems may be modified to facilitate management practices like pruning of trees, changes in sowing time of crop etc. Both the tree crop as well as associated crops need proper management of irrigation and drainage. The soil should not be hard and should have good water holding capacity. Preventive measures against the infestation of pests and diseases should be taken in advance.

# AGRO-FORESTRY CROPS

## AGARU

*Aquilaria malaccensis*

*Aquilaria malaccensis* is one of the most utilized high value aromatic trees of NE India. Two variants of Agar tree are observed in NE Region- '*Jati Sanchi*' and '*Bhola Sanchi*'. Usually, *Jati Sanchi* appears to yield more agar products than the latter. Agar is famous for its two high value products agar wood and agar oil.

**Soil & climate:**

Agar prefers high humid subtropical climate with rainfall 1800-3500 mm per annum, grows from sea level up to 500 m altitude and requires bright sunshine. Its performance is best in well drained deep sandy loam to loam soil rich in organic matters. It grows well in hill slopes and forest environments preferably in acidic soil.

**Method of propagation:**

Propagated by seed which ripens in June-July. In some trees viable seed can be harvested during late September to 1$^{st}$ week of October. Seeds are first germinated in a sand bed and after 25 days of emergence seedlings are transferred to a poly bag of size 5 cm x 10 cm under temporary shade or seed can directly be sown in raised bed. Seed has short viability for 7-10 days. Shifting of bags should be done at monthly intervals to prevent the penetration of roots into the soil followed by light irrigation.

**Planting / Transplanting:**

For mono crop, spacing is 2.5 m x 2.5 m. After 10 years of growth 50% of trees may be harvested. The planting of the saplings is done in well prepared pits of size 50 cm x 50 cm x 50 cm. Agar tree is suitable for growing in field boundaries and for dividing the whole plot into subplots, in pond dykes, in blocks.

**Manures & fertilizers:**

Well decomposed cow dung/FYM @ 10 to 15 kg/pit should be applied and well mixed with soil prior to planting. N, $P_2O_5$ and $K_2O$ at the ratio of 10 : 10 : 4 is applied in 2$^{nd}$ year @ 200 g/tree followed by 400 g/tree and 500 g /tree, respectively in 3$^{rd}$ and 4$^{th}$ year. Fertilizer should preferably be applied in two splits, one at onset of monsoon and another at cessation of monsoon along with decomposed cow dung/ FYM. From 6-7 year onwards, an additional dose of nitrogenous fertilizer @ 400- 500 g/tree/year may be applied in two splits.

**Intercropping:**

Vegetables/pulses/fruits or medicinal and aromatic crops like Patchouli (*Pogostemon*

*cablin*), Sugandh mantri (*Homalomena aromatica*), Kalmegh(*Andrographis paniculata*), Gathion (*Kaempferia galanga*), pineapple, etc. can be cultivated during the first 3-5 years of plantation. Ginger/turmeric may also be planted during the initial 2 to 3 years. In later stages shade tolerant medicinal plants like *Sarpagandha* (*Rauvolfia serpentina*), *Pipali* (*Piper longum*) and Kalmegh can be grown. In homestead agar trees can also be grown along with areca nut, coconut, banana, etc.

**Tending operation:**

**Coppicing:**

In agar plantation regeneration takes place freely which facilitates harvesting of infected tree leaving the tree trunk for quick regeneration for a 2nd crop as well as seed production from the coppiced tree once identified as a good mother plant. Coppicing during 10-15 years of age, the growth of new shoots is at fast and attained harvestable stage within next 10-15 years with comparatively higher distillable wood. Higher infestation of wood borer and fungal infection are observed in coppiced trees. Best results are obtained during March-May. Coppicing during monsoon and winter months gives poor results.

**Augment oil formation:**

**Cultural treatment to augment oil formation:**

Formation of agar wood can be initiated by creation of open wound on the trunk of agar tree. This is done just before breaking the dormancy i.e. before spring by giving a deep slanting cut in the trunk with a sharp *Dao*. The '*Dum type*' product obtained out of this treatment for oil extraction is locally known as '*Ghapmal*'. A 20-year old tree that may produce only 5-10 kg of '*Dum*' without any treatment but treatment by mechanical injuries resulted in more than 30 kg in about 2 years.

**Artificial inoculation:**

In artificial inoculation method 6-8 holes of 1.0-1.5 cm diameter are made at the trunk of tree at the distance of 30 cm, followed by inserting suitable inoculum and the holes are closed with cotton for 6-7 months.

After that holes are reopened to provide a suitable environment for fungal activities.

In this method, essential oil production starts after 9-10 months. Works on commercialization of this method are in progress.

**Detection of productive trees**:

Since agar is located deep within the trunk, its detection from outer appearance is not easy. Generally, such trees are distinguished by certain external symptoms whether or not the tree harbours precious agar oil or garu deposits.

(a) A poor crown, decayed branches, and uneven bole; Swelling or depressions and cankers on the bole.

(b) The appearance of hordes of ants in the fissures; A distinctly yellowish to brownish

tinge in the wood under the outer bark; and Signs of ill-health partially a die-back symptom of the top and outer branches and a yellow tint to the woody tissues.

(c) The visible wounds, cankers on the bole, stem distortions, smaller leaves and the rotten branches provide evidence of agaru deposits within a tree. Wood assumes distinctly yellowish tinge when agar formation takes place. The normal wood in the healthy trees is of pale brown buff colour. The change can be observed by removing the bark of the tree. Sometimes screw augers are driven inside at various depths and samples are drawn for examination. The disease or the fungal infection usually takes some time to make it manifest, hence agaru is hardly found in young shrubs.

**Harvesting:**

**Yield:**

From an established plantation thus a net income of Rs. 25-30 lakh/ha after 15 years may be generated giving an average of Rs. 1, 96,400/year/ha. Intercropping in the early stages of growth can generate extra income.

**Post-harvest processing:**

The harvested tree is processed for two products: (a) agaru or agarwood that is used as incense and (b) essential oil or agar oil or agar attar.

(a) Agaru is obtained from older trees while oil is distilled from old as well as younger trees. After felling a tree, the smaller branches are removed. Then the tree is cut into logs (pieces of 2-2.5 ft.). Thereafter, the logs split to separate out the infected and non-infected woods. The agarwood of any grade, if detected, is first separated out with the help of indigenous tools like hacksaw blade and '*Batali*' and graded them based on the oleoresin impregnation, colour density, specific gravity and finally the odour. These are then dried, cleaned by removing the white woody portions as far as practicable, polished and graded for marketing.

(b) Agar oil is obtained by steam distillation of harvested wood chips or coarse powder in a special type of SS made distillation unit. Distillation is continued for 5-10 days or more using firewood as the energy source.

**Plant protection:**

**Major pests:**

In agar plantation generally no serious insect pests and diseases have been observed. However, *Hoertia virusoids, a* leaf eating caterpillar, is considered to be the most destructive pest causing damage by complete defoliation of agar trees and has become a real menace to the plantations in NE Region. The intensity of attack is more in the trees grown in open condition than under shade. During March/April (dry season) the infestation is comparatively higher than July/August (rainy season). The pest found to cause defoliation twice in a year in May/June and August/September. The intensity of attack is more severe during May/June and can cause death of well grown trees due to complete defoliation.

**Control:**

For the management of leaf eating caterpillar collection and destruction of early instars of caterpillar clusters should be done. At severe attack spraying of contact insecticides profenphos 50EC @ 2 ml/*l* using foot sprayer at 10-15 days interval should be done; while spraying, it is kept in mind that the beneficial insect borer associated with agar formation is not affected. Severe infected trees should be given an extra dose of nitrogen.

**Gross return:**

(a) At 8-10 years *Dum* 600 x 20 x10 = Rs. 1, 20,000/ha

(b) At final harvest *Dum* 900 x 50 x 50 = Rs. 22,50,000/ha

(c) Agarwood 500 x 0.5 x 2000 = Rs. 5,00,000/ha

(d) Total= Rs. 28, 70,000/ha

(e) Net return: (Rs. 28, 70,000 – Rs. 4, 04,000) = Rs. 24, 66,000/ha

(f) From an established plantation thus a net income of Rs. 25-30 lakh/ha after 15 years may be generated giving an average of Rs. 1, 96,400/year/ha.

(g) Intercropping in the early stages of growth can generate extra income.

# NEEM

*Azadirachta indica* A. Juss.

*Azadirachta indica* is a popular tree species for its medicinal uses. It is used to treat skin diseases like eczema, psoriasis. Neem products are believed to be anthelmintic, antifungal, antidiabetic, antibacterial, antiviral, contraceptive and sedative. Neem oil is used for healthy hair, to improve liver function, detoxify the blood, and balance blood sugar level. Neem leaves are dried and placed in cupboards to prevent insects eating clothes and in tins where rice is stored. In Assam, the rain shadow belt includes Karbi Anglong, Hojai and parts of N.C. Hills are considered suitable for its commercial plantation. In Brahmaputra valley the hillocks are suitable for its plantation. *Azadirachta indica* based Agri-silviculture agroforestry system has tremendous scope in Assam especially in flood free areas where soil degradation and air pollution is a problem. Neem tree purifies air; as such it is suitable for plantation in urban and industrial areas. However, the extracts from *Azadirachta indica* can affect certain freshwater wildlife including fish and tadpoles.

**Soil and climate:**

Neem grows well on widely varied soil; it grows well in moist, dry, stoney, clayey or shallow soils. However, water inundated areas are not conducive for its growth. It can tolerate a wide range of soil pH from 5-10. Neem grows luxuriantly on deep well drained soil with high subsoil water level. It grows best in areas with rainfall ranges between 480 to 1000 mm, and a temperature from $0^0$C to $40^0$C.

**Altitude:** It survives best in altitudes between 50 to 100 m above MSL.

**Species/varieties:** Local elite type

**Method of propagation:** Seeds, stem cutting and root cutting

**Pre-treatment of seeds:**

Pre-treat of seed in cold water for 24 hours increases germination percentage.

**Nursery:**

Seeds have short viability of 2-3 weeks and so mature seeds should immediately be sown in seed bed in rows of 15- to 20 cm apart and at the distance of 2.5 to 5 cm within rows. The seedling can be raised in a basket and also in a polythene bag.

**Land preparation:**

The area of planting is completely cleared of all vegetation including removal of all root stocks and herbs/shrubs. Land should be prepared by ploughing and harrowing.

**Planting time:** Ideal time of planting is March to June with onset of pre monsoon shower.

**Spacing:** 5 m x 4 m

**Pit size:** 45 cm x 45 cm x 45 cm

**Planting:**

Pits are dug and left for 15-20 days exposed to sunlight. Pits are filled up in such a way that water does not accumulate in the pit. The planting time is from March to June with onset of pre monsoon showers; however, planting can be done throughout the year if a proper irrigation facility is available. Neem is suitable for planting as boundary/in field/on bunds/homestead.

**Manures & fertilizer:** Well rotten FYM @ 5 kg/pit

**Intercultural operations:**

Periodical pruning of the tree once in a year during November- December provides a good framework and faster growth of foliage as well as seed production of the tree.

**Intercropping:**

All the field crops including oilseeds and pulses, vegetables, spices, pineapple and forage crops can be cultivated as intercrops in young plantations.

**Harvesting:**

Neem starts bearing fruit after 5 year and comes to full bearing at the age of 10- 12 years. Generally harvesting of seed is done in the month of September. The best time for harvest of leaves is the spring season and late summer.

**Yield:**

Fruit yield is 5-20 kg/tree/year in the initial year. Mature trees produces 35-50 kg fruit/year. Oil content is 40-43% of seed on dry weight basis. It is estimated that a 10 year old tree can yield 5-6 cft of timber.

**Plant Protection:**

**Major pests:**

**Tea mosquito bug** (*Helopeltis antonii*)**:** Nymphs and adults suck the sap from plant tissues after sunset.

**Control:** Spray clothianidin 50 WDG @ 60 g ai/ha

**Diseases:** *Azadirachta indica* is affected by damping off *Rhizoctonia* leaf blight, leaf spot and blight induced by *Collectotrichum*, *Alternaria* and *Pseudo cercospora.*

**Control:** Damping off and blight can be controlled by spraying of azoxystrobin 23EC or trifloxistrobin 25WP @ 1 g/liter of water.

**Benefit: cost ratio:** 2.66 (excluding timber)

# GOMARI

*Gmelina arborea*

*Gmelina arborea* has immense potential for its timber and medicinal value. It is a preferred species by farmers, forest departments and ayurvedic industries due to the multipurpose utility, rapid growth, and maximum economic returns. Gomari wood is used for pulp, particle board, plywood, matches, carpentry and packing. It is also used for construction of boards, carving and musical instruments. The leaves and fruits of Gomari are used as a fodder, and also used for rearing silkworms. Gomari based Agri-silviculture system has tremendous scope in Assam especially the foot hill region and flood free areas of LBVZ and CBVZ. It is an ideal choice for large-scale afforestation programmes due to its high carbon fixation ability, recycling of nutrients and improvement of soil health.

**Soil & climate:**

Gomari is moderately sized to large deciduous tree with straight trunk. It is wide spreading with numerous branches forming a large shady crown, attains a height of 30 m or more and a diameter of up to 4.5 m. It grows normally in moist, fertile, well drained soils. It is grown in acid, calcareous, alluvial or lateritic soil; preferable pH ranges from 5-8. Gomari grows in locations having the temperature range from $20^0$C to $28^0$C and the annual rainfall between 750 mm to 4500 mm. It can tolerate drought period upto 6 month per annum.

**Altitude:**

Gomari is suitable in the altitude up to 1500 m; however, it grows most luxuriantly up to the altitude of 525 m.

**Species/varieties:** Local elite type

**Method of propagation:** Seed, root sucker, branch cutting and tissue culture

**Pretreatment of seeds:**

There are 3 methods (i) Immerge in water for overnight, (ii) Dip in hot water for 30 minutes and (iii) Dip in concentrated Sulphuric acid for 5 minutes.

**Nursery:**

Seeds are sown directly in the root trainer or raised bed of 0.6 m in height, 1 m in width and convenient length. The bed should be filled with sand up to height of 0.5 m. The seeds are closely placed the bed in a row with a gap of 5 cm. The beds are to be watered twice in a day with the help of cane. Fresh seeds germinate quickly; germination percentage is about 70-90%. The optimal temperature for germination is about 30°C. The seedbed should be exposed to full sunlight as partly or full shade will reduce germination. After germination, the seedlings can be transplanted to containers.

**Stump preparation:**

8-10 month-old seedlings are uprooted from nursery bed; stem and roots are pruned

keeping 30 cm stem and 15 cm primary root.

