Pusa Safed Baingan-1 is the first white coloured oval fruited brinjal variety which has been developed by single plant selection from an indigenous material collected from the farmer’s field of West Garo Hills, Meghalaya by the Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi. The materials were highly variable and single plant selection was carried out till the progeny became homozygous. This variety was identified by IARI Variety Release Committee, recommended for release by the Delhi State Seed Sub-Committee on 19th Dec, 2017 and notified by the Central Sub Committee on Crop Standard, Notification and Release of varieties for Horticultural Crops vide S.O. 692 (E) in 2019 for cultivation in the National Capital Region of Delhi including Delhi and adjoining areas in the states of Haryana, Rajasthan and Uttar Pradesh in kharif.

The plants of Pusa Safed Baingan-1 are non-spiny with semi erect branches. The leaves are green with green mid-ribs and veins, attaining a height of 85-90 cm at peak fruiting stage. Flowers are light purple in colour. The fruits are small oval round, egg shaped and average fruit weight is 50-60 g with non-spiny green calyx. The fruits are borne in clusters. It is an early variety having a maturity period between 50-55 days from transplanting to first fruit harvest. The average fruit yield of the variety is 35 t/ha and the performance over the years in IARI, New Delhi and different locations are given in Table 1 and Table 2. Brinjal is one of the vegetables having highest antioxidant activities owing to its high content of phenolics and Pusa Safed Baingan-1 is having high total phenolic content (31.21 mg GAE/100 g) with high antioxidant activity (3.48 CUPRAC μ moltrolox/g, 2.58 FRAP μ moltrolox/g) (Table 3). The growers will be benefited because of its attractive white coloured fruit, high yielding, non-spiny calyx and less number of seed at marketable stage. There is also a long standing demand by the consumer for white coloured brinjal probably due to its medicinal as well as nutritional value given to diabetic patients and also for strengthening gums from ancient time.
Pusa Safed Baingan-1: A new brinjal variety
Ravinder Kumar, A D Munshi, Partha Saha, T K Behera, Y A Lyngdoh, B S Tomar and N Bhanushree

Our Guest Speaks
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Bineeta Singh

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Siddhartha Sankar Biswas, Ram Pal and Kalaivanan N S

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Vegetable grafting for combating stresses and to increase productivity
Praveen K Singh, Selvakumar R, Mam Chand Singh, Hira Singh Bhupal, Jugender Kumar and Ravi Gautam

Malabar Tamarind at a glance
T Janakiram
Exploring potential of semi-arid regions for human welfare

A SEMI-ARID region receives precipitation below potential evapotranspiration, but not as low as a desert climate. There are different kinds of agro-climate in semi-arid regions, depending on variables such as temperature, soil, humidity and wind velocity, and they give rise to different biomes. The semi-arid horticulture encompasses a gamut of low volume and high value crops such as aonla, bael, jamun, custard apple, tamarind, khirni, chironji, karonda, wood apple, gonda, mulberry, mahua, phalsa, manila tamarind, palmyra palm, timru, cucurbits, legumes, solanaceous vegetables, spices, flowers crops, and medicinal and aromatic plants. Since most of them are tolerant to abiotic stresses, they can be cultivated commercially by adopting site-specific production technologies. Some of these fruits have gained popularity in past few decades but majority are still not cultivated commercially.

The major bottleneck in development of semi-arid horticulture industry is poor availability of quality seed and planting material. These are most precious input to increase production of horticultural crops in such regions. Thus, production of quality seed and planting material and their availability to the farmers at affordable price will enhance the production potential in such regions. The expansion in area under such crops and yield potential has increased manifold owing to development of new varieties and application of advance agro-techniques. Semi-arid horticulture also provides an opportunity for introduction of newer crops. Development of cropping models and orchard floor management for optimum utilization of natural resources; value addition, development of cottage industry can be adopted for generation of employment for rural masses in semi-arid region for better livelihood. Simultaneously, these fruits and vegetables are rich in antioxidants, nutraceuticals, vitamins and bioactive compounds which can be used for formulation of various ayurvedic medicines.

There is a tremendous scope of expansion of area under horticultural crops in semi-arid region with vast potential under changing climatic scenario of horticultural production of our country. The need of the hour is to create awareness among the growers with the latest technological advancement including improved varieties and their cultivation practices, abiotic and biotic measures so that export quality of horticultural produce can be achieved for better livelihood and economic security to dwellers in such regions.

A. K. Singh
Incharge, Regional Station
CHES (ICAR-CIAH), Godhra, Gujarat
**Hi-Tech cultivation of capsicum**

Capsicum (sweet pepper or bell pepper) is a high-value greenhouse crop widely cultivated in temperate zones than in the tropics. The name capsicum is derived from Greek word kapto, meaning to bite or to swallow. Despite being a single species, *C. annuum* has many forms, with a variety of names, even in the same language. The official names in American English is *sweet pepper*, any variety lacking heat, and those sweet peppers that have a blocky-shape are referred to as *bell peppers*, whereas, variety that produces capsaicin is known as a *hot pepper* or *chili pepper*. In British English, the sweet varieties are called peppers and the hot varieties as chillies, whereas in Australian English and Indian English, the name capsicum is commonly used for bell peppers exclusively and chilli is often used to encompass the hotter varieties.