**Land preparation:**

Removal of all vegetation including root stocks and herbs/shrubs followed by ploughing and harrowing should be done.

**Planting time:**

Ideal time of planting is March to June with onset of pre monsoon shower.

**Spacing:** The seedlings are planted with the spacing of 3 m x 3 m, 4 m x 4 m or 5 m x 5 m with intercrops. Block plantations for bio energy and pulp wood the spacing of 2 m x 2 m is the most suitable. Boundary plantation of 1-2 rows at the spacing of 1 m x 1 m is adopted.

**Pit size:** Pit size of 45 cm x 45 cm x 45 cm is ideal.

**Planting:**

Pits are dug and stump of gomari are planted followed by filling up with top soil tightly. Gomari is suitable for growing in field boundaries, in field as block plantation, and homestead.

**Manures & fertilizers:** Well rotten farmyard manure like cow dung, garden compost, vermin compost or any manure made from green leaves can be used. A basal application of 5 kg of FYM and 70 g of N-$P_2O_5$-$K_2O$ complex fertilizer plus 10 g of borax is suggested.

**Intercultural operations:**

**Weeding:**

In the first year, weeding is done during June to August. Second year onwards weeding is not required. Soil working during October to November enhances the growth of plant.

**Irrigation:**

1-2 irrigations are necessary in first and second year during prolonged drought period.

**Pruning**:

Pruning is an important practice in the cultivation of *Gmelina arborea* in farmland; pruning decides the growth, clear bole and intercropping ability. Pruning of side branches is usually carried out in every six months. The pruned branches can be used as firewood.

**Thinning:**

Thinning of *Gmelina arborea* is an important practice to enhance the production of saw log in block plantation. It begins at 4-5 years of age for the woods that are used for pulp productions. The alternative trees in the row are to be thinned, to avoid competition between the trees and maximize the growth.

**Intercropping:**

Field crops can be grown as intercrop up to 3$^{rd}$ year of plantation. Thereafter some shade tolerant crops like Turmeric, Ginger, vegetables and fodder etc. can be cultivated as intercrop. Black pepper, Betel vine and *Dioscorea* may be grown as companion crops.

**Harvesting:**

Harvesting of gomari is done in 4-5 after planting for pulp and firewood; however, it is harvested 15 years onwards for log production.

**Yield:**

The total yield per hector is around 250 – 300 tones / ha. The wood of *Gmelina arborea* fetches Rs.8000/ton in local market.

**Plant protection:**

**Major pests:**

One of the most serious insects of *Gmelina arborea* in Assam is *Calopepla leayana*. It creates havoc mainly during May- June and August- September by eating up the leaf lamilae completely. Another important insect causing heavy damage to *Gmelina arborea* is *Alcides ludificalar* which bores longitudinal gallaries on the cambial layer of the plant. Some other minor insect pests are *Chrysodeixis chalcites*, *Ancheronlia lachesis*, *Attachus* sp., *Glenea indiana*, *Ozola minor*, are observed in nursery.

**Control:**

Spraying profenphos 50 EC @ 2 ml/*l* or any contact insecticide. Insect attack may be drastically reduced in mixed plantations of *Gmelina arborea* with *Shorea robusta*, *Ficus hispida*, *Dipterocarpus turbinatus*, *Acacia mangium*, *Hopea odorata*. In addition, application of fungi viz. *Beauveria bassiana* and *Metarrhizium anisopliae*, which are having the ability to control insects, especially *Calopepla leayana* may also be applied.

**Diseases:**

Leaf spot disease is the most important disease of *Gmelina arborea* at seedling stage which is caused by the fungus (*Orynespora cassicola*). The disease occurrence starts during last part of July and becomes havoc during October-November. Other diseases are collar rot, damping off, root rot, nodal blast and leaf burning.

**Control:**

Leaf spot disease can be controlled by spraying chlorothalonil 75WP @ 0.2% or azoxystrobin 23SC @ 0.1%. To control other diseases chemically seed treatment with carboxin @ 0.25% may be adopted. Seed can be treated organically with *Trichoderma viride*, *Trichoderma harzianum* and *Aspergillus terreus* @ 0.5%. treated seeds should be planted in pretreated soil either with chemical chlorothalonil 75WP @ 0.2% or azoxystrobin 23SC @ 0.1% or organically with Homicil/Neemcake/enriched organic matter @ 500 g/$m^2$.

**Benefit: Cost ratio:** 10.0

# TITACHOPA

## *Michelia champaca*

*Michelia champaca* is an evergreen or semi-deciduous, small to medium sized tree up to 50 m tall. The tree is a light demander and coppices well up to a fair size. *Michelia champaca* has a finely textured, dark brown and olive-colored wood, which is used in furniture making, construction, and cabinetry. It is accepted as suitable for the manufacture of grade I commercial and moisture proof plywood and plywood tea-chests. A variety of camphor is extracted from the wood by distillation. Flowers yield an essential oil used in perfumery. Leaves are fed to silkworms rearing. Leaf extract is toxic to the rice fungus, *Pyricularia oryzae*. Fatty oils extracted from the seeds show antibacterial activity against *Bacillus pumilus*, *B. subtilis*, *Salmonella typhosa*, *S. paratyphi*, *Micrococcus pyogenes* var. *albus* and *Staphylococcus aureus*. Titachopa is used to reforest in eroded areas and ornamental purposes. *Michelia champaca* based Agri- silviculture system has tremendous scope in Assam especially in the foot hill regions and flood free areas.

**Soil &climate:**

Titachopa is well suited for sandy loam soil and also it occurs on moist deep, well drained, fertile soil; however, it cannot tolerate water stagnation. It grows well in the areas where maximum temperature varies from 37.5 $^0$C - 47.5 $^0$C and minimum temperature ranges from 0 $^0$C to 17.5 $^0$C. Rainfall requirement varies from 2250 – 5000 mm with relative humidity varies from 80 – 90% in July and 60 – 80% in January

**Altitude:** Titachopa performs well in an altitude of 500 -1500 m above MSL.

**Species/varieties:** Local elite type

**Method of propagation:** Seeds, coppice

**Nursery:**

Ripe fruits are collected from the trees in August-September. Seeds should be cleaned and dried in the shade. The seed should be sown within two weeks of collection as it loses its viability very rapidly. Seeds are sown in August – September in shaded nursery beds for protection against the sun, either broadcast or in drills 8-10 cm apart, with a thin layer of earth sprinkled over the seeds. The shade is removed by June of the following year. Thatch grass or brushwood may sometimes be spread over the bed to hasten germination.

**Preparation of land:**

The area of planting is completely cleared of all vegetation including removal of all root stocks and bushes. Plough the land thoroughly and level it properly. Mark the areas for pit digging by alignment and staking.

**Planting time:** Onset of monsoon

**Spacing:**

The spacing for block plantation adopted is 2.4 m x 2.4 m in Assam. Planting single

row or double rows in crop field boundary may be adopted at a spacing of 2.4 m x 2.4 m.

**Pit size:** 45c m x 45cm x 45 cm

**Planting:**

The most successful method of propagating *Michelia champaca* is by planting out nearly one year old seedlings at the break of the monsoon of the following year. Planting out with ball of earth or with naked roots, though success chiefly depends upon congenial planting weather. The ball of earth should be 7.5 to 10cm in diameter and 15cm long.

**Manures & Fertilizers:**

Well rotten farmyard manure like cow dung, garden compost, vermin compost or any manure made from green leaves can be used @ 5kg/pit at the time of planting.

**Intercultural operations:**

Weeding is not required after the second or third year, as the plantation closes up rapidly. The first thinning in well-stocked plantations will normally be required in the 5th year if the spacing is about 2.4 m x 2.4 m.

**Intercropping:**

Field crops can be grown as intercrop in the boundary plantation of *Michelia champaca*.

**Harvesting:**

Harvesting of Titachopa should be done after 50 years of planting for timber production.

**Yield:** The total yield per hector is around 275 – 325 tones / ha

**Plant protection:**

**Major pests:** *Michelia champaca* is subject to the attacks by *Urostylis punctigera*, the champa bug, occurs as a pest, causing appreciable damage in pure plantations and it produces five generations in a year. The nymph sucks sap of newly formed leaves and tender shoots resulting in weathering of plant. The adult sucks the petioles and green shoots, as also the main stem of the young tree. Because of its size and longer life, the adult causes more damage than the nymph.

**Control:** Mix plantation of *Michelia champaca* with other non-susceptible species appreciably reduces pest infestation. Spraying with thiamethoxam 25WG @0.3 g/*l* or imidacloprid 17.8 SL@ 0.5 ml/*l*.

**Biological control of insects:** The natural enemies of the bug such as *Pachyneuron pentatomivora*, a parasite and *Calvia tricolor* a predator can be introduced to control *Urostylis punctigera*. Red ants collected and released on plantations will kill the bugs of *Urostylis punctigera*.

**Diseases:** *Prociphilus micheliae* causes leaf curling in trees and *Phomopsis micheliae* causes a leaf spot disease.

**Control:** Leaf spot disease can be controlled by spraying chlorothalonil 75WP @ 0.2% or azoxystrobin 23SC @ 0.1 %.

**Benefit: Cost ratio:** 6.67

# TEAK

*Tectona grandis*

*Tectona grandis* is a large deciduous tree; it grows up to 40 m tall with grey to grayish brown branches. Due to high oil content, high tensile strength and tight grain it is particularly suitable for weather resistance. Teak is used in the manufacture of outdoor furniture and boat decks. It is also used for cutting boards, indoor flooring and counter tops and as a veneer for indoor furnishings. It is used extensively in India to make doors and window frames, furniture, and columns and beams. It is resistant to termite attacks and damage caused by other insects.

Teak based Agri-silviculture agroforestry system has tremendous scope especially in the foot hill region, hills and hillocks and flood free plains of LBVZ and CBVZ of Assam.

**Soil & climate:**

It grows in a variety of habitats and climatic conditions from arid areas with only 500 mm of rain per year to very moist forests with up to 5000 mm of rain per annum. However, in most suitable areas annual rainfall is 1250-1650 mm with a 3-5 month dry season.

**Altitude:** It occurs from sea level to an altitude of 1200 m above MSL.

**Species/varieties:** Local elite type

**Method of propagation:** Seed, Grafting, Rooted stem cutting and Micro propagation

**Pretreatment of seed:**

Germination of seeds involves pretreatment to remove dormancy arising from thick pericarp. Pretreatment involves alternate wetting and drying of seed. Seeds are soaked in water for 12 hours followed by drying in sunshine for 12 hours. This is repeated for 10-12 days and then the seeds are sown in shallow germination bed of coarse peat covered by sand

**Nursery:**

Well drained sandy loam with gently sloping terrain is suitable for preparing nursery. In moist location the beds are raised to a height of 30 cm from ground level to prevent water logging. In dry zones, beds are made flush with the ground level. 5 kg seeds are commonly used for 12 sqm bed. The seeds germinate after 15-30 days.

**Stump preparation:**

8-10 month-old seedling is uprooted from nursery bed; stem and roots are pruned keeping 30 cm stem and 15 cm primary root.

**Land preparation**:

Plough the land and level it properly. Mark the areas for pit digging by alignment and staking.

**Planting time:**

Best planting season for teak wood farming is monsoon; preferably after the first shower.

**Spacing:**

Teak can be planted at 2 m x 2 m, 2.5 m x 2.5 m or 3 m x 3 m. It can also be raised along with agricultural crops at a spacing of 4 m x 4 m or 5m x 1 m. Boundary plantation of 1-2 rows at the spacing of 2 m x 2 m is adopted.

**Pit size:** Pit size of 45 cm x 45 cm x 45 cm is ideal

**Planting:**

Pits are dug and stump of teak are planted followed by filling up with top soil tightly. Teak is suitable for growing in field boundaries, in field as block plantation, and homestead.

**Manures & fertilizers:**

Apply 5 kg of FYM in pit. Fertilizer application @ 67-89 g of Urea, 94-125g of SSP and 25-33 g of MOP/plant should be applied every year from 2$^{nd}$ year up to 5$^{th}$ year. The same amount of fertilizer may be applied in 8$^{th}$ and 11$^{th}$ year after plantation.

**Intercultural operations:**

**Weeding:**

In the first year, 3 weeding are done during June to August; in second year 2 weeding is required and in the 3$^{rd}$ year only one weeding is necessary. Soil working during October to November enhances the growth of plant.

**Irrigation:**

1-2 irrigations are necessary up to 3$^{rd}$ year during prolonged drought period.

**Pruning**:

Pruning is an important practice in the cultivation of *Tectona grandis* in farm land; pruning decides the growth, clear bole and intercropping ability. Pruning of side branches is usually carried out in every six months. The pruned branches can be used as fire wood.

**Thinning:**

The thinning in block plantation of *Tectona grandis* is an important practice to enhance the production of saw log. First thinning at 5th year and second thinning at 10$^{th}$ year after plantation is suggested so as to keep only 25% trees for better growth. The alternative trees in the row are to be thinned, to avoid competition between the trees and maximize the growth. The thinning operation may also be done at the age of 18, 28 and 40 years.

**Intercropping:**

In block plantation of teak, the common intercrops are paddy, chilli, maize, wheat, sesame and various vegetables during the initial two years of planting.

**Harvesting:**

Teak can be harvested in 14-15 years after planting for poles; however, mature tree can be harvested in 50 years onwards for timber.

**Yield:** Each teak tree yields 0.283 - 0.425 $m^3$ (8 - 11 cft) wood /tree in about 14 years and 0.596 - 4.241 $m^3$ (16-115 cft) wood/tree in 50 years.

**Plant protection:**

**Major pests:** Teak defoliator and skeletoniser (*Hyblaea puera* and *Eutectona machaeralis*) cause extensive damage to young plantations in teak. Root rot due to*Polyporous zonalis* is also common in teak plantations. Pink disease fungus causes cankers and bark flaking. Powdery mildew caused by *Olivea tectonae* and *Uncinula tectonae* leads to premature defoliation.

**Control:** Fresh leaf extracts of *Calotropis procera*, *Datura metal* and *Azadirachta indica* are found to be most effective against teak skeletonizer. This method is of immense importance in insect pest control considering its harmless and pollution free implication on the environment, further avoiding the operational and residual hazards that involve in the use of organic and inorganic insecticides. Spray Profenfos 50EC @2 ml/*l*.

**Diseases:** Pink disease (*Corticium salmonicolor*), leaf spot disease (*Phomopsis sp*.), wilting disease (*Colletotrichum gloeosporioides*), stem rot (*Burkholderia solanacearum*) are the important diseases of teak.

**Control:** Soil drenching with copper fungicide and nematicide (Bordeaux mixture and spraying chlorothalonil 75WP @ 0.2% or azoxystrobin 23SC @ 0.1%), effectively control leaf spot diseases.

**Benefit: Cost ratio:** 12.5

# SISU

## *Dalbergia sissoo*

*Dalbergia sissoo* is a medium to large deciduous tree with light crown; it grows up to 25 m height and 2-3 m diameter.The wood is suitable for house construction, e.g. for door and window shutters, frames, flooring and paneling. It is widely used for cabinet making, vehicle bodies, boat building etc. Wood of *sisu is suitable for making* shoe lasts, carving, veneer and plywood. It is excellent for high-class bentwood furniture, walking-sticks, umbrella handles and other bentwood articles. Pulp from the wood is suitable for papermaking. It is highly valued as firewood and for charcoal production. A non-drying oil which is suitable as a lubricant for heavy machinery can be obtained from the heartwood. Leaves are used as animal feed.

Being a nitrogen-fixing species, *it* is widely used as a shade tree in agroforestry systems. It. is acknowledged for its environmental benefits, increasing soil fertility and reducing soil erosion. *Sisu* based Agri-silviculture system has tremendous scope throughout the state especially in homestead, waste land and eroded areas.

**Soil & climate:**

It is the most suitable for the moist tropics and subtropics and growth is most prolific in areas where there is considerable soil moisture, but not in waterlogged soils. It is most typically found on seasonally inundated alluvium and on eroded/gullied areas in the sub-Himalayan tract, in river-beds, along water channels and on alluvial flats subject to annual floods. The optimum temperature of 18-24°C, annual rainfall of 1000- 1700 mm is suitable for growth of the species. It prefers porous soils with adequate moisture, light/medium texture, and neutral to acidic reaction, and which may be composed of sand, pebbles and boulder alluvium.

**Altitude:** Sisu can be grown up to altitudes of 1000 m above MSL.

**Species/varieties:** Local elite type

**Method of propagation:** Seeds, root sucker, stem cutting

**Pretreatment of seed:**

It is done by soaking seed in water for 12 - 24 hours which accelerates germination

**Nursery:**

Well drained sandy loam with gently sloping terrain is suitable for preparing a nursery. In moist locations the beds are raised to a height of 30 cm from ground level to prevent water logging. Mature pods are broken into 1-seeded pieces and sown in a nursery bed in 15 cm x 5 cm spacing. Germination of fresh seed takes 7 - 21 days; germination is almost 100%. Shading is recommended during the hottest hours of the day during the germination period.

**Stump preparation:**

6-8 month-old seedling is uprooted from nursery bed; stem and roots are pruned keeping 20 cm stem and 10 cm primary root.

**Land preparation**:

Plough the land and level it properly. Mark the areas for pit digging by alignment and staking.

**Planting time:**

Best planting season is monsoon for *Dalbergia sissoo*; preferably after the first shower.

**Spacing:**

2.5 m x 2.5 m. It can also be raised along with agricultural crops at a spacing of 4 m x 4 m. Boundary plantation of 1-2 rows at the spacing of 2 m x 2 m is adopted.

**Pit size:** 45 cm x 45 cm x 45 cm

**Planting:**

Pits are dug and stump of sisu are planted followed by filling up with top soil tightly. Sisu is suitable for growing in field boundaries, in fields such as block plantation, homestead, roadside plantation and waste land.

**Manures & fertilizers:** Apply 5 kg of FYM in pit

**Intercultural operations:**

**Weeding:**

In the first year, weeding is done during June to August. Second year onwards weeding is not required. Soil working during October to November enhances the growth of plants.

**Irrigation:**

1-2 irrigations are necessary in the first and second year during prolonged drought periods.

**Pruning**:

Pruning is an important practice in the cultivation of sisu in farm land; pruning decides the growth, clear bole and intercropping ability. Pruning of side branches is usually carried out every six months. The pruned branches can be used as firewood.

**Thinning:**

Thinning of sisu is an important practice to enhance the production of saw log in block plantation.

**Intercropping:**

*Dalbergia sissoo* is suitable for plantation in the boundary of field crops. Intercropping of different field and horticultural crops in sisu plantation at a wider spacing of 4 m x 4 m can be done.

**Harvesting:**

Sisu can be harvested for 40 years onwards after planting.

**Yield:**

Tree productivity of *Dalbergia sissoo* increases with advancement of its maturity. The productivity has been shown as follows:

| Year | Tree productivity | |
|---|---|---|
| | $m^3$/ha | $m^3$/ha/yr |
| 10 | 10 | - |
| 20 | 100 | 5.0 |
| 30 | 210 | 7.0 |
| 40 | 280 | 7.0 |
| 50 | 370 | 7.5 |
| 60 | 460 | 7.5 |

**Plant protection:**

**Major pests:** Major pests of Sisu and their control measures are mentioned below:

| Sl. No. | Insect-pest | Control measure |
|---|---|---|
| 1. | *Plecoptera reflexa* (a defoliator), | Spraying profenphos 50EC @ 2 ml/*l* or thiamethoxam 25WG@ 0.3 g/*l* |
| 2. | *Dichomeris eridans* (leaf binder) | any contact insecticide |
| 3. | *Brachytrupes portentosus* | |
| | (causing nursery damage) | |
| 4. | Termites | Apply 0.2-0.3% fipronil or imidacloprid |

**Diseases:** Major diseases of Sisu and their control measures are mentioned below:

| Sl. No. | Disease | Control measure |
|---|---|---|
| 1. | *Cercospora sissoo* (Leaf spot) | Selection of seeds, which are free of fungi, spraying of chlorothalonil @ 0.2%, good drainage |
| 2. | *Colletotrichum sissoo* (Leaf blight fungus) | -do- |
| 3. | *Fusarium solani dalbergiae* (Leaf wilt) | Drench the potting medium with copper fungicide |

**B:C ratio:** 5.4 **(**after 30-50 years of plantation)

# MANJUM

*Acacia mangium*

*Acacia mangium* is a very fast-growing evergreen tree species growing up to 30 m height and 0.5 m diameter. *Acacia mangium* is very fast growing and possesses the beneficial property of trapping atmospheric nitrogen; thereby increases soil organic matter and nutrients. *Acacia mangium* is used to make excellent particle board and is suitable for plywood, paper pulp, fence posts, firewood and charcoal. It is important source of wattle timber; the wood is used for construction, boat building, furniture and cabinet making, and veneer. Young shoots and leaves are browsed by buffalo and cattle. For production of honey, *Acacia mangium* is a suitable crop. It has ample potentiality for plantation in wasteland including *char* areas of the Brahmaputra river and its tributaries.

**Soil & climate:**

It is typically found in the tropical, humid zone characterized by a short dry season and a mean annual rainfall between 150-3000 mm; it can tolerate moisture stress, temperature requirement ranges from 31-37$^0$C during summer and a minimum of 12-25$^0$C in winter. The growth seems to be slow down with decreasing rainfall and temperature. *Acacia mangium* can tolerate low fertility soils with impeded drainage, but prefers fertile soils with good drainage. It grows in a wide range of pH from 4.0-7.5 and has been found to tolerate water logging.

**Altitude:** The tree has altitudinal range up to 900 m above MSL.

**Species/varieties:** Local elite type

**Method of propagation:** Seeds, Coppice, stem cutting, grafting, air layering and tissue culture

**Pretreatment of seed:**

Pre sowing treatment gives rapid and higher germination (75- 90%) occurs within 1 month. Seeds are immersed in boiling water (100$^0$C) for 30 seconds followed by soaking in cold water for 24 hours; alternately, they may be manually scarified.

**Nursery:**

Seeds may be sown in seed beds and pricked out 6-10 days after sowing. Sowing in germination trays and pricking out the seedlings 6-10 days after sowing should be done when the radicle emerges giving 85% survival. Another option is direct sowing in the containers (polythene bags, open-ended hanging pots called ‘root trainers’ or other permanent pots), followed by pricking out to maintain1 seedling per container. The sowing media may comprise mixtures of topsoil, peat, old saw dust, rice husks, sand and vermiculite. Seedlings of 25-40 cm height are ready for plantation in the main field.

**Stem cutting:**

Single nodded stem cutting of 4-5 cm long, 0.5-1.5 cm diameter with 0.5-1 phyllode gives profuse rooting. The application of Indole-butyric acid or rooting powder results in 65-

75% rooting in cuttings.

**Air layering:** It also gives promising results.

**Land preparation**:

Plough the land and level it properly. Mark the areas for pit digging by alignment and staking.

**Planting time:**

The best planting time for *Acacia mangium* is monsoon; preferably after the first shower.

**Pit size:** 45 cm x 45 cm x 45 cm

**Spacing:**

3 m x 3 m is the most common spacing for *Acacia mangium*. It can also be reduced to 2 m x 2 m, 2.5 m x 2.5 m for fast growth and straight bole height in the initial stage. It can also be raised along with agricultural crops at a spacing of 5 m x 4 m. Boundary plantation of 1-2 rows at the spacing of 2 m x 2 m should be adopted.

**Planting:**

Pits are dug and stump of Manjum are planted followed by filling up with top soil tightly. Manjum is suitable for growing in field boundaries, in field as block plantation, and homestead. The species is suitable for boundary plantation, block plantation, waste land and homestead.

**Manures & fertilizers:**

Apply 5 kg of FYM in pit. Fertilizer application of N-$P_2O_5$-$K_2O$ @ 50-100-50 kg/ha in the form of Urea, SSP and MOP/plant should be applied every year from 2$^{nd}$ year up to 5th year.

**Intercultural operations:**

i) **Weeding:** In the first year, weeding is done during June to August. Second year onwards weeding is not required. Soil working during October to November enhances the growth of plants.

ii) **Irrigation:** 1-2 irrigations are necessary in the first and second year during prolonged drought periods.

iii) **Pruning**: Pruning is an important practice in the cultivation of *Acacia mangium* in farm land; pruning decides the growth, clear bole and intercropping ability. Pruning of side branches is usually carried out every six months. The pruned branches can be used as firewood.

iv) **Thinning:** Thinning of *Acacia mangium* is an important practice to enhance the production of saw log in block plantation. It begins at 4-5 years of age for the woods that are used for pulp productions. The alternative trees in the row are to be thinned to

avoid competition between the trees, and to maximize the growth.

**Intercropping:**

Sesamum in *kharif* and niger in *rabi* season give a good return up to 4$^{th}$ year in tree spacing of 5 m x 4 m; however, the productivity of intercrop is decreased with increased tree canopy. All field crops and vegetables can be grown in a field surrounded by boundary plantation of *Acacia mangium.*

**Harvesting:** Manjum can be harvested 15 years onwards for log.

**Yield:**

Timber volume calculated on the basis of mean data has been recorded as 1.1902 $m^3$/tree in 16-year plantation.

**Plant protection:**

**Major pests:** Important insect pests are root feeders (*Stenocera aequisignata* and termite), branch and stem borers (*Synoxylon* sp.) and red coffee borer (*Zeuzera coffeae*). These can cause death, deformity or reduced biomass production of *Acacia mangium*.

**Control:** As the preventive measure of *Stenocera aequisignata* in nursery by soil drenching with bifenthrin 2.5EC @ 0.05 g ai/ha. For controlling *Zeuzera coffeae* in the plantation, insecticides can be injected into the holes where larva pushes out their frass. For control of *Synoxylon* sp., the broken branches in which insect breeding has taken place is removed and burnt. Inject profenfos 50EC @ 2 ml/hole.

**Diseases:** The important diseases observed in nurseries are damping off, powdery mildew, stem galls, die back, leaf spot, charcoal root rot and root knot. Important diseases in plantation are root rot, heart rot, pink disease, die-back and stem canker. Root rots are caused by many fungus species like *Ganoderma* sp., *Phellenus* sp. and *Rigidoporus lignosus*.

**Control:** The dead and diseased trees should be destroyed to avoid spread of root rot diseases. There is no specific control measures at present for heart rot, die-back and stem canker. The diseases in nursery can be controlled by conventional nursery management techniques and prophylactic fungicidal spray.

**B:C ratio:**

Income of *Acacia mangium* based Agroforestry system in 16 years, where Sesamum-niger grows up to 4$^{th}$ year, followed by Hybrid Napier, is Rs. 19, 25,680/ha.

# SANDAN

*Santalum album*

*Santalum album* is a thorn less, small-sized and evergreen tree growing up to 6-8 m height. It is a hemi-parasitic plant and parasitizes the roots of other tree species. It draws part of its nutrition (mainly Ca and K) from the soil and part of its nutrition (mainly N and P) from host plants through haustoria developed with secondary host plant. For Assam conditions plants like Bhatgila, Amlakhi, Karach, Coconut, Agarwood, Neem may be used as secondary host plants.

Sandan wood is heavy, hard, durable, strong, resistant to termites attack and strongly aromatic as it seasons. Heartwood is much used for ornamental and carving work. Formerly, in China the most expensive coffins were made of sandalwood, while in India it was the preferred wood for funeral pyres. The dust of sandalwood is utilized for Agarbatti manufacturing. Oil is used as flavouring agent in a range of foods including chewing gum, ice cream and bakery products. It is a basic component of countless perfumes, cosmetics and toiletries. The oil has been widely used in folk medicine for treatment of common colds, bronchitis, skin disorders, heart ailments, general weakness, fever, infection of the urinary tract, inflammation of the mouth and pharynx, liver and gallbladder maladies. It possesses anti-microbial and antioxidant properties. Leaves of *Santalum album* provide green manure. Sandalwood based Agri-silviculture agroforestry system has tremendous scope as boundary plantation, block plantation and homestead especially in the foot hill region of rain shadow areas of Assam.

**Soil and climate:**

It is adapted to wide range of soil; normally grows in sandy or well drained soils. It grows in locations having the temperature range from 0 to 38°C and the annual rainfall of 500 mm to 3000 mm. *Santalum album* should be planted in the areas with bright sunshine; stagnated areas are not at all suitable for the tree.

**Altitude:** *Santalum album* grows up to 700 m above MSL.

**Species/varieties:** Local elite type

**Method of propagation:** Seed, root sucker, branch cuttings, cleft grafting and tissue culture.

**Nursery:**

Seed from ripe fruit is collected between November to February. Seeds are sown on raised and well-prepared bed in line. Sandal wood seed show about 30-40% germination. Fresh seeds take about 20 days to germinate and continued another 25-30days to complete. Healthy seedlings at 2-4 leaf stage are transferred to previously fill up black polybag of size 30 cm x 14 cm. Arhar or *Ocium* species seeds sown to serve primary host for better growth of sandalwood seedling. Poly bag should contain soil mixture of ratio 2 : 1 : 1 (Sand: Garden soil: FYM). Poly bags are placed in rectangular beds with proper shade and irrigation.