**C**APSICUM species are members of the Solanaceae family which includes tomato, potato, tobacco, and petunia. This genus contains about 31 species of which five are domesticated, namely *C. annuum*, *C. frutescens L.*, *C. chinense* Jacq., *C. baccatum* L., and *C. pubescens* R. and 25 wild species. Mexico is believed to be the centre of origin of *C. annuum*, whereas *C. frutescens* and the other cultivated species (*C. baccatum* var. *pendulum*, *C. chinense* and *C. pubescens*) originated in South America. By the mid-17th century Capsicum was being cultivated throughout southern and middle Europe as a spice and medicinal drug, with introduction of one species to Japan and five to India. One medium green capsicum can provide up to 8% of the recommended daily allowance of Vitamin A, 180% of vitamin C, 2% of calcium and 2% of iron.

Internationally Netherlands, Japan, France, Germany and United States are the leading countries in terms of area under protected cultivation. Fresh pepper is cultivated in 126 countries of the world in all the continents. The world’s largest producer is China with over 18 million tons annually, followed by the Mexico with about 3.5 million tons. The maximum percentage of sharing for capsicum production is in Karnataka (Table 1) under protected cultivation. The Government of India has initiated a number of schemes and programmes namely Mission for Integrated Development of Horticulture (MIDH) by subsuming various schemes such as National Horticulture Mission (NHM), National Horticulture Board (NHB), Rashtriya Krishi Vikas Yojana (RKVY) and Horticulture Mission for North East and Himalayan States (HMNEH) for the promotion and development of protected cultivation.

![Production share of hydroxyl by region Average (FAOSTAT 2019)](image-url)
Table 1. Indian production of capsicum

<table>
<thead>
<tr>
<th>State</th>
<th>Production ('000 Tonnes) 2017-18</th>
<th>Production Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karnataka</td>
<td>65.27</td>
<td>20.04</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>57.76</td>
<td>17.74</td>
</tr>
<tr>
<td>Haryana</td>
<td>40.05</td>
<td>12.30</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>33.03</td>
<td>10.14</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>2391</td>
<td>7.34</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>22.96</td>
<td>7.05</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>16.69</td>
<td>5.13</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>15.70</td>
<td>4.82</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>13.63</td>
<td>4.19</td>
</tr>
<tr>
<td>Odisha</td>
<td>6.99</td>
<td>2.15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>295.99</strong></td>
<td></td>
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</tbody>
</table>

Source: NHB-2019

Climate

Temperature plays a key role in the flowering, fruit setting, seed setting, shape and number of fruits per plant in capsicum under protected condition. As seeds germinate best at 25-30°C where optimal temperatures for productivity should be between 18-30°C. The functioning of the female organs of flower are affected by low (14°C or less) night temperatures, and the number of viable pollen grains per flower reduce markedly which causes parthenocarpic (seedless fruit) effect and impairs germination. The fact of low night temperature effect is associated with reduced starch accumulation in pollen grains at 3 days before anthesis and a decrease of total soluble sugars in the mature pollen grains. To prevent the low night temperature affect during winter, exposing Capsicum plants to extremely high day temperatures (day/night temperatures of 36 ± 2°C), obtained by keeping the greenhouse closed during the day to exploit solar heating. Flower buds will usually abort when night temperatures reach 30°C.

Growing media

(i) **Soil system:** It can be grown from sea level to an altitude of zero meters in loam or sandy loam soil with good water holding capacity but soil pH should be 5.5 to 6.8 for successful capsicum cultivation. While preparing the field for crop, soil should be worked to a fine tilth by repeated ploughing and pulverizing. Dead roots and weeds collected, removed and burnt. Well-decomposed organic manure @4-5 kg/m² should be mixed thoroughly in the soil. The width of the bed should not more than 100 cm with a length of 150 cm to 200 cm. The inner bed spacing should be enough to facilitate weeding and watering without trampling the top of bed. The beds should be raised to about 1 cm above the field surface, so as to provide proper drainage of excess water. Mostly greenhouse capsicum crop is grown under drip irrigation systems. After preparation of beds, drip lines of 16:2:30 are laid on the beds and two drips lines are laid on each bed at a distance of 60-65 cm depending upon the bed size.

(ii) **Soilless system:** In hydroponic system, Capsicum plants are grown in various media. First, system called the nutrient film technique (NFT) in which plants are placed in a polyethylene tube that slits cut in the plastic for the roots to be inserted. Nutrient solution is pumped through this tube for dipping the roots. The solution is re-circulated and nutrients are added as depletion occurs. Other systems use rockwool, saw dust or perlite as the supporting medium, while nutrients are applied in liquid form. These production systems are very clean, with no organic material present. In addition, they give the grower complete control over the crop’s nutritional needs to maximize growth and fruit production. However, it requires a very strict and specific fertilization schedule. Mistake in calculation of quantities used for scheduling would result in immediate and visible deficiencies or toxicity in the crop than in the other methods employed.

Selection of site and structures

Selection of site for taking up of protected cultivation is a critical step and this has to be done with utmost care. Places having high rainfall and humidity are not suitable for its cultivation, since this encourages many foliar diseases. Also the areas with high wind velocity are not suitable since they are likely to damage the structure and the polyethylene sheet frequently, thereby enhancing the maintenance cost of the structure. Avoid the location or
area where heavy rains accompanied with gusty winds are prevalent to avoid damage to the protected structure. Protected structures act as physical barrier and play a key role in integrated pest management by preventing spreading of insects, pests and viruses causing severe damage to the crop. The selection of protected structure should be determined by the grower’s expectations, suitable varieties (Table 2), experience, and above all its cost-effectiveness in relation to the available market for the produce.

Types of polyhouse for capsicum cultivation
(1) **Natural ventilation polyhouse:** Natural ventilation uses no specific control devices for regulating environmental parameter inside the polyhouse hence, low initial investment. It can be constructed with locally available material such as bamboo, timber etc. also, and is suitable during cold weather, especially in hilly areas. The external cool air enters the greenhouse through the lower side openings while the hot internal air exits through the roof openings due to the density difference between air masses of different temperature and resulting in the lowering of temperature in the greenhouse. In order to prevent insect intrusion and decrease insecticide use, it is common practice to position insect screens in the ventilation openings.

<table>
<thead>
<tr>
<th>Table 2. Varieties available in India for protected cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
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<tr>
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<tr>
<td>1</td>
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<td>7</td>
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<td>8</td>
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</table>

(2) **Semi-climate control polyhouse:** In this type of polyhouse, the structure frame is made up of galvanized iron pipes. Exhaust fans are used for ventilation, these are thermostatically controlled. Cooling pad is used for humidifying the air entering the polyhouse. These are suitable for cultivation during mild winter and mild summer for the low hills or plains of north western part of india.

(3) **Climate control polyhouse:** The fully climate control polyhouses are completely based on sensors. Their frames are made up of iron or Aluminium having designs are either dome shaped or cone shaped. These are highly durable but 5-6 times costlier. Growing medium used in these types of polyhouse are peat, perlite, vermiculite, rockwool. In India coco fibres and rice husks are used as growing media as these materials are cheaper. Fertigation and pesticide sprays are done by fogging machine. In these polyhouses, capsicum can be grown throughout the year with 3-4 harvesting per year and with 90% A grade fruit quality.

(4) **Net house:** These simple-frame structures are of two types, namely, shade nets and insect-proof nets. Shade nets are perforated plastic materials used to cut down the solar radiation and prevent scorching or wilting of leaves caused by marked temperature increases within the leaf tissue from strong sunlight. These nets are available in different shading intensities ranging from 25% to 75%.

Insect-proof nylon nets are available in different intensities of perforations, ranging from 25 mesh to 60 mesh. Nets of 40 or higher mesh are effective means to control entry of most flying insects and save crop from diseases. These structures permit early planting of capsicum without the risk of vector. Higher mesh size, however, reduces the air exchange of the structure. Now-a-days UV stabilized nets are available which have a longer life.

![Semi-control type polyhouse at CPCT-IARI, New Delhi](image)

Given the year-round demand for capsicum, farmers can choose one of the suitable protected structure options.

<table>
<thead>
<tr>
<th>Growth cycle</th>
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<tbody>
<tr>
<td>July</td>
</tr>
<tr>
<td>Climate control polyhouse</td>
</tr>
<tr>
<td>Semi-climate control polyhouse</td>
</tr>
<tr>
<td>Natural ventilation polyhouse</td>
</tr>
<tr>
<td>Net house</td>
</tr>
</tbody>
</table>

Given the year-round demand for capsicum, farmers can choose one of the suitable protected structure options.
Hi-tech nursery for capiscum

Growing media used in hi-tech nurseries are highly modified mixtures of organic and inorganic materials. With reference to plant propagation, growing media are defined as all those solid materials, other than soil, which alone or in mixtures can guarantee better conditions than agricultural soil (for one or more aspects). Mainly three viz, coco peat, vermiculite and perlite are being commercially used as a rooting media for raising the nursery in the high-tech nursery greenhouse. These ingredients are mixed in the volume ratio of 3:1:1 before filling in the trays.

Coco peat (Coir pith): It is produced by partial decomposition of plant material under low-oxygen conditions and a by-product of the coconut industry, used widely as a substrate due to its low cost, aeration, drainage and long life. It is usually marketed in compressed bricks form to which water is added. The bricks weigh about 4–5 kg and can expand to 4–5 times of their volume once water is added after loosening them. It is advisable to use coco peat after treatment with steam or other means of disinfection. It has a pH of about 5.0 making and contains low levels of micronutrients, but higher levels of phosphorus and potassium. Coco peat is lightweight and has a water-holding capacity of three to four times of its weight. Media containing vermiculite should be mixed dry. When mixed wet, the desirable physical properties deteriorate because particles tend to collapse flat. Furthermore, vermiculite can hold positive-charged nutrients such as K, Mg and Ca.

Vermiculite: Vermiculite is produced by heat treatment of mica at 700 to 1000°C temperature. It is porous and light and has a water-holding capacity of three to four times of its weight. Media containing vermiculite should be mixed dry. When mixed wet, the desirable physical properties deteriorate because particles tend to collapse flat. Furthermore, vermiculite can hold positive-charged nutrients such as K, Mg and Ca.

Perlite: Perlite is a natural mineral of volcanic origin which is light in weight. The pH is usually neutral to slightly alkaline. Its high porosity helps to control the water-holding capacity and aeration of the substrate. Perlite can be used alone or mixed.

Pro-tray or seedling trays

There are two kinds of plastic trays used for raising seedlings. One tray 187 cavities of 3.75 cm (1.5”) size, whereas the other tray is having 345 cavities of 2.5 (1.0”) size. These trays help in proper germination, provide independent area for each seed to germinate, eliminate the mortality rate, maintain uniform and healthy growth of the seedlings, are easy in handling and storing, reliable and economical in transportation. These trays are fixed in thermocol trays having the same number and size of cavities before filling the media. Thermocol base provides a good insulation to help in minimizing fluctuation in root temperature.