**Land preparation:**

Land should be completely cleared of all vegetations followed by ploughing and harrowing.

**Planting time:**

Planting should be done during March to June with onset of pre monsoon shower. However, planting may be carried out throughout the year if proper irrigation facility is available.

**Spacing:** 4 m x 4 m

**Pit size:**

45 cm x 45 cm x 45 cm. Pits are dug for both sandal wood and secondary host plant and left for 15-20 days exposing to sunlight.

**Planting:**

After filling up the pits a well grown perennial species as host plant like agar tree or any other suitable host tree seedlings should be planted. It is advisable to establish the host plant prior to plantation of sandal tree. After two months sandalwood seedlings are planted in the pit.

**Manures & fertilizers:**

Well rotten FYM @ 5 kg/pit should be applied before planting. After 4 month of planting when the seedlings are well established, organic manures like compost or FYM @ 2 kg/plant is applied and mixed with the soil around crown of the plant. Application of FYM @ 3-4 kg/plant at 8-9 month of planting is beneficial. Second year onwards, manuring of FYM @ 4-5 kg/plant twice in a year, before and after monsoon followed by light earthing up, may be done.

**Intercultural operation:**

For quick initial growth, irrigation may be done at 15-20 days interval during drought period in winter. The host plant is lopped to provide enough light to sandalwood seedling. Fencing is required to protect the seedling against browsing by animals. Soil working is done to a radius of 50 cm once in six months.

**Intercropping:**

Oilseed and pulse crops can be grown as intercrop up to 3$^{rd}$ year of plantation. Thereafter, some shade tolerant crops such as Patchouli, Sarpagandha, Satmool, Ginger, Turmeric, pineapple etc. can be cultivated as intercrop.

**Harvesting:** Sandan can be harvested in 15-20 years after planting.

**Yield:**

Average yield of heartwood of *Santalum album* in Assam is in the range of 20- 30 kg after 20 years of plantation. On steam distillation, the essential oil production is about 1.5 kg.

**Plant protection:**

**Common Insect pest and diseases of Sandal wood and their control measures are mentioned below:**

| Sl. No. | Insect-pest | Control measure |
|---|---|---|
| | **a) Insect defoliator** | |
| 1. | *Sympiezomias cretaceus* | Spraying profenfos 50 EC @ 2 ml/*l* |
| 2. | *Holochlora albida* | any contact insecticide |
| 3. | *Teratodes monticollis* | |
| 4. | *Letana inflata* | |
| 5. | *Cryptothelea cramerii* | |
| 6. | *Acanthopsyche moorei* | |
| 7. | *Pteroma plagiophleps* | |
| | **b). Sucking Insect** | |
| 8. | *Ceroplastes ceriferus* | Spraying of thiamethoxam 25 WG @ 0.3 g/*l* or imidacloprid 17.8 SL @ 0.5 ml/*l* or acetamiprid 20 SP @ 0.2 g/*l* |
| 9. | *Saissetia* sp. | |
| 10. | *Inglisia bivalvata* | |
| 11. | *Tachardina lacca* | |

**Diseases of Sandal wood:**

| Sl. No. | Disease | Control measure |
|---|---|---|
| 1. | Pre-emergence rot | Selection of seeds, which are free of fungi, seed-dressing with carboxin; good drainage |
| 2. | Damping off *Fusarium or Phytophthora or Rhizopus* spp. | |
| 3. | Fusarium wilt *Fusarium or Phytophthora* species | Drench the potting medium with copper fungicide (Bordeaux mixture) and nematicide with good drainage |

**B:C ratio:** 12.23

# BAGHNALA

*Litsea glutinosa*

*Litsea glutinosa* is an evergreen tree of medium size which grows to 6-10 m high, bark 2-2.5 cm thick. The bark has high commercial value due to its binding properties. It is principally used to bind fractured limbs, tablet formulations and in making incense sticks. Incense stick (Agarbatti) industry is using huge quantity of bark over a period of time. The wood is used for making agricultural tools, root fiber for making ropes and paper pulp, young leaves for fodder, seed oil for making candles, soaps and seed powder for treating skin boils. The bark also acts as a demulcent and mild astringent in diarrhea and dysentery. The invasive properties of *Litsea glutinosa* can also be used for restoration of damaged soils.

**Soil & climate:**

Average annual temperature requirement is 19-21$^0$C with 7-8 months> 20$^0$C. It grows best in hot and humid situation under subtropical climate with annual rainfall of 2500 mm.It prefers alluvial soil and also red soil with acidic reaction having pH value of5.0 to 7.0. Soil depth should be 0.5 to 1.0 m and well drained. It is suitable to high land, hilly and flat tropical conditions and grows in secondary forest or rehabilitated forest after slash- and-burn cultivation. This is a species requiring moderate moisture, average light.

**Altitude:** It is usually found below 1,000 m elevation in humid areas.

**Species/varieties:** Local elite type

**Method of propagation:** Seeds, Coppice

**Pretreatment of seeds:** The ripe fruits are collected in Oct-Nov and rinsed to remove the fruit coat.

**Nursery:**

The seeds are sown in moist sand. Seeds sprout after 10-15 days and are then planted in poly bag of size 20 x 10 cm. Partial shade is provided for the seedlings (40%). Germination is not very rapid; approximately 85% germination is achieved in 15- 45 days.

**Preparation of land:**

Land should be prepared after clearing of bushes and shrubs, if any. Areas having gentle slope can be leveled with minor land shaping and providing suitable type of bunds across the slope.

**Planting time:** Ideal time of planting is March to June with onset of pre monsoon shower.

**Spacing:** For mono crop, spacing is 3 m x 3 m.

**Pit size:**

The planting of the saplings is done in well prepared pits of size 45 cm x 45 cm x 45 cm in deep soil and 60 cm x 60 cm x 60 cm in shallow soil.

**Planting:**

Ideal planting time is May-June. One sapling/pit should be planted. Bagnala is suitable for planting in boundary, crop field, bunds, pond dyke and homestead garden.

**Manures and fertilizers:**

For each pit, about 5 kg of well decomposed FYM or compost is applied at the time of plantation. Well decomposed cow dung/FYM @ 10 to 15 kg/ tree should be applied from 2$^{nd}$ year onwards.

**Intercropping:**

It can be inter-cultivated with other species of broad leaved-light preference in order to salvage shade coverage in early period. Mixed planting of bean, groundnut and other legumes can be done in first two years. It is recommended for forest planting in mixed system/agroforestry system.

**Harvesting:**

Leaves, twigs, ripe berries and bark are harvested. Harvested at 7.5 years after planting i.e., felling 15 cm above ground level enabling to regenerate the coppice shoots and the total bark is removed. Alternatively, bark can be collected without felling the tree. The bark is peeled off in vertical stripe with 6 cm interspaced between each stripe. The peeled off area is renewed with fresh bark in one to two years. Then, the bark on the other areas can be peeled off without cutting the tree.

**Yield:**

The estimated yield of wood and bark of 7.5 years old plantation are as follows:

| | |
|---|---|
| Fresh weight of the wood (without bark) | =92 kg/tree |
| Fresh weight of the bark | =20 kg/tree |
| Dry weight of the bark (sun drying) | =2.8 kg/tree |
| Number of tree after mortality | =1000/ha |
| Dry weight of the bark | =2800 kg/ha |

**Plant protection:**

**a). Major pests:** Common mime butterfly (*Papilio clytia clytia*) is a defoliator of both nurseries as well in tree

**Control**: Spraying contact insecticides profenphos 50 EC@ 2 ml/*l*

**b). Disease**: Fusarium wilt (caused by *Fusarium solani*) in nurseries

**Control**: Application of azoxystrobin 23 SC @ 1 ml/liter of water

**Benefit: Cost ratio:** 5.22

# FOREST ZONE MODELS

***When the area of Baree is > 3500 $m^2$ (after utilizing 250 $m^2$ for vegetable, 100 $m^2$ for plastic house, 100 $m^2$ for net house, 1296 $m^2$ for Fruit Zone, 1296 $m^2$ for Forest Zone and about 400$m^2$ to 500 $m^2$ for other purposes/open space)***

The excess area over 3500 $m^2$ may be utilized for any one or more of the followings depending upon the available land area and choice of the farmers:

***Option-I:*** To incorporate more tree species or more numbers under a species for fuel wood or species for other minor purposes (as mentioned in about3500 $m^2$) at 4m x 4m spacing mostly for household use; however, after fulfilling the household needs excess produces may be sold. Selection of the species and/or their number should be as per the choice of the farmers.

(Table for fuel wood/minor purposes)

***Option-II:*** Raising single or mixture of several species of bamboo for both household use and market is one of the most prominent options. Spacing of some of the important species for this purpose is mentioned below:

| Species | Spacing | Clumps/bigha (nos.) |
|---|---|---|
| *Bambusa balcooa* | 6-8m x 6-8m | 20-37 |
| *Bambusa cacharensis* | 5-7m x 5-7m | 27-53 |
| *Bambusa nutans* | 5-7m x 5-7m | 27-53 |
| *Bambusa tulda* | 5-7m x 5-7m | 27-53 |
| *Dendrocalamus giganteus* | 10-12m x 10-12m | 9-13 |
| *Dendrocalamus hamiltonii* | 7-10m x 7-10m | 13-27 |

The variation in spacing depends upon the feasibility of the location and intercrops. *Ananas comosus, Musa* sp*, Zingiber officinale, Curcuma longa,* annual vegetables, field crops, medicinal plants, fodder, green manuring crops, etc. can be raised successfully in interspaces for initial 2-4 years. Intercrops should preferably be shade tolerant.

When bamboo is grown for the production of shoots mostly for market, the spacing will have to be increased by 1-3 mtr of the spacing mentioned above.

***Option-III:*** Plant species needed for silkworm culture is one of the viable options in many of the feasible areas. Besides feasibility of the location, preference of the farm family, imparting knowhow/techniques for culturing silkworm by the farm family, availability of area etc. are some other factors needed to be considered. Spacing of few plant species for sericultural purposes is as follows:

| Kind of silk | Plant species | Assamese name | Spacing | Plant ( no./bigha) |
|---|---|---|---|---|
| Muga | *Machilus bombycina* | Chom | 7m x 7m | 27 |
| | *Litsaea poliantha* | Xoalu | 6m x 6m | 37 |
| Eri | *Ricinus communis* | Era | 2m x 2m | 333 |
| | *Heteropanax fragrans* | Kecheru | 6m x 6m | 37 |
| Mulbery silk (Paat) | *Morus alba* | Nuni | 3m x 3m | 148 |

***Option-IV:*** Raising tree species for fuel wood only, both for household use and market, is also one of the option where maximum production is needed from short duration plants; the size of the plant does not matter to be utilized as fuel wood. Fast growing tree species as mentioned in 'about 3000 $m^2$ area' should be preferred for this purpose. The spacing should be 1-2 m x 1-2m depending upon the rate of growth of the species; both monoculture and mixed culture may be adopted.

***Option-V****:* Growing plant species for pulp production needed for industrial purposes only may be one of the viable options depending upon the availability of the market and profitability of the produces. For this purpose, planting should be done at the spacing of 2-3m x 2-3m which are to be cultivated as monoculture. Several species as mentioned in *Option-VI* below may be raised depending upon the market price.

***Option-VI:*** Raising tree species mostly for saw timber/veneer logs is one of the most attractive market-oriented options. Spacing required for this purpose varies from species to species; few of these are mentioned below

| Species | | Spacing | Plant materials needed (no./bigha) |
|---|---|---|---|
| Scientific name | Assamese name | | |
| *Acacia catechu* | Khair | 3m x 1m | 444 |
| | | 2.5m x 2.5m | 213 |
| *Adina cordifolia* | Kelikadam | 3m x 1m | 444 |
| | | 2.5m x 2.5m | 213 |
| *Albizia lbbek* | Sirish | 3m x 1m | 444 |
| | | 2.5m x 2.5m | 213 |
| *Artocarpus chama* | Cham | 8m x 6m | 27 |
| | | 8m x 8m | 20 |
| | | 10m x 10m | 13 |
| *Artocarpus heterophyllus* | Kathal | 10m x 10m | 13 |
| | | 12m x 10m | 11 |
| | | 12m x 12m | 9 |

***Option-VII:*** Raising medicinal plants as monoculture with bulk production of output for mostly for market is one of the promising options. Spacing needed for this purpose is as follows

| **Species** | | **Spacing** | **Plant (no./bigha)** |
|---|---|---|---|
| Scientific name | Assamese name | | |
| *Aloe barbadensis* | Ghritakumari | 60cm x 45cm | 4937 |
| *Andragraphis paniculata* | Kalmegh,Kalpatia | 45cm x 30cm | 9521 |
| *Azadirachta indica* | Mahaneem | 5m x 5m | 53 |
| *Bacopa monnieri* | Brahmi | 45cm x 30cm | 9521 |
| *Chlorophytumborivillian* | Safed musli | 30cm x 22cm | 20196 |
| *Costus speciosus* | Jamlakhuti | 60cm x 60cm | 3702 |
| *Daturastramonium* | Bogadhotura | 1.5m x 1.0m | 888 |
| *Embica officinalis* | Amolokhi | 6m x 6m | 37 |
| *Eupatorium cannabinum* | Tongloti | 75cm x 60cm | 2962 |
| *Garcinia xanthochymus* | Tepor | 4m x 4m | 83 |
| *Hydrocotylerotundifolia* | Xarumanimuni | 30cm x 30cm | 14811 |
| *Lawsonia alba* | Jetuka | 3m x 3m | 148 |

***Option-VIII:*** Growing annual and perennial fodder/fodder tree to meet up the requirements for subsidiary components like dairy, goatery, etc., when carried out in relatively larger scale for market, may be a prominent option. The spacing requirement and production expected from such species are mentioned below:

| **Species** | | **Spacing** | **Expected Production (t/bigha)** |
|---|---|---|---|
| Scientific name | Assamese name | | |
| Annual | | | |
| *Pennisetum pedicellatum* | Dinanath | 30cm x 10cm | 6.5-8.0 |
| *Vigna unquiculata* | Lechera | 35cm x 10cm | 4.0-6.0 |
| *Vigna umbellata* | Rice bean | 35cm x 10cm | 4.0-6.0 |
| *Zea mays* | Gomdhan/Makoi | 30cm x 10cm | 4.0-4.5 |
| *Euchlaena maxicana* | Teosinte | 40cm x 15cm | 3.5-4.5 |
| *Avena sativa* | Oats | 25-30cm x 5-7cm | 3.5-4.0 |
| *Medicago sativa* | Lucerne | 5cm x 5cm | 2.5-3.0 |
| Perennial | | | |
| *Pennisetum purpureum* | Hybrid napier | 50cm x 50cm | 10.5-13.5 |
| *Setaria sphacelata* | Setaria | 50cm x 50cm | 10.5-13.5 |
| *Leucaena leucocephala* | Subabul | 100cm x 30cm | 2.2 -2.5 (Green fodder) |

***Option-IX:*** One of the most important market-oriented options is growing *Camellia chinensis*; several tree species may be raised as shade trees along with *Camellia chinensis* as mentioned below:

***Option-X:*** Growing *Aquilaria malaccensis* as the market-oriented species in feasible localities

of the state at the spacing of 2.5-3.5 m x 2.5-3.5 m. Several crops like *Areca catechu, Musa* sp. *Cocos nucifera, etc.* may be grown, as currently practiced, along with *Aquilaria malaccensis.* However, the most feasible intercrops, at least for initial 3-4 years, are *Zingiber officinale, Curcuma longa, Ananas comosus, Pagostemon cablin,* etc.