Seed sowing and application of nutrients and water

The best time for seed sowing is August-September in nursery with the optimal temperature at 25-30°C at the depth of 0.5 inch in the nursery tray. First filled the tray with the mixture of root media and then the seeds are sown in the cavities (one seed in each cavity). If the seeds are of good viable capacity and not old than will take 6-10 days for germination elsewhere germination range from 15-21 days depends on the quality and genetic constituent of the seeds. Usually healthy seeds germinate without pre-soaking in normal water but in case germination hampered by internal dormancy or seed coat then 24-36 hr pre-soaking help in the uniform germination of seeds. The seedlings are ready within 25-30 days after sowing. For healthy and vigorous growth, fertigation will be promising by applying NPK 19:19:19 @ 1g per litre water once in a week at 3-4 stage of leaf through fine sprinkler.

Transplanting

Seedling are transplanted on a planting distance of 60 × 30 cm around 4,200-4,300 seedlings are required for planting in 1,000 m² area of greenhouse. Mostly transplanting is done in the evening and the nursery must be sprayed with systematic insecticides like confidor or mebayl @1/2 ml/litre of water before taking it out from the nursery greenhouse for protecting the plants from post transplanting infestation of leaf curl virus or mites.

Pruning and training

In greenhouse conditions, to ensure good growth and fructification, plants are cultivated with one, two or three branches. Fewer ramifications on the plant result in improved air circulation, increased lighting and reduced pests. Perform pruning at 10–14-day intervals as new shoots appear. Remove the base leaves, shoots and some flowers to stimulate plant growth and development. Pruning the plants to a single stem, two stems or four stems facilitate better management, permit closer planting, early maturity of fruits, higher yield of larger sized fruits as well as uniform light penetration in the plant canopy. Due to the heavy vegetative growth and fruit load on the coloured pepper plants, shoot pruning proves to be one of the important factors in proper utilization of production area. Capsicum plants are pruned after 30 days of transplanting at an interval of 8 to 10 days which resulted in bigger fruits with better quality and high productivity. Each capsicum plant is trained to retain only 2 or 4 stems. Shorten the lateral shoots, leaving 2–3 fruits on secondary shoots. There should be a maximum of 2–4 branches: the lowest at 15–20 cm from the ground or mat, the next at 20–25 cm. Prune secondary shoots or
branches to leave only the ramifications of the main stem. This practise of pruning is usually done under protected or polyhouse structure cultivation with the only purpose to get maximum and continuous production by making indeterminate type of plant.

The plants are trained along the plastic twines tied to the main stem after 6-7 weeks of transplanting. A grid is prepared over the plants with a GI wire for this purpose. The main stem grows to a height of 3.5–4.0 m and must be trained to remain vertical. Use threads or plastic or metal rings to trellis each fructification stem of the pepper so it can bear the weight of the fruits. Trellising is necessary only for the main branches, not for secondary ramifications.

**Weeding and hoeing**

Usually weeding and hoeing are done once in a month manually if mulching is not being used on transplanting beds. But mulching of beds especially of yellow colour plastics protect the capsicum from weeds as well as against leaf curl virus, which is spread by an insect white fly. Yellow plastic mulch is black from the other side, which helps in weed control and soil moisture conservation. The yellow plastic mulch has reflective properties, which interfere with the movement of white flies.

**Harvesting**

In greenhouse production of capsicum, fruits are harvested when they reach full colour and are still firm on the plant itself for marketing them to up market and getting very high price of the produce. When fruits are harvested a week after the harvestable green stage the fruits will turn gradually into colour, which is not desired. Green capsicum requires about 40-42 days developing from pollination to mature green fruit, a further 14-21 days are required to fully i.e. from green to red or yellow etc., depending upon the temperature. Best colour develops between 18 to 24°C whether the fruits are on the plants or in storage. Capsicum fruits must be harvested with a very sharp knife or scissors to get a smooth stem end appearance and so to minimize damage to other fruits. It is better to start harvesting of fruits early in the morning and to finish before the hottest hours of the day. It is most important that harvesting, handling and packaging should be done with greatest care because capsicum fruits are very prone to handling damage. Fruits will mature in flushes, certainly in beginning of the production. In peak periods frequent harvesting is needed coloured fruits once or twice a week and green fruits once per fortnight.

**Yield**

On an average capsicum varieties can produce 60-70 tonnes of coloured fruits and 100 to 120 tonnes of green fruits per hectare under greenhouse conditions. Although, yield directly depends upon the suitable variety, climate conditions and crop management for protected cultivation. Average weight of quality coloured fruits is 160 to 190 g/ fruit with mostly four lobes.

**Grading of fruits**

Capsicum fruits are graded according to colour of the fruit, size and shape of the fruit. A+ grade fruits are mostly four lobed, firm and bright in colour and their average

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>% in dry weight</th>
<th>Micronutrient</th>
<th>(ppm or mg/ kg dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>3.0–4.5</td>
<td>Iron (Fe)</td>
<td>60–300</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.30–0.60</td>
<td>Manganese (Mn)</td>
<td>30–150</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>3.0–7.5</td>
<td>Zinc (Zn)</td>
<td>20–100</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1.0–2.5</td>
<td>Copper (Cu)</td>
<td>6–25</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>0.35–0.90</td>
<td>Boron (B)</td>
<td>25–80</td>
</tr>
</tbody>
</table>
fruit weight is 180-190 g. The next grade fruits may have 3-4 lobes with average fruit weight of 150-160 g followed by ‘B’ grade with 2-3 lobes fruit with average fruit weight of 120-50 g. Grade ‘C’ fruits are with conical fruit shapes or 1-2 lobes and small in size with average fruit weight of 90-100 g per fruit. A* and A grade fruits after proper packing and proper clearing sold to high market and ‘B’ and ‘C’ grade fruits are sold to the local markets.

Physiological disorders
Conditions of high relative humidity (e.g. 85%) in a greenhouse can lead to disorders, such as poor or incomplete pollination, sunburn, fruit cracking and red fruit.

Disease and management
The major pests and diseases, their symptoms and their management in capsicum are given below.

Thrips

Symptoms: Thrips cause upward curling of leaves, sucks sap and reduce leaf growth, plant growth, yield and market value of produce. It also reduces leaf area and hinders absorption of nutrients and water by the plants. Increased infestation leads to blackening and drying of leaves and irregular fruit bearing.

Management: Remove affected plant parts including leaves, flowers and fruits. Keep the plots clean by removing all the dropped plant parts. Spray acephate (1.5 g/L) or Imidacloprid (0.5 ml/L) for better result and adopt integrated approach.

Mites

Symptoms: Young larvae and adults feed on leaves, bud and fruits, suck sap from plant parts which in turn causes downward curling of leaves. The size of leaf, fruit and plants gets reduced, affecting the market value of the produce. This pest infestation increases with increased temperature coupled with high humidity.

Management: Remove the pest damaged plant parts including leaves, flowers and fruits and spray dicofol (2 ml/L) or wettable sulphur (2 ml/L) or abamectin (0.5 ml/L) or ecomite or chlorophenapyr (1 ml/L).

Aphids

Symptoms: Nymphs and adult aphids suck sap from leaf veins and younger leaves resulting in reduced plant growth and decrease in yield. Its infestation not only causes curling of leaves but also spreads viral diseases.

Management: Keep a close watch on the plants at regular intervals for aphids’ infestation. Spray imidacloprid (0.5ml/L) or thiomethoxam (0.5g/L) or dimethoate (2ml/L). Use reflective mulches and apply weed control.

Mites infected leaves of capsicum

Fruit borer

Symptoms: Fruit borers are very active during night. The adults lay eggs on fruits, flowers and leaves in large number and the nymphs that come out of eggs, feed on fruits and leaves causing heavy destruction of crops and severely affects the quality of the produce. Whenever night temperature is low, coupled with cool and high humidity the infestation is increased. Since eggs are laid in group, the larva also feeds gregariously on leaves at one place, which can be easily identified and destroyed.

Management: Pick and destroy nymphs and adult insects. Generally eggs are laid and hatch in groups, which is easy to identify from a distance. Hence they should be identified and destroyed immediately. Spray thiodicarb (1 ml/L) or carbaryl (3 g/L) or indoxcarb (1 ml/L) fipronil (1 ml/L).

Nematodes

Symptoms: Nematodes are commonly seen in solanaceous crops when grown 3-4 times continuously in the same field. Initially yellowing of leaves can be observed followed by reduction in leaf size, count and drastic reduction in size of fruits. When infected plant is uprooted and observed, small and big nodes filled with large number of nematodes nodules can be observed on roots depending on the level of infestation.

Management: Cotation with non-solanaceous crops like marigold, sweet corn and cabbage may be followed to avoid nematode. Bio-pesticides enriched neem cake (as explained earlier) is to be applied @ 800 kg/acre 4-5 days before transplanting to the beds. Apply carbofuran (furadan) granules @ 20 kg/acre at the time of planting. Keep a close watch on nematode infestation of the plants, particularly in 2nd and 3rd crop. The insecticides should always be mixed with spreader or sticker while spraying. The plants from top to bottom should come in contact with spray for better result and adopt integrated approach for better plant growth, use root-knot nematode-resistant varieties, fumigate infested soil.

Damping off

Symptoms: Infection takes place at the base of the young seedlings just above the ground level which leads to wilting and later death of seedlings. Any damage caused to seedlings while transplanting can also lead to damping off or seedling wilt besides fresh infection in main field or infection that is carried from nursery.

Management: Drench carbendazim (1 g/L) or metalaxyl MZ (2 g/L) or copper oxychloride (3 g/L) or captan (3 g/L) drenched to the base of the plant at about 25-50 ml/plant.

Powdery mildew

Symptoms: The disease initially appears as tiny yellow spots on surface of leaf and powder like material on the lower surface leading to a powdery growth covering the entire lower surface of leaf which leads to drying and dropping of leaves at later stages. The disease reduces growth of leaves and fruits leading to low quality and quantity of the produce.
Management: Spray wettable sulphur (2 g/L) or penconazole (0.5 ml/L) or flusilazole (0.5 ml/L).

Cercospora leaf spot

Symptoms: Cercospora appears initially as tiny yellow spot on leaf surface leading to increased dark grey spots which spreads on entire leaf resulting in dropping of leaf.

Management: Spray chlorothalonil (2.5 g/L) or mancozeb (2.5 g/L) or carbendazim (1 g/L).

Phytophthora

Symptoms: This disease appears during fruiting and flowering stage resulting in tiny oil like spot on leaf surface resulting in rottening and blackening of plants. Later plant weakens and dies in 2-3 days. Heavy and continuous rainfalls coupled with high humidity favour disease appearance and its quick spread. Phytophthora disease is relatively more severe in net houses which may lead to 40-80% crop damage.

Management: Spray copper hydroxyl chloride (3 g/L) or Ridomil (2 g/L) or azoxystrobin (0.5 ml/L). Severely infected plant parts should be destroyed. It is better to avoid capsicum cultivation in severely affected net-houses.

Viral diseases

Symptoms: Viral diseases are transmitted through aphids and thrips leading to upward and downward curling of leaves with yellow spot in the middle of leaf and sometimes on fruit also. Heavy infestation leads to dropping of leaves, stunted plant growth and reduces quality and quantity of fruits. Virus affected fruits are unmarketable.