***Option-XI:*** Growing high valued vegetables for market as per choice of the farm families and profitability of the commodity.

| **Shade tree** | **Spacing** | ***Camellia chinensis* (no./bigha)** | **Shade tree (no./bigha)** |
|---|---|---|---|
| *Albizia* sp. | 10m x 10m | 2000-2500 | 13 |
| *Areca catechu* | 3m x 3m | 1926 | 148 |
| Khasi mandarin | 5.25m x 5.25m | 1700 | 48 |

***Option-XII:*** Growing flowers (single species or multi-species) for market like Marigold, Gerbera, Anthurium, Gladiolus, Chrysanthemum, Orchids, etc. along with minor species like Joba, Aparajita, Tilingajoba, Kathana, etc. as per market demand, profitability and choice of the farm family. Spacing of some of the species is as follows:

| **Species** | | **Spacing** | **Planting material needed (no./bigha)** |
|---|---|---|---|
| **Scientific name** | **Assamese name** | | |
| *Gerbera jamesonii* | Gerbera | 40-50cm x 10-15cm | 17770-29620 |
| *Tagetes* sp. | Narji/Gendha | 30cm x 25cm (Dwarf) | 17770 |
| | | 35cm x 35cm (Medium) | 10880 |
| | | 60-100cm x 50-60cm (Tall) | 2220-4440 |
| *Gladiolus communis* | Gladiolus | 45-50cm x 10-15cm | 17770-29620 |
| *Chrysamthemum* sp. | Indramalati | 40cm x 35cm | 9520 |
| *Anthurium andraeanum* | Anthurium | 35cm x 35cm | 10880 |
| *Hibiscus rosa-sinensis* | Joba | 1.5-2.0m x 1.5-2.0m | 330-590 |
| *Hibiscus rosa-sinensis* | Tilingajoba | 1.5-2.0m x 1.5-2.0m | 330-590 |
| *Clitoria ternatea* | Aparjita | 1.0m x 1.0m | 1330 |
| *Tabernaemontana* sp. | Kathana/Kathanda | 1.5-2.0m x 1.5-2.0m | 330-590 |

***Option-XIII:*** Raising nursery plants for market as per demand, profitability and suitability of area available for the purpose.

***Option-XIV:*** Growing fruit crops commercially (as discussed in Fruit Zone) depending upon the market demand, profitability of the commodity, choice of the farm family and suitable area available for the purpose.

***Option-XV:*** Raising market-oriented nut crop based multistoried cropping system (as discussed in Fruit Zone) depending upon the availability of suitable land and choice of the farm

family.

***Option-XVI:*** Utilizing for subsidiary activities in larger scale especially dairy, fishery, piggery, chicken rearing (backyard and broiler chicken), duckery, goat rearing, pigeon rearing, nursery, etc. either alone or in combined manner of selected components depending upon the area availability, choice of the farm family, market and profitability.

***Option-XVII:*** Utilizing the excess area (over 3000 $m^2$) for serving more than one purpose as mentioned in 'Option-I to Option-XVI' in relatively smaller blocks depending upon the land area available, choice of the farm family, suitability of land and profitability of the components.

# MEDICINAL PLANTS

## ASHWAGANDHA

*Withiania somnifera*

Ashwagandha is an alternative plant for medicinal uses. Its roots, leaves and seeds have some medicinal values. The plants have wide adaptability and grow up to an altitude of 1200 m from M.S.L.

**Land situation**:

Well-drained upland having mild acidic to mild alkaline soil is the most suited for cultivation. It thrives well in loamy or clay loam soil. A friable loam rich in humus is ideal.

**Field preparation**:

The preparation of land should start with the onset of monsoon. The land should be ploughed 3-4 times followed by several times harrowing and laddering in order to bring the soil to better tilth. At the time of final land preparation, sufficient amount of cow dung or compost or FYM may apply in the soil.

**Manures and Fertilizers**:

Depending upon the availability, well decomposed FYM or compost up to 20 t/ha may be applied either by broadcast over the beds or in the soil prior to sowing. No inorganic fertilizers are generally used for this crop.

**Sowing method**: Seeds are either broadcasted or sown in lines 50-60 cm apart.

**Sowing time**:

June and July. Generally, germination starts with the beginning of summer to mid monsoon season.

**Plant population**:

The plant stand should be maintained at 30-40 plants per sq. m i.e. 3 to 4 lakhs per ha. Transplanting of 25 to 35 days old seedlings may be done to maintain the optimum plant stand. If transplanting of seedlings in the well-prepared field is to be done, spacing between the lines and plant should be 50 to 60 cm.

**Weeding, thinning and interculture operation**:

Weeding is done at the early stage of the crop depending on the weed infestation. To maintain the optimum population thinning should be done 25-35 days after sowing. A light hoeing and earthing-up may be done during the time of weeding after thinning operation.

**Harvesting and post harvesting operation**:

At 150 to 180 days after sowing (in the month of December when sown in June-July),

the crop is harvested. At maturity, the leaves of the crop turn yellow and the fruits turn red. Leaf shading may also occur. Crops are uprooted and the entire roots are to be separated by cutting at base or 1 to 2 cm above the ground. Fruits are also collected separately.

Ripe fruits are sun dried for several days and after drying seeds are preserved in polythene bags. Roots are beaten to clean from the soil particles and hairy roots. Cleaned roots are cut into 7-10 cm long pieces, sun dried and preserved in gunny bags.

**Medicinal uses**:

It is medicinal in sexual and general weakness and rheumatism. It is also used as diuretic. Root powder is used in ulcers and inflammations as well as antibiotic, more particularly antibacterial.

**Yield:**

| | |
|---|---|
| Dry roots | :350 to 500 kg/ha |
| Seeds | :50 to 75 kg/ha |

**Economics:**

| ***Expenditure*** | **(Rs/ha)** |
|---|---|
| Land preparation | :5000.00 |
| Manure & Fertilizer | :9000.00 |
| Seed @Rs. 60.00 | :40.00 |
| Chemicals | :500.00 |
| Total operational cost | :10000.00 |
| **Total expenditure** | **:24540.00** |

*Income*:

| | |
|---|---|
| From dry root (400 kg x Rs. 120/-) | :48000.00 |
| From seed (60 kg x Rs.60/-) | :3600 kg |
| Gross return | :51600.00 |
| **Net return** | **:27060.00** |

**Benefit: Cost ratio:** 1.1 to 1.6

# ALOE VERA

*Aloe barbadensis*

**Planting time:**

Suckers are planted in July-August. Under irrigated condition planting can be done all round the year except in winter (Nov-Feb).

**Land preparation:**

One to two ploughing followed by leveling should be done. Field should be divided in to suitable size plots (10-15 m x 3 m). About 3-4 month-old suckers having 4-5 leaves and about 20-25 cm in length should be selected for planting

**Spacing:** Suckers are planted 15 cm deep at spacing 60 cm x 60 cm

**Planting and manuring:**

10-15 t FYM/ha should be applied at the time of soil preparation, Application of 10 g wood ash in pits at the time of planting helps in establishment of plants, Fertilizer dose of 85-45-20 kg N-$P_2O_5$-$K_2O$ /ha is applied

**Irrigation:**

First irrigation is required just after planting, followed by 2-3 irrigations till establishment. After each picking of leaves, light irrigation may be given

**Intercultural operation:**

2-3 hand hoeing, followed by light hoeing per year promote growth and suckering of Aloe. In the first year, intercrops such as cluster bean, ground nut, sesamum, isabgol, coriander, cumin etc. can be easily grown by giving a light irrigation

**Harvesting and Yield:**

3-4 pickings per year can be taken. 15-20 t/ha fresh leaf is obtained from 2$^{nd}$ year onwards with an average of five years of economical production. Well irrigated crop yields 30-35 t/ha fresh leaf per year.

**Benefit: Cost ratio**: 4.5

# SAFED MUSLI

*Chlorophytum borivilianum*

It is an annual herb with sub-erect slightly yellowish lanceolate leaves and plant height is about 1.5 ft (45 cm). The root system is tuberous, which is the economic part of the plants. The tuber is of 0.9cmx8.0cm in size and number varies from 5-30 per plant and white in colour.

**Soil:**

The crop needs high land having light to medium textured soil i.e., sandy loam to loam. Water-logged soils are not suitable. During the rainy days drainage system should be maintained to drain out the excess rainwater from the field. The crop requires warm and humid climate. For better growth soil pH should be around neutral.

**Propagation and planting material:**

The crop can be propagated by seeds and root- tubers with some portion of crown attached to each tuber. Root-tuber takes lesser crop duration in comparison to crop grown from the seeds. In general, previous year root- tubers are used for cultivation. The sprouted root-tubers with crowns are the best to use as planting material. Root tubers with crown disc having the weight of 15-20g may be used for commercial scale production.

**Land preparation:**

It requires systematic land preparation. Deep ploughing followed by several times harrowing should be done to attain a good tilth. Sufficient amount of well decomposed FYM/compost should also be applied at the time of final land preparation.

After land preparation, raised beds of 90 cm to 200 cm width may be prepared and these may be done easily by making 15 cm deep furrows between the beds to drain out the excess rainwater.

**Planting time**: Last week of May to June.

**Seed treatment**:

Planting materials may be treated with chlorothalonil 75WP or carboxin @ 2 to 2.5 gm/kg of seed or root-tuber.

**Seed rate**: 1200 kg/ ha or 165 kg/bigha

**Spacing**: 20-24 cm between plants and 30 cm between rows

**Manures and fertilizers**:

10-t FYM/ha or sufficient quantity of well-decomposed (FYM or) cow dung should be applied at the time of final land preparation. Nitrogen fertilizer is to be applied in the form of urea @ 100 kg/ha in two equal splits at 15 and 30 days after planting. As a basal dose of DAP @ 120 kg/ha and MOP @ 100 kg/ha are to be broadcasted before final land preparation.

**Irrigation**:

Crop is grown generally in rainfed condition. Sufficient soil moisture in the bed should be maintained throughout the growing period and till the harvesting of crops. Sprinkler irrigation system may be employed for better growth and results.

**Weeding**:

Two to three times manual weeding is necessary to maximize tuber yield.

**Deflowering**:

All the flowers should be removed from plants for healthy growth of the tubers, more particularly during the early growth phases.

**Harvesting**:

The crop is ready for harvest in eight months after planting. Root tubers turn into brown or brownish red from white. Harvesting of tubers may be delayed up to April, if tubers are used for planting materials. The small tubers with crown are stored for planting in the next season, while the biggest size tubers are processed for marketing.

**Yield**: The average yield of fresh Musli is 5-6 t/ ha or dry Musli 1.0 to 1.2 t/ ha.

**Post harvest management**:

- **Drying**: After uprooting the tubers, it should be spread in shade for about 4 to 7days and then peeled to remove the skin.
- **Processing**:
- Large tubers are washed and outer skin is peeled off with the help of knife and then dried for 2 to 3 days. The dried tubers (18 to 20% of fresh weight) are stored in airtight poly bags.
- **Grading**: The dried tubers/fingers are graded on the basis of colour and size.

**Medicinal uses**:

It is a principal ingredient in Ayurveda, Unani and Allopathic medicine, as a vitalize and health tonic and as a curative for pre-natal and post-natal problems. It acts as a natural aphrodisiac, alternative to Viagra, restorative for immunity improvement and as a remedy for diabetes and arthritis, used against rheumatism and joint pains. It is also useful for brain development in children and to cure physical weakness.

**Chemical constituents**:

| | |
|---|---|
| Alkaloids | 25% |
| Protein | 8.9% |
| Carbohydrate | 42% |
| Steroid saponins | 0.1-1.7% |
| Fiber | 34% |

Glycosides, vitamins and polysaccharides are also present. The alkaloids and saponins are responsible for medicinal properties of the plant.

# SARPAGANDHA

*Rouvolfia serpentina*

Sarpagandha is cultivated for its alkaloids. Ajmaline, Deserpidine, Rescinnamine, Reserpine, Serpentine are some of the important alkaloids from this plant. Nearly 90% of the total alkaloids are found in its underground portion of stem and roots. And, therefore, "roots" (underground stem, rhizome and root) are the important organs of the plant which are harvested for commercial purposes.

**Plant description**:

- **Habit**: Erect herb, 50-70 cm high Root: Tap root system, deep-rooted Stem: Cylindrical
- **Leaves**: Ovate elliptic, glabrous, 8-20 cm long, in whorls of 3-4.
- **Flowers**: Tubular, 1-5 cm long, 5-merous, white or pink, in cymose inflorescence; peduncle deep red.
- **Fruits**: Small, round, 1-seeded, sometimes two fruits united, turning dark purple to black when ripe.

**Variety**: RS-1 (Released from JNKVV, Indore) or local.

**Soil**: Sandy loam, clayey loam or clay soil, with pH 4 to 7.5.

**Climate**: Humid and hot to moderately hot climate

**Propagation**: Sarpagandha can be propagated by seeds, branches and root cuttings.

**a. Seed Propagation:**

- **Nursery beds:** 1m x 8m size x 12 beds (for 1 hectare of main field)
- **Seed requirement:** 500 g per bed (6 kg for 12 beds) (seed viability: 5 to 30% in one year old seeds)
- **Sowing time:** April-May.
- **Seed treatment:** Before sowing, seeds are treated with Carboxin or Nabam @ 2 g/kg
- **Irrigation:** After sowing, light irrigation should be given to keep the beds moist.
- **Seedling emergence:** 5 to 8 weeks after sowing. At 4-6 leaf stage seedlings are transplanted in the main field.