Management: Grow nursery beds under nylon cover (50 mesh), proper management of aphids, mites and thrips which act as disease transmitting vectors and disposal of diseased/infected plants, control infestations of viral diseases.

Challenges in capsicum cultivation under polyhouse.

High capital investment: Capsicum cultivation under polyhouse requires high initial investment for creating structures, therefore, there is a need for developing low cost poly house designs suitable for various agro climatic zones. There is also a growing need for credit for meeting working capital and post-harvest facilities as well as banks need to channelize credit facilities for promotion of polyhouse cultivation.

High cost of planting material: The cost of imported seeds and planting materials of capsicum for polyhouse conditions is very high. Though, government provides 50% subsidy for initial year for purchasing planting materials and cultivation of capsicum under polyhouse which is not sufficient for sustainability. Thus, the subsidy scheme for planting materials may be continued every year and also there is a need for developing domestic varieties for higher productivity and quality.

Lack of proper marketing facilities: There is a need for formation of farmer’s producer’s organization and linking farmers with super markets for assured and sustainable income.

Incidence of pest and diseases: There is a need to educate the farmers about the management of pests and diseases for polyhouse cultivation through the department of horticulture and other line departments for providing technical guidance to the farmers.

Advantages of capsicum cultivation under polyhouse

• Higher productivity and profitability
• Better quality of produce
• Efficient use of water and fertilizers
• Better management of pests and diseases
• Off-season production
• Additional employment generation

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Leaf curl virus disease in capsicum
Menthol mint cultivation – Step towards Atmanirbhar Bharat

Improving farmer’s income through technological intervention is the urgent need in rural areas for making Indian farmers self-dependent and achieving Atmanirbhar Bharat dream for better India. Adoption of improved package of practice developed for menthol mint cultivation is needed to get higher returns and crop diversification. Menthol mint is grown for menthol used in pharmaceutical and flavour industry. India is a leading supplier of menthol mint oil to the world, and a large number of farmers in India are being benefitted by its cultivation. Menthol mint is today a major industrial crop, thanks to research scientists for providing farmers with high oil-yielding superior varieties of the mint plant.

Among different essential oils produced in India today, Mentha arvensis (menthol mint) oil holds prominent position in terms of acreage under the crop production and domestic consumption and export to the world market. Today India is the largest producer and exporter of natural menthol in the world. The annual turnover of the menthol industry has been in the range of ₹3,500–4,000 crores during the past one decade. Menthol mint is presently cultivated in more than 2.50 lakh hectares land of North India. It is believed that over 5 lakh farming families grow menthol mint crop contributing 75–80% global menthol mint oil produce. Uttar Pradesh contributes about 70–75% of the total national production of menthol mint oil. Menthol mint yields 130–150 kg mint oil/ha (single harvest) giving a net profit in the range of ₹60–70,000 in about 3 and a half months. Taking the lesson of success of menthol mint cultivation from the farmers of UP, the area under mint is now spreading to other states in the country including Bihar, parts of Punjab.

CSIR, in its efforts to improve the socioeconomic status of people in the country who are at the bottom of the pyramid of life, is focusing to bring S&T interventions in the areas of health, agriculture, and energy, resulting in equitable and inclusive growth. One such classic example of the proper utilization of a CSIR technology for the economic empowerment of rural India is the cultivation of superior varieties of mint, commonly called Pudina. India today dominates the world market contributing about 80% (30,000 tons) of menthol mint in various forms – Menthol crystals and powder, demontholised mint oil, and arvensis oil. Mint cultivation occupies 300,000 ha across the country. Over 90% of the mint cultivated area is covered by CSIR developed varieties. Continuous development and deployment of improved high-oil yielding, short duration, location-specific varieties and related agrotechnologies is a part of CSIR success stories in promoting

Overview of menthol mint field
Mint cultivation. Further value-addition has taken place through improved distillation process and products. Most importantly, CSIR, with its mint production enhancement technologies has generated employment to the extent of 648 lakh man days in the farms and 162 lakh man days in the industry.

**Improved varieties**

**Kosi:** The high-yielding variety Kosi developed through half-sib progeny selection, is tall with robust growth and wider adaptability in different parts of the country. The variety is early maturing by about 10 days, and the essential oil is containing 75–78% menthol. On an average it gives 100-125 q/acre herb yield with oil content of 0.6–0.7%. It gives the highest herb and oil yield when harvested at 150 days after planting. The per capita productivity of a superior variety Kosi, enabled farmers to take this crop as a bonus between Rabi and Kharif.

**CIM-Saryu:** Another high-yielding variety developed with large canopy and huge biomass. The leaf fall is less as compared to other varieties and is also tolerant to sudden rainfall at maturity. The variety yields 140–150 kg essential oil /ha containing 78–80% menthol.

**CIM-Kranti:** The improved variety ‘CIM-Kranti’ of menthol mint has been developed through half-sib progeny selection. The variety is cold and frost tolerant and has the potential to produce higher oil (≤100 kg/ha oil having 80% menthol) when grown in winter compared to all popular commercial varieties. However, during winter (September to January) when all other varieties suffer senescence by the cold and frost conditions, CIM-Kranti remains green in the field. During this period, the variety CIM-Kranti growing vigorously yields two to three times higher essential oil, compared to the popular commercial varieties Kosi and CIM-Saryu. The oil yield during the main summer crop from this variety is 10–12% higher compared to the best check varieties. Hence, this variety is suitable for commercial cultivation to generate additional income without any extra input during both winter and summer seasons.

**CIM-Vishisht:** The variety CIM-Vishisht rich in pulegone was developed through a half-sib progeny selection in menthol mint cultivar, Shivalik. The new variety has the potential of yielding 60 kg/ha of essential oil rich in pulegone in the range of 65–68%. The pulegone has wide usage in aromatherapy, flavouring agents, perfumery, etc. and also can be chemically converted into some other important compounds like menthone, carvone or thymol and into high value commercially important menthofuran through biotransformation. Therefore, this new variety CIM-Vishisht will be helpful in opening new avenues for industry and research.

**Other mint varieties**

Some of the prominent varieties of mint developed by CSIR include: Sambhav, Ganga, Damroo, Neerkalka, CIM-Indus, CIM-Patra, Anant Carvomint, and CIM-Madhuras.

**Neerkalka** is a hybrid mint plant developed by employing sexual crossing between *Mentha arvensis* and *Mentha spicat*. It has high oil yield and shows combined characteristics typical of both parent plants. Another CSIR developed variety of mentha, CIM-Indus contains menthofuran, one of the major aromatic constituents of the essential oil extracted from the leaves of *Mentha piperita*. Another high menthofuran containing mint genotype is CIM-Patra, which is an ideal candidate for commercial utilization. Yet another CSIR developed variety of sweet smelling peppermint (*Mentha piperita*) christened CIM-Madhuras produces characteristic essential oil having medicinal, therapeutic and beverage properties.

**Cultivation**

**Climatic requirements:** Mentha can be grown all over India, wherever assured irrigation is available. It needs a well distributed rainfall of 200-250 cm and bright sunshine for good growth.

**Soil Type:** Well-drained, sandy loam to loamy soil with moderate to high organic matter, is best for this crop. The soil should be free from acidity, salinity, alkalinity and water-logging.


**Time of planting:** The best planting time is the mid-January to the end of January, however, Kosi should be planted from end of January to mid of February. The crop can also be raised by transplanting in April.

**Seed rate:** Mentha is propagated through suckers. About 2 q of freshly dug 5-8 cm long suckers are enough for one acre.

**Method of planting:** The suckers are laid end to end, 4-5 cm deep in furrows, 45 cm apart and are then covered with soil by planking lightly. For higher biomass production and water saving, planting should be done on 67.5 cm wide beds (two rows) or ridges should be made at 60 cm spacing after broadcasting the suckers. Apply 24 q of paddy straw mulch per acre and apply a light irrigation after planting.
Indian Horticulture

Use two quintals of disease free sucker for planting an acre.

Do not plant sprouted suckers, as most of such suckers die.

Sow the crop during mid January to end January, however, Kosi variety can be sown up to mid February.

For water saving and higher yield, sow the crop on beds/ ridges and apply paddy straw mulch @ 24 q / acre.

For higher returns, grow mentha as an intercrop in sunflower/sugarcane or onion as an intercrop in mentha.

**Intercropping**

Mentha can also be grown as intercrop.

**a) Sugarcane + mentha intercropping:** Plant one row of mentha between two rows of sugarcane. Mentha and sugarcane can be planted simultaneously in the first fortnight of February. Use one quintal of mentha suckers per acre. In addition to fertilizers recommended to sugarcane, apply 18 kg N (39 kg urea) and 10 kg P₂O₅ (62 kg super phosphate) per acre. Half N and full phosphorus may be applied at planting and remaining half N about 40 days after planting. Take only one cutting of mentha.

**b) Sunflower + mentha intercropping:**

Mentha can be successfully intercropped with sunflower. Sow two rows of mentha in end January between two lines of sunflower grown at 120 cm × 15 cm in North-South direction. Use 150 kg of mentha suckers per acre. In addition to fertilizers recommended to sunflower, apply 23 kg N (50 kg urea) and 12 kg P₂O₅ (75 kg single superphosphate) per acre. Full phosphorus and half nitrogen be applied at planting and remaining half nitrogen at 40 days after planting.

**c) Mentha + Onion intercropping:** Onion can be grown as intercrop in mentha. Both mentha and onion should be planted simultaneously from the mid-January to end January. Plant one row of onion in between the two rows of mentha planted at 45 cm, keeping plant to plant spacing of onion at 7.5 cm. Apply 13 kg N (29 kg urea), 7 kg P₂O₅ (44 kg SSP) and 7 kg K₂O (12 kg MOP) per acre in addition to recommended fertilizer of mentha. Full phosphorus and potash and half nitrogen be applied at planting and the remaining half nitrogen about 40 days after planting.

**Fertilizer application:** Mentha responds favourably to organic manuring. Apply 10-15 tonnes of well-rotten farmyard manure per acre before planting. The following quantities of inorganic fertilizers are recommended: Nutrients (kg/acre), Fertilizers (kg/acre) N, P₂O₅, Urea, DAP* or Single Superphosphate 60, 16, 130, 35, 100.* When 35 kg DAP is used, apply 115 kg urea per acre. Drill one-fourth of nitrogen and the full quantity of phosphorus at planting. Apply another one fourth of nitrogen about 40 days after planting. Add the remaining

Processed mentha oil

Distillation units for extracting mentha oil
half dose of nitrogen in two equal splits after the first cutting of the crop. The first split may be applied immediately and the second split 40 days afterwards.

**Irrigation:** Mentha requires frequent but light irrigations. Irrigate at 10 days interval till the end of March and at five or six days interval till the onset of the monsoon. During the rainy season, irrigate according to the need.