**b. Stem cutting/root cutting:**

- Mature stem cutting (12-15 cm long) and root / rhizome cutting (5-8 cm long) are planted in the nursery beds.
- Saplings for transplantation: 3 months after nursery planting.

(This method records 40 to 80% more success in comparison to propagation through seeds.)

- 100-120 kg rhizome/stem/root will be required to develop saplings for the one hectare main field (13 to 16 kg per bigha).

**Land preparation**:

Land should be deeply ploughed and beds of 1.0-1.5 m breadth, 15 cm high and convenient length may be prepared ensuring proper drainage.

**Transplanting:** Transplanting of seedlings/saplings is done at 4-6 leaf stage

**Planting time**: July-August

**Spacing**:

Seedlings should be transplanted with a spacing of 45 cm between rows and 30 cm between plants.

**Manures & fertilizers**:

FYM @ 2.5 to 3 t/ha (3 to 4 q/bigha) should be applied at the time of final land preparation.

Alternatively, N-$P_2O_5$-$K_2O$ @ 40-60-40 kg /ha (12 kg urea, 50 kg SSP and 9 kg MOP per bigha) can be applied with about 1 tonne of FYM. One third of N along with full doses of P and K should be applied as basal dose. Rest of the N should be top-dressed at 3 months interval.

**Interculture**:

At least two weeding are required before flowering. A light hoeing between the rows followed by application of FYM is required at 30-45 DAP.

**Harvesting:**

- Harvest time: From 16 to 24 months after planting.
- Harvested roots/rhizomes/stems (0.5 to 2.0 cm in diameter) should be washed in water and sun dried.
- At nearly 8% moisture content, these are stored in airtight poly bags.

Fruits get matured in July to October. Black fruits are collected during July to October, crushed with sand in hard surface giving gentle pressure, sun dried seeds are stored. Seeds remain viable for about 8 months.

**Yield:** 15 to 25 q dry root/rhizome/stem per hectare.

**Benefit: Cost** (at the end of 2 years)**:** 3.3

# PATCHOULI OR PANCHPUT

*Pagostemon cablin*

Patchouli is an introduced aromatic crop and adopted very well in Assam. The essential oil extracted from leaves of the plant has various uses in perfumery and drug industries. The best quality of patchouli oil contains 30-33% Patchouli Alcohol, 2-3% Caryophyllene, 2-4% â-selinene, 2.0-2.5% Pagostol and 0.8 to 1.0% other Alcohol. Because of having high demand of patchouli oil, in the national and international markets, it has an assured market.

**Plant description**:

- **Habit**: Erect or semi-erect herb, 1 to 2 m high Root: Adventitious, shallow rooted
- **Stem**: Quadrangular, semi woody below
- **Leaves**: Opposite broadly ovate, acute, 5 to 15 cm long, with serrated margins and long petiole
- **Flower**: Small, pink, in clusters arranged in racemes Fruit: Capsular

**Variety**: Indonesian variety is suitable for Assam.

**Soil**:

Clay-loam to sandy-loam soil with good amount of humus and devoid of water stagnation. The ideal soil pH is 5.5 to 6.5.

**Climate**:

Moderately warm and humid climate. The basic requirement is partial shade (30 to 40%) and frequent irrigation.

**Propagation**: Branch-tips with 3-4 nodes are good propagating organ.

**Nursery**:

- **Bed size:** 1m breadth and convenient length (with sand rich medium +sufficient amount of FYM or compost). Fresh cuttings are to be planted at 3-5 cm gap. Poly bags filled with well-prepared sand medium with single cutting can also be used for nursery raising. Light irrigation should be given to keep the beds moist.
- **Land preparation**: Land should be well ploughed and beds of 130 to 150 cm breadth and length of convenient size are to be prepared with 50 cm gap between the beds.

**Manure and Fertilizer**:

Sufficient amount of FYM/compost/well rotten cowdung/poultry litter (10 to 15 t/ha or 1.5 to 2 t/bigha) are to be applied at the time of final land preparation.

- Alternatively, Chemical fertilizers can be applied @ 100 : 50 : 60 kg/ha N, $P_2O_5$and $K_2O$ (30 kg urea, 42 kg SSP and 13 kg MOP per bigha). SSP and MOP should be applied as basal dose, at least four days before planting and urea should be applied in four equal splits.

**Plantation**:

- Planting time: March-April and October- November.
- Planting material: Rooted cuttings
- Spacing: 45 cm x 45 cm.

**Intercropping**:

Tall shrubby crops like *Arhar*, *Jatropha*, Papaya etc. can be cultivated at a spacing of 1-2 m x 1-2 m. Patchouli can also be cultivated as intercrop in arecanut or ornate-tree plantation or homestead woodlands.

**Interculture**:

Weeding at early growth stage and one light hoeing between the lines at 25-35 days after planting is very essential.

**Plant protection:**

- **Mite:** Ethion @ one teaspoon mixed with two liter of water to be sprayed.
- **Nematode:** Application of neem- cake or mustard-oil cake can control nematodes.
- **Root rot:** Soil should be sprayed near the stem base with azoxystrobin 23 SC @ 2 g/liter of water. The disease may also occur if there is water stagnation.

  **In case of severe infections by pests and diseases (if any):** The plants should be harvested for leaves immediately and the stems should be uprooted. Uprooted stems should be dried and burnt, and soil should be treated with appropriate medicine. Crop rotation is also a good solution as non-chemical management of these problems.

**Crop cycles:** Following crop cycle can be maintained:

- March-April to July-September.
- October-November to March-April.
- One to two year crop stand (depending on crop health & situation).

**Harvesting**: Crop is ready for harvest 4-5 months after planting

- **In seasonal crop cycle:** Plants are cut at base.
- **In annual or biennial crop cycle:** Less than 50% leaves with young branches of each plant are cut in intermittent harvestings. The crop will be ready for second harvest within 30-45 days after the 1st harvest during summer season. Urea or vermicompost or FYM or well rotten cowdung should be top dressed after harvest.

**Drying**:

Harvested leaves are dried in shade for 1 to 2 weeks. Mature and thick stalks should be removed. Dried leaves are then packed in cotton or jute bags and hanged from the roof of the store house. Ageing of leaves in storage improves oil quality. Market fluctuation, if any, can also be avoided by storing the leaves. Bamboo hut can be constructed with few bamboo "*chang*" on walls. Leaves should be kept on the mats in thin layers for drying. Storage bags can be hanged from the roof of the house.

**Yield:** 5 to 7 q dry leaves per bigha (i.e., 37 to 52 q dry leaves / ha)

**Benefit: Cost ratio**: 2.00 (First year); 3.00 (Second year)

# APICULTURE

Honeybees are essential for pollination of many cross-pollinated crops, and also for production of honey which generates income to the farmers. There are four major honeybee species *viz*., Rock bee (*Apis dorsata*), little bee (*Apis florea*), Indian bee (*Apis cerena*) and Western bee (*Apis mellifera*). Out of them, the former two are wild and the latter two are domesticated species. Indian bee is a brownish black, locally available domesticated Asiatic species. The beekeeping practice of North-East India is mainly based on this species. This is indigenous to India with average honey yield of 12 kg per hive per annum and the foraging range is 0.8-1.0 km. Western bee is an exotic golden yellow species most widely and commercially reared in the world. This is larger in size than Indian bee having average honey yield of 35-40 kg per annum with a foraging range of 2 km. The species is successfully introduced in Northern India and effort is being made to introduce it in Assam including Northeast India.

**Apiary site:**

An apiary is a place where honeybee colonies are reared. Site with proper sunlight, air circulation and shade should be selected for the apiary. Good apiary location is one with abundance of nectar and pollen producing plants. Commercial beekeepers generally migrate their colonies from one place to another for flora and produce more than one api crop of several types. Some of the important bee foraging crop-plants are rapeseed- mustard, niger, buckwheat, sunflower, safflower, sesamum, bottle gourd, pointed gourd, pumpkin, ridge gourd, sponge gourd, maize, soyabean, *jamun, litchi*, mango, drumstick, guava, citrus, coconut, areca nut, date palm, pummelo, ironwood, tamarind, mayflower, pomegranate etc.

**Beehive and other equipment:**

Honeybees are reared in the modern beehive based on the principle of bee space. Beehive is composed of brood chamber and honey chamber. The brood chamber is meant for rearing progeny and the super or honey chamber is used for secreting honey. The following beekeeping equipment are required for honeybee rearing.

**i)** Beehive**:**

- **a)** ISI A type 8 frame for Indian bee, ISI B type 10 frame for Indian bee.
- **b)** Langstroth 10 frame for Western bee.

**ii)** Smoker to produce smoke for effective handling of the colony

**iii)** Bee veil to prevent bee stinging during handling of the colony

**iv)** Hand gloves for effective handling of the colony

**v)** Swarm-catcher for collection of colonies from natural source

**vi)** Honey extractor for extraction of honey

**vii)** Uncapping knife

**Rearing Season:**

Seeds or colonies are normally available during spring i.e. February to March as this is a peak-breeding season for the honeybees. Colonies can be collected from the natural sources or may be procured from the beekeepers. Rearing can be started with three or four frame worker bees having one-year mated queen. During winter (December to January) and in spring (February to March) are the best seasons to start beekeeping.

**Seasonal Management:**

There are generally three seasons for bee management.

**Spring Management:**

Beekeepers calendar starts with the activity of honeybee colonies after prolonged rain and winter cold. As this is a major flowering season, worker bees become busy for collecting nectar and pollen from flowers and thereby help in building the colonies. This is known as honey-flow season and in this season mostly extraction operations are done. However, there is a problem with swarming, which is acute in Indian species but less in western species. Swarm prevention can be done by frequent inspection of the colony, removing the queen cell, dividing the strong colony and helping the week one.

**Summer and Rainy season management:**

In the summer management, honeybee colonies should be kept under shade just to protect from scorching sun. As there is continuous rainfall in Assam during the rainy season, honeybee colony should be provided with artificial diet, composed of carbohydrate, protein and water. Effective artificial diet comprises of sugar (as carbohydrate); black gram or green gram or soybean powder (as protein source) and water @ 1 kg of sugar and 100 gm protein powder mixed in 1 liter of water. It should be administered as per requirement of the colony.

**Winter management:**

The honeybee colonies should be taken out from the shade and exposed to the sunlight.

**Migration of the colony:**

During winter, honeybee colonies should be migrated to the oilseed crop fields (mainly rapeseed-mustard crop) and then to spring blooms of fruit, forage crops and forest plantations. In this practice both the beekeepers and farmers will be mutually benefited in terms of honey and crop production. Migration is essential for getting substantial yields of crops as well as honey.

**Disease and Enemy Management**

Several diseases, *viz*., and fungal, bacterial, viral and protozoan diseases infect honeybees. Out of these, viral and protozoan diseases are the most serious ones in Assam.

**a). Sac-brood disease:**

This is a viral disease caused by Thai-sac strain. The symptoms of this disease are.

- The larvae become pale; then turn brownish-black and gradually dry up.
- The punctured capping with dead pupa within the cell.
- The infection is usually in worker, seldom in drone and spread by drifting nurse bees.

**Control:**

**Dequeening and Requeening:** Create broodlessness for some time by dequeening and requeening through production of new queen cell. Infected colony should be treated with antibiotics like teramycin 250 mg @ 1 tablet per 4 liter of sugar syrup.

**b). Nosema disease:**

Nosema disease is found in adult Western bee colony. The infected bees show the symptom of crawling, disjointed wings and the mid-intestine becomes swollen with pale colour.

The treatment with hydroxy quinoline mixed with sugar @ 250 mg/4 liter of sugar syrup will give effective control. Against fungal disease, proper aeration and exposure to the sunlight prove to be effective.

**Natural Enemy:** Almost half a dozen natural enemies such as lizard, wasp, wax moth, cockroach, birds, ants and mites infest honeybee colonies. Out of them, wax moth and predatory wasp are the most serious enemies.

**c). Wax moth, *Galleria mellonella:***

Wax moth lays eggs on the stored combs or on the spare combs in the colony. Larvae develop by feeding on wax and pollen in comb cells. Wax moths are most active in summer and rainy seasons. To manage this pest; store combs by removing extra combs from the colony. Fumigate stored combs in air-tight space (in hive chambers, sealed between with mud or dung) and treated with acetic acid or formalin. But fumigation with sulphur smouldering is most effective. Removal and destruction of the infected portion of the comb is also recommended. The biocontrol practice of treatment with *Bt* formulation var. *kurstaki* @ 0.5 gm/100 ml. of water per hive gives effective control of the pest.

**d). Predatory wasp:**

Among the wasps, the burrowing (*Vespa magnifica.*) and aerial wasps (*Vespa cinta*) are two common species in Assam, which predate on honeybees. To protect the colonies from the wasp, practices such as destruction of wasp nests in the vicinity of the apiary and artificial net covering (with nylon net of 1 cm mesh size) over the beehive colonies are found to be effective.

For controlling bee mites, honeybee colonies should be exposed to the sunlight and in acute cases chlorbenzilate fumigation gives effective control. Sulphur dusting @ 200 mg/hive on top bars of frames is also effective.

**Honeybees in crop production**

Honeybees are essential for pollination of all the cross-pollinated crops. It has been clearly demonstrated through experimentation at AICRP on Honeybee schemeAAU, Jorhat that honeybee colonies enhance crop yield to the tune of 1.5 to 2 times as shown below:

| Crop | Colony requirement | Yield (q/ha) | Percent yield increase over open pollination |
|---|---|---|---|
| Mustard | 5 | 12.2 | 157.65 |
| Niger | 6 | 6.1 | 146.98 |
| Buckwheat | 5-6 | 14.2 | 152.68 |
| Litchi | 5-6 | 66.7 | 142.75 |
| Assam lemon | 4 | - | - |

Hence honeybee colonies are considered as essential input for increasing productivity of cross-pollinated crops. Migration of honeybee colonies is necessary for both crop and honey yield.

**Pesticidal Poisoning to Honeybees:**

In order to protect the honeybees from pesticide poisoning eco-friendly pesticides, which are less toxic to honeybees should be recommended. Moreover, the application of pesticide on flowering crops should be done in the afternoon when the bee activity stops in the field. Some of the bee friendly pesticides with inorganic and organic compositions are oxydemeton methyl and botanicals. Biopesticides such as *Bt.* formulation, NPV, etc. which are having less or no residual toxicity should be incorporated in the Integrated Pest Management Packages.

**Recommendation of Bt. Formulation against Wax moth:**

Wax moth, *Galleria mellonella* is one of the most serious pests of honeybee causing severe damage to the colonies. Various remedial measures such as cultural, chemical were adopted without having any full proof effect. In order to have effective management of this pest, biocontrol experiments with *Bt* Formulation, var. *kurstaki* @ 0.5 per cent controlled the wax moth effectively. Hence, *Bt* var. kurstaki 0.5 g/hive/liter of water has been recommendedagainst wax moth.

# CONSTRUCTION OF LOW COST VERMICOMPOST UNIT

## Design and specification of Low-cost vermicoposting unit

**1. Dimension**: 2.5 m (L) x 0.91 m(B) x 0. 76m (D)

**2. Materials to be used**:

a. Bamboo structure for the shed over the tank and construction of vermicomposting unit

b. Roof: UV stable silpulin/Thatch

c. Sides: Locally available material e.g. Dried banana leaves/ agroshed Net



d. Pit: A pit connecting the vermicomposting unit . A half-inch diameter PVC pipe may be used.

e. Inside the pit: Bamboo made vermicomposting tank and Wash collection tank should be laid with Black polythene sheet(Best Quality)

f. The bottom should have a mild slope towards the Wash collection tank.

g. A layer of fine pebble and layer of sand should be placed over the plastic sheet in the vermicomposting tank.

h. The vermicomposting tank should be filled with Semi-decomposed (pre-decomposed ) and subsequently, earthworm of proven species is to be released. The dried cow dung should be free of local earthworm species.

i. A side drain may be laid out around the vermicomposting unit to prevent ant problem.

| | |
|---|---|
| **Size of each tank** | : 0.91m (B) x 0.91m (D) x 2.5m (L) |
| **Annual Production capacity** | : 900 Kg/ one cycle x 3 cycle = 2700 Kg |
| **Duration of each cycle** | : 3 months during summer and 4 months during winter |
| **Duration of the structure** | : 3 years |

# APPENDIX I

## Pesticides banned for manufacture, import and use in India

**Source**: Central Insecticides Board & Registration Committee, Directorate of Plant Protection, Quarantine & Storage, Ministry of Agriculture, Faridabad

(Web site: http://www.cibrc.nic.in/list_pest_bann.htm)

**A. Insecticides/ Acaricides/ Rodenticides**

1. Aldicarb
2. Aldrin
3. Benzene Hexachloride
4. Calcium Cyanide
5. Carbaryl
6. Chlorbenzilate
7. Chlordane
8. Chlorofenvinphos
9. Copper Aceto arsenite
10. Diazinon
11. Dieldrin
12. Endosulfron (vide ad-Interim order of the Supreme Court of India in the Writ Petition (Civil) No. 213 of 2011 dated 13th May, 2011 and finally disposed of dated 10th January, 2017)
13. Endrin
14. Ethyl Parathion
15. Ethylene Dibromide
16. Fenthion
17. Heptachlor
18. Lindane (Gamma-HCH)
19. Maleic Hydrazide
20. Menazon
21. Methyl Parathion
22. Metoxuron
23. Pentachlorophenol
24. Phenyl Mercury Acetate
25. Sodium Cyanide ( banned for Insecticidal purpose only vide S.O 3951(E) dated 8th August, 2018)
26. Tetradifon

27. Thiometon
28. Toxaphene(Camphechlor)
29. Trichloro acetic acid (TCA)

**B. Fungicides**

1. Ethyl Mercury Chloride
2. Pentachloro Nitrobenzene (PCNB)
3. Fenarimol
4. Tridemorph
5. Methoxy ethyl mercuric chloride
6. Benomyl

**C. Herbicides**

1. Nitrofen
2. Paraquat di-methyl sulphate
3. Metoxuron
4. Linuron
5. Sodium Methane assonate

**D. Nematicides**

1. Aldicarb
2. Diazinon
3. Dibromochloropropane
4. Ethylene Dibromide

**E. Others (Growth regulators)**

1. Maleic hydrazide
2. Trichloroacetic acid

# APPENDIX II

## Pesticides/ pesticide formulations banned for use but their manufacture is allowed for export

**A. Insecticides/ Acaricides/ Rodenticides**

1. Nicotin Sulfate

**B. Fungicide**

2. Captafol 80% Powder

# APPENDIX III

## Pesticides withdrawn

**A. Insecticides/ Acaricides/ Rodenticides**

1. Formothion
2. Nickel Chloride
3. Paradichlorobenzene (PDCB)
4. Warfarin

**B. Fungicides**

1. Ferbam

**C. Herbicides**

1. Dalapon
2. Simazine
3. Sirmate

# APPENDIX IV
## Pesticides restricted for use in India

**A. Insecticides/ Acaricides/ Rodenticides**

1. **Aluminium Phosphide** (The Pest Control Operations withAluminium Phosphide may be undertaken only by Govt./Govt. undertakings / Govt. Organizations / pest control operators under the strict supervision of Govt. Experts or experts whose expertise is approved by the Plant Protection Advisor to Govt. of India except [1]Aluminium Phosphide 15 % 12 g tablet and [2]Aluminum Phosphide 6 % tablet.)
2. **Cypermethrin** (Cypermethrin 3 % Smoke Generator is to be used only through Pest Control Operators and not allowed to be used by the General Public.
3. **Diazinon** (Diazinon is banned for use in agriculture except for household use.)
4. **Dichloro Diphenyl Trichloroethane (DDT)** (The use of DDT for the domestic Public Health Programme is restricted up to 10,000 Metric Tonnes per annum, except in case of any major outbreak of epidemic. M/s Hindustan Insecticides Ltd., the sole manufacturer of DDT in the country may manufacture DDT for export to other countries for use in vector control for public health purpose.)
5. F**enitrothion** (The use of Fenitrothion is banned in Agriculture except for locust control in scheduled desert area and public health.)
6. **Fenthion** (The use of Fenthion is banned in Agriculture except for locust control, household and public health.)
7. **Methyl Parathion** (Methyl Parathion 50 EC and 2% DP formulations are banned for use on fruits and vegetables.)
8. **Monocrotophos** (Monocrotophos is banned for use on vegetables.)

**B. Fungicides**

1. Captafol (The use of Captafol as foliar spray is banned. Captafol shall be used only as seed dresser. The manufacture of Captafol 80 % powder for dry seed treatment (DS) is banned for use in the country except manufacture for export.)
2. Dazomet (The use of Dazomet is not permitted on Tea.)

3. Methoxy Ethyl Mercuric Chloride (MEMC) (The use of MEMC is banned completely except for seed treatment of potato and sugarcane.)

**C. Herbicides**

1. Dazomet (the use of Dazomet is not permitted in tea)
2. Methyl bromide (under strict supervision of experts in non crop situation)
3. Trifluralin (only in wheat but not to be used near the water basin)

**D. Nematicides**

1. Dazomet (The use of Dazomet is not permitted on Tea)
2. Diazinon (Diazinon is banned for use in agriculture except for household use.)
3. Methyl Bromide (Methyl Bromide may be used only by Govt./Govt. undertakings/ Govt. Organizations / Pest control operators under the strict supervision of Govt. Experts or Experts whose expertise is approved by the Plant Protection Advisor to Govt. of India.)

# APPENDIX V

## MINISTRY OF AGRICULTURE AND FARMERS WELFARE
## (Department of Agriculture and Farmers Welfare)

(CG-DL-E-16022023-243654)

## NOTIFICATION

New Delhi, the 2nd February, 2023

## List of Prohibited Insecticides

| Sl No. | Name of Insecticide | Decision of Central Government |
|---|---|---|
| **1** | Dicofol | The registration, import, manufacture, formulation, transport, sale is prohibited and its use is completely banned from the date of publication of this order. |
| 2 | Dinocap | The registration, import, manufacture, formulation, transport, sale is prohibited and its use is completely banned from the date of publication of this order. |
| 3 | Methomyl | The registration, import, manufacture, formulation, transport, sale is prohibited and its use is completely banned from the date of publication of this order. |
| **Names of crops to be omitted from approved usage** | | |
| 1 | Carbofuran | All other formulations of Carbofuran except Carbofuran three percent Encapsulated granule (CG) along with the crop labels may be stopped from use. |
| 2 | Malathion | Sorghum, Pea, Soybean, Castor, Sunflower, Bhindi, Brinjal, Cauliflower, Radish, Turnip, Tomato, Apple, Mango and Grape. |
| 3 | Monocrotophos | All other formulations of this pesticide except Monocrotophos fifteen percent Water soluble granules (SG) may be stopped from use in respective label crops. |
| 4 | Quinalphos | Jute, Cardamom and Sorghum. |
| 5 | Mancozeb | Guava, Jowar and Tapioca. |
| **6** | Oxyfluorfen | Potato and Groundnut |
| 7 | Dimethoate | Label deletion of fruits and vegetables that are consumed as raw food items. |
| 8 | Chlorpyriphos | Ber, Citrus and Tobacco. |

# APPENDIX VI

## Technical and Trades Names of Insecticides & Acaricides, Rodenticides and biopesticide formulation

| Technical Name | Trade name |
|---|---|
| **A. Insecticides** | |
| **1. Neonicotinoids** | |
| Imidacloprid 17.8 SL | Confidor, Seamer, Josh, Imidastar, Imiden, Courage, Midas 2000, King Dor , Jumbo |
| Imidacloprid 70 WG | Admire , Tatamida 70WS , Josh 70 , Dzire , Global 777 , Ad-Fyre , Victor Plus , Tagmyre& Tropical Magic , Pactus , Sumida |
| Clothianidin 50WDG | Dentotsu |
| Acetamiprid 20SP | Manik , Ekka , Rapid Crytal, Rekord t, Active , Award , King Prid , Acetacel , Aceta , Echo 797 , Stona , Lift , Dhan Preet , Crop Pride , Sharp , Proud |
| Thiamethoxam 25WG | Actara , Kri-Oxm , Battalion , Theme , King Tara , Maxima , Wonderex , Renova , Devitara , Maestro 707 , Maxtara , Giltara , Click , Areva , Arrow , Actor |
| **2. Synthetic pyrethroids** | |
| Bifenthrin 2.5 EC | Superflex , Biflex TC |
| Bifenthrin 8 SC | Relstar Plus ., Wilstar SC |
| Bifenthrin 10 EC | Talst, Buland |
| Lambda cyhelothrin 5EC | Karate, Lamor Pro |
| **3. Phenyl pyrazole** | |
| Fipronil 5SC | Regent SC , Ruler , Stargazette , Sonic Flo , Devigent Plus , Fipro King , Vizent , Sonic Flo , Rabid |
| **4.Avermectin** | |
| Abamectin 1.9 EC | Abacin , Cymbush , Vertimec , Tagmec |
| Milbemectin 1EC | Milbeknock |

| | |
|---|---|
| Emamectin benzoate5SG | Proclaim , Missile , Emstar 5 , Starclaim , Robot , Spolit , Empower , Tatkal , Wegon , EM-1 , Xplode , Benzer , |
| **5. Diamide** | |
| Chlorantaniliprole 20SC | Rynaxypyr, Coragen |
| Chlorantaniliprole 18.5SC | Cosko, Coragen, Cover Liq |
| Flubendiamide 39.35 SC | Fame , Superzite , Voter |
| **6. Benzoylureas** | |
| Nuvaluron 10 EC | Remostar , Pedestal |
| Buprofenzin 25 SC | Jawaa , Flotis , Trust , Irvy , Devifezin , Buprostar , Hillblaze , PI Bupro , Applaud , Braun 111 , Apple , Phentom |
| **7. Organophosphorous** | |
| Ethion 50EC | Tafethion , Krithion , Mit-505 , Mitkill , King Mite , Fosmite , Deviastra , Vithion , Fighter , Sumite , Hilmite , Shakti Acaron, Dhanumit |
| Profenofos50EC | Curacron , Celcron , Jashn , Kriphos , Proven , King Cron , Carina , Devi-soldier , Profenofos 50 EC , Banjo , Maxcron , Jashn , |
| Oxydemeton methyl 25 EC | Metasystox |
| **B. Acaricide** | |
| **Tetranoic acid derivatives** | |
| Spiromesifen 22.9 SC | Oberon , Voltage |
| **Diphenyloxazole** | Borneo , |
| Etoxazole 10 SC | |
| **Pyrazole** | |
| Tebufenpyrad 20WP | Pyranica,Karia |
| **Sulfite ester** | Omite , Simbaa |
| Propargite 57 EC | |
| **C. Rodenticide** | |
| Zinc Phosphide 80% Powder | Ratox, Ratol, Commando , |

| | |
|---|---|
| Bromadiolone 00.25CB | Kalrat CB , Ratcon CB |
| Bromadiolone 00.005 RB | Dr.Pest , Racumin Sure |
| Aluminum Phosphide 56.00% 3g Tablet, 10g Pouch | Celphos , Quickphos ,Phostoxin |
| **D. Biopesticide** | |
| *Bacillus thuringiensis* var. *kurstaki* | Delfin, Halt |

# APPENDIX VII

## Technical and Trade Names of Fungicides/Antibiotics/Plant Products/ Antagonists

| Technical name | | Trade name and formulation |
|---|---|---|
| **A.** | **Inorganic copper compounds** | |
| | Copper oxychloride | Akomin, Blitox-50, Fytolan, Kilex, Fycop, Nagcoper, Dhanucop, Fycop, Blue Copper 50, COC 50WP, Copsaan, Coprex, Copsin, Cupravit, Hondacop |
| **B.** | **Elemental inorganic sulphur compounds** | |
| | Wettable sulphur | Hexasul, Thiovit, Sulfex,Akrisulf, Appu, Cosavet-DF, Microsulf, Mitex S, Pesto Sulfur 80WP, Sulfasaan, Sulphur 85WP |
| **C.** | **Systemic fungicide** | |
| | Carboxin | Vitavax, Hiltavax |
| | Edifenphos | Hinosan |
| | Pyroquilon | Fongoren |
| | Tricyclazole | Beam, Trooper |
| | Propiconazole | Tilt, Radar |
| | IBP | Kitazin 50 EC |
| | Hexaconazole | Sitara, Hexazole, Montaf, Contaf |
| | Propineb | Antracol |
| **D.** | **Antibiotics** | |
| | Streptomycin sulphate | Streptocycline +Tetracycline |
| | Hydroxyquinoline | Entakon-M |
| **E.** | **Fungal antibiotics** | |
| | Validamycin | Sheathmar |
| **K. Plant derived products** | | |
| | Neem products | Achook, Neemazal, Neem Gold, Nimin |
| | Cymbopogon product | Wanis |
| **L. Antagonists** | | |
| | *Pseudomonas fluorescens* | Biofor-PF (Jaiva Kiran), based product Pseudocon |
| | *Trichoderma* spp. based | Bicure F, Trich-X-P, Viricon-L, products Bioderma, Trichostar |

# APPENDIX VIII
## Technical and Trade Names of Herbicides

| Technical name | Trade name and formulation |
|---|---|
| Fluchloralin | Basalin |
| Isoproturon | Graminon, Arelon, Taurus, Delron, Agrolon,Avonil, Bilron 75WP, Dararon 75WP, Dhar, Gold Medal, Haragron 75, Hilproturon 75WP, Iso 50, Isocin, Isof\guard 75WP, Isokil 75, Isomol 750, Isopar, Isoveer, Isovip, Nocilon 75 |
| Methabenzthiazuron | Tribunil |
| Pretilachlor | Rifit |
| Anilofos | Arozin,Aninoguard,Anilokil 30, Anilotaf,Anilveer, Avail 30EC, Dhanumon, Sardar Guard, Strong 30EC, Surya, Weedonil |

# APPENDIX IX

## Technical and Trades Names of Micronutrient formulation

| Technical Name | Trade name and formulation |
|---|---|
| **Micronutrient formulation** | Tracel, Agromin, Borax Sulphate, Zinc Sulphate |

# APPENDIX X

## Plant food contents in manures and fertilizers

| Manures/Fertilizers | | N (%) | $P_2O_5$ (%) | $K_2O$ (%) |
|---|---|---|---|---|
| 1. | Farmyard Manure | 0.4 | 0.3 | 0.2 |
| 2. | Compost | 0.5 | 0.25 | 0.5 |
| 3. | Cowdung | 0.5 | 0.2 | 0.4 |
| 4. | Poultry | 1.6 | 1.5 | 0.9 |
| 5. | Sheep Manure | 0.8 | 0.6 | 0.3 |
| 6. | Cotton Seed Cake | 3.9 | 1.8 | 1.6 |
| 7. | Groundnut Cake | 4-5 | 2.0 | 1.5 |
| 8. | Castor Cake | 4-5 | 2.0 | 1.9 |
| 9. | Neem Cake | 5-6 | 1.8 | 2.0 |
| 10. | Mustard Cake | 4-5 | 1.8 | 2.0 |
| 11. | Fish Meal | 4-10 | 4-8 | 0.3-1.5 |
| 12. | Bone Meal | 3-4 | 20-22 | - |
| 13. | Ammonium sulphate | 20 | - | - |
| 14. | Ammonium chloride | 24-26 | - | - |
| 15. | Ammonium Phosphate | 16 | 20 | - |
| 16. | Urea | 46 | | - |
| 17. | Calcium ammonium nitrate | 20 | - | - |
| 18. | Potassium nitrate | 14 | - | 44.4 |
| 19. | Potassium ammonium nitrate | 16 | - | 28 |
| 20. | Super phosphate (single) | - | 16 | - |
| 21. | Super phosphate (double) | - | 16 | - |
| 22. | Super phosphate (triple) | - | 32 | - |
| 23. | Rock Phosphate | - | 48 | - |
| 24. | Muriate of potash | - | - | 60 |

# APPENDIX XI
## Conversion Table (Nutrient-Fertilizer)

| | |
|---|---|
| 1 Kg N | 2.17 Kg Urea |
| 1 Kg $P_2O_5$ | 6.25 Kg SSP |
| 1 Kg $K_2O$ | 1.66 Kg MOP |
| 1 Kg DAP | 2.875 Kg SSP and 400 g |
| Urea 1 Kg N + 1 Kg P + 1 Kg K | 6.66 Kg Sulphala (15-15-15) |

| Rate of Application of Nutrients | Urea (46% N) kg/ha | Ammonium sulphate (20%) N (kg/ha) | SSP 16% $P_2O_5$ (kg/ha) | MOP (60% $K_2O$ (kg/ha) |
|---|---|---|---|---|
| 10 | 22 | 20 | 62.5 | 17 |
| 20 | 44 | 40 | 125.0 | 34 |
| 30 | 66 | 60 | 187.5 | 51 |
| 40 | 88 | 80 | 250.0 | 68 |
| 50 | 110 | 100 | 312.5 | 85 |
| 60 | 132 | 120 | 375.0 | 102 |
| 70 | 154 | 140 | 437.5 | 119 |
| 80 | 176 | 160 | 500.0 | 136 |
| 90 | 198 | 180 | 562.5 | 153 |
| 100 | 220 | 200 | 625.0 | 170 |
| 110 | 242 | 220 | 687.5 | 187 |
| 120 | 264 | 240 | 750.0 | 204 |
| 130 | 286 | 260 | 812.5 | 221 |
| 140 | 308 | 280 | 875.0 | 238 |
| 150 | 330 | 300 | 937.5 | 255 |
| 160 | 352 | 320 | 1000.0 | 272 |
| 170 | 374 | 340 | 1062.5 | 289 |
| 180 | 396 | 360 | 1125.0 | 306 |
| 190 | 418 | 380 | 1187.5 | 325 |
| 200 | 440 | 400 | 1250.0 | 340 |

# APPENDIX XII

## Some unconventional organic pesticidal preparations

**A) TOBACCO DECOCTION**:

This can be effectively used against aphids and other similar soft bodied insect-pests of vegetable crops. The decoction is prepared in the following way:

1. Steeping 500 g of tobacco wastes in 4.5 liter of water for 24 hours.
2. Dissolving 120 g of sliced ordinary bar soap in another container and adding it to the decoction under violent agitation.

The final solution should be diluted 6-7 times before spraying.

**B) NEEM KERNEL SUSPENSION**

This preparation acts as repellent againt locusts, grasshoppers and other chewing insects particularly belonging to Lepidoptera.The following are the steps to be followed for preparing this suspension.

1. Kernels should be ground into a coarse powder form.
2. This suspension is effective only at a concentration of 0.1 to 0.3% (for preparing 0.1% suspension 1 g of powdered neem seeds required per liter of water).
3. The required quantity of neem powder should be put in a bag of muslin cloth and dipped in the corresponding volume of water contained in a bucket for about 12 hours.
4. Thereafter, the bag is to be squeezed repeatedly after dipping in the fluid until the out-flowing liquid turns light brownish.

The suspension is now ready for use.

**C) KEROSENE EMULSION**:

This contact insecticide is very effective against a wide range of sucking insects. The procedure for its preparation is outlined below:

1. 500 g of ordinary bar soap is to be sliced finely and dissolved in 4.5 liters of hot water.
2. The solution is to be allowed to cool down.
3. 9 liters of kerosene should be added to it under violent agitation till the oil is fully emulsified. This stock solution should be sprayed after it is diluted 15-20 times.

**D) ASAFOETIDA – TURMERIC MIXTURE**

This preparation can be used for controlling bacterial wilt of solanaceous vegetables like to tomato. This should be applied as soil drench for three times after 15, 30 and45 days of transplanting the vegetables. This mixture can be prepared in the following way:

1. Both asafoetida and turmeric should be ground into powdery forms.

2. 1.5 g asafoetida and 5 g turmeric powders should be dissolved in a little amount of water.
3. Finally, the volume of the mixture is to be made up to 10 litres by pouring required quantity of water into it.
4. The mixture is now ready for soil drenching.

# APPENDIX XIII

## Preparation of some common fungicides and organic manures

**A) BORDEAUX MIXTURE (1%):**

i) Dissolve 100 g of powdered copper sulphate in 5 litters of water in a plastic bucket.

ii) Prepare milk of lime in another plastic bucket by dissolving 100 g of quick lime in 5litres of water.

iii) Pour the copper sulphate solution and the milk of lime from the above two vessels into a third one by gently stirring the mixture all the while. This will give a final volume of 10 liters.

iv) The mixture is to be tested before use for the presence of free copper which is toxic to the plant. Dip a polished knife in the mixture. If the blade shows a reddish colour add more lime to the mixture till the blade does not show staining on dipping.

**B) BORDEAUX PASTE:**

Dissolve 100 g of copper sulphate and 100 g of quick lime each in 500 ml of water in two separate plastic vessels. Mix these two solutions together in a third vessel to make one liter of the paste.

**C) CHESTNUT COMPOUND**:

i) Powder of 60 g of copper sulphate and 330 g of ammonium carbonate and mix well. This dry mixture can be stored in airtight containers for 24 hours before use.

ii) Take 25 g of this mixture and dissolve it in a little amount of hot water

iii) Make up the volume of the mixture to 8 liter by adding cold water

iv) The mixture is now ready for soil drenching

**D) VERMICOMPOST:** It is a practice of converting biowastes into organic matter by using different worms. It is a relatively quicker method.

- **Construction of concrete tank and shed:** The size of the tank should be 90-100 cm X 75-90 cm (Breadth and height) with convenient length is suitable for vermicomposting. The inside walls of the tank must be fine plastered providing a netted outlet at the bottom for drainage. The tank is preferably constructed in a shady area and shed is provided to avoid direct sunlight and rainfall.
- **Materials required:** Partially decomposed animal dung as well as dried bio waste.
- **Earthworm species:** The most commonly used earthworm species for vermi composting are *Eisenia foetida, Eudrilus euginiae, Perionyx excavates, Amyanthus defringens,* etc.
- **Composting time:** 3 to 4 months in general

- **Methodology:** After construction of the tank, about ½ to ¾ inches of the tank bottom has to be filled with dry sand or sandy soil. Afterwards, a layer of about 2 to 3 inches of partially decomposed animal dung is spread over it. Above it, chopped partially dried biowaste is spread with a thickness of 5 to 7 cm. Alternately, animal dung and bio waste layers are spread to fill up the tank excluding top of 15-20 cm. After filling up the tank, earthworms are to be released. In general, around 1 kg to 2 kg earthworms should be used per square meter tank area for good result.

Besides, the waste material in the tank to be covered with gunny bag or rice straw to keep the moisture level. Water must be sprinkled time to time. Watering must be stopped as an when vermin cast appears on the top of the composted material and the compost to be harvested soon. For easy separation of vermin earthworms, a heap of harvested material to be made. Now, the harvested material is sieved and stored for use.

**E) ENRICHED COMPOST:**

For better quality compost with the highest organic matter and nutrients, we need enriched composting. It generally contains (approx.) 1.85 to 1.97 % Nitrogen, 1.03 to 1.15 % Phosphorous and 0.81 to 0.91% potassium. Enriched composting is an improved technology for rapid decomposition of the agricultural waste materials which are produced as non-product outputs during the production and processing activities of the agriculture sector. The organic waste materials are allowed to compost under controlled environment with the supplementation of mineral additives like wood ash, pyrites, bone meal and rock phosphate. Further the worth of the compost can be enriched by addition of beneficial microbial mass *viz., Azospirillum* spp., *Azotobacter* spp, *Aspergillus spp*., *Pseudomonas spp.* and *Bacillus spp.* To maintain the moisture content after addition of organic products, curing materials must be covered with low-cost gunny bags. Quality and nutrient content of the final product fetches good prices in the market within 15 to 20 days interval.

# APPENDIX XIV

## List of government/private agencies of various horticultural inputs

| Sl. No. | Agency | Materials supplied |
|---|---|---|
| 1. | Division of Vegetable Crops, Indian Institute of Horticultural Research, 255 Upper Palace Orchards Bangalore 560080 | Seeds/planting materials of horticultural crops |
| 2. | Indian Agricultural Research Institute, Pusa, New Delhi 110012 | Seeds/planting materials of horticultural crops |
| 3. | ICAR-IARI Regional Station, Katrain, Kullu Valley, HP 175129 | Cole crop seeds |
| 4. | Indian Institute of Vegetable Research, Post Bag No. 01, PO Jakhini, Shahanshapur, Varanasi, Uttar Pradesh 221305 | Seeds of vegetable crops |
| 5. | National Horticultural Research & Development Foundation Post Darna Sangvi, Tq Niphad (Via – Panchavati S.O.), Dist. Nashik 422 003 MS | Seeds of onion, garlic and okra |
| 6. | National Seeds Corporation Ltd., Beej Bhawan, Pusa Complex, New Delhi 110012 | Seeds of vegetable crops |
| 7. | Directorate of Onion & Garlic Research, Nasik-Pune Highway (NH-50), Taluka Khed, Rajgurunagar, Pune, MS 410505 | Seed & planting materials of onion and garlic |
| 8. | Central Institute of Subtropical Horticulture, Rehmankhera, PO Kakori, Lucknow UP 226101 | Planting material of fruit crops |
| 9. | National Research Centre on Litchi, Mushahari, Muzaffapur, Bihar 842002 | Planting material of litchi |
| 10. | Maharashtra Hybrid Seeds Co. Pvt. Ltd., Jalna – Aurangabad Road, Post Box no. 76, Dawalwadi, Jalna 431203 | Hybrid seeds of vegetable crops |
| 11. | Indo-American Hybrid Seeds Co. Ltd. Sy No 13/4 & 14, 7th Km, Banashankari-Kengeri Link Road, Channasandra, Rajeshwarinagar, Bengaluru, Karnataka 560098 | Hybrid seeds/planting material of horticultural crops |
| 12. | Jain Irrigation Systems Ltd., Jain Plastic Park, NH No.6, Bambhori, Jalgaon 425001 Maharstra | Irrigation systems, Tissue culture, Processing of Fruits, Vegetables, Spices |
| 13. | Geo-Hortifloritech, Vill & PO Silchang, Morigaon, Assam 782412 | Green House / Plastic House and Net House materials |

# APPENDIX XV

## Safe waiting period of pesticides in vegetables

| Pesticides | Rates (kg ai/ha) | Waiting period (days) | Maximum residue Limit (MRL) (PPM) |
|---|---|---|---|
| **BHENDI** | | | |
| Fenvalerate 20 EC | 0.05 | 1 | |
| | 0.10 | 1 | 1.0 |
| | 0.15 | 2 | |
| **TOMATO** | | | |
| Metalaxyl (Ridomil MZ 72 WP) | 0.2% 5 sprays | 10 | 1.0 |
| | 0.25% 5 sprays | 10 | |

# APPENDIX XVI
## Conversion table for various units

| **Multiply** | **By** | **To get** |
|---|---|---|
| Hectare | 2.47 | Acre |
| Hectare | 7.50 | Bigha |
| Acre | 3.125 | Bigha |
| Bigha | 5 | Katha |
| Parts per million (ppm) | 1.001 | Gram per liter |
| Parts per million (ppm) | 0.0001 | Percent solution |
| Percent solution (%) | 10000 | ppm |
| Kg N | 2.17 | Kg Urea |
| Kg $P_2O_5$ | 6.25 | Kg SSP (Single) |
| Kg $K_2O$ | 1.67 | Kg MOP |