**Drip irrigation and fertigation:** Menthol mint should be drip irrigated at 3 days interval with a lateral pipe having dripper discharge of 2.2 litre per hour and dripper placed at 30 cm apart as per following schedule: Fertigate with first $1/10^6$ of N and $P_2O_5$ with first irrigation just after planting and thereafter, remaining 9 doses of N and $P_2O_5$ should be fertigated in 9 equal splits at 9 days interval starting one month after planting. This will result in about 25% higher oil yield along with saving of 36% irrigation water and 20% nutrients over check basin. Use urea (46%) and mono ammonium phosphate (12-61-0 grade) for supplying N and $P_2O_5$ respectively.

**Weed control:** In the early stages of growth, a wheel-hoe may be used.

**Harvesting and yield:** The crop should preferably be harvested at the flower initiation stage. If the lower leaves of the plants turn yellow and start shedding, harvesting may be done earlier. Harvest the crop, leaving 6-8 cm long stumps to secure better sprouting. Two cuttings can be taken, first in June and the second in September. The yield of the crop is 100-125 quintals per acre of fresh herbs which contains 0.5 to 0.75% oil.

**Processing and marketing**

After harvesting, allow the crop to wilt overnight in the field and subject it to simple distillation. Some private distillation units provide facilities for farmers to extract oil. The farmers are advised to plant mentha only in that area where the distillation units are available.

**Plant protection**

**Insect pests**

1. **Termite (Odentotermes obsesus):** Termites attack the underground parts of the plants and damage the roots and the stems of mentha.
2. **Cutworm (Agrotis spp.):** Cutworms cut the young plants at the ground-level. They remain hidden near the base of the plants during day-time.
3. **Jassid and Whitefly:** The attack of these sucking pests adversely affects the plant growth and oil content.
4. **Hairy caterpillars:** Hairy caterpillars, if appearing in an epidemic form, cause serious damage by feeding on the leaves and the tender stems. When young, they feed gregariously. The grown up caterpillars may migrate from one field to another.

Farmers are advised to adopt the following control measures:

- Young larvae are gregarious. They can be destroyed by plucking the infested leaves or by pulling out the infested plants and burying them underground. The grown up caterpillars can be destroyed by crushing them under feet.

**Diseases**

Root rot and Stem rot (**Rhizoctonia bataticola**): The infected portion shows brown lesions which turn dark and later increase in size. The leaves wither and die. Infected plants should be uprooted and destroyed. Planting stock should not be from an infected field. Mentha farming should be avoided year after year in the same field.

**Conclusion**

India has now attained the distinction of being the largest exporter of menthol mint and its oil. Touching the lives of rural masses through S&T interventions, the story of cultivating superior varieties of mint by Indian farmers unquestionably proves that scientific research is all set to transform rural India by bringing equitable and inclusive growth, which is reflected in enhancing the socio-economic status of the rural populace.

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Sharda – New variety of okra

The okra or lady’s finger (Abelmoschus esculantus (L.) Monch) is a gift from African continent to the people of other parts of the world. There are altogether 38 species of genus Abelmoschus under family - Malvaceae. It is an important vegetable crop grown in summer and rainy season but in coastal region of Maharashtra, it is grown throughout the year. Okra is rich source of vitamins, minerals such as calcium, iron, potassium, iodine and dietary fiber too. Tender green fruits are fried to prepare Bhujia and cooked in curry, soups and stews which are also popular dishes. The fruits also help in case of renal colic, goiter, leucorrhoea and general anemia especially in poor women.

Due to massive okra improvement programme going on at several Research Institutes and SAU’s in India, over two dozen HYV’s of this vegetable, have been developed and released for commercial cultivation. Owing to this systematic research programme, India has bagged first position in okra production in world. It produces 5,784 thousand tonnes which is 72% of total okra production of world. Although many varieties of green colour of okra have been developed but red / scarlet red colour varieties are few. Another challenge in okra cultivation is yellow vein mosaic disease which reduces the yield up to 90-95% in severe attack. Fruits of Sharda variety of okra are scarlet red colour and crop is field resistant to yellow vain mosaic disease. Its yielding ability is 200-215 q/ha under intensive cultivation.

After continuous several years of mutation breeding programme to develop a HYV of scarlet red colour okra, AKS University has given a gift of scarlet red colour variety of okra to the farmers of Vindhya region of Satna during November 2019.

Fruits of Sharda variety of okra are 24-25 cm long having five ridges and have good cooking quality as compared to green colour varieties. Commercial cultivation of this variety will improve the economic conditions of vegetable growers of Madhya Pradesh and India too.

This variety is named after name of Maa Goddess – Sharda of Maihar (Madhya Pradesh).

The data on growth and yield parameters of 10 varieties of okra presented in Table 1 revealed that variety Sharda is the most promising variety with an yield of 215 q/ha. Its fruit are longer (24.50 cm) than other varieties and scarlet red in colour. Regular consumption of this variety will check anemia and goiter disease in poor women. Organoleptic test conducted on above varieties showed that variety Sharda is more tasty as compared to rest of the varieties. Sharda variety of okra attracts consumers in the market due to its longer length of fruits and attractive colour.

Agro-technique for growing Sharda:
1. Time of sowing:
   * In summer – Middle of February.
   * In rainy season – Middle of June.
2. Land requirement – Sandy loam soil most suitable.
3. Land preparations – 3 ploughings followed by planking.
5. Fertilizers –
   * Single super phosphate – 350 kg/ha
   * Muriate of Potash – 125 kg/ha
   * Urea – 137 kg/ha

N.B. – Total FYM, Single Super Phosphate and Muriate of Potash will be applied at the time of field.
Table 1. Growth and yield parameters of different varieties of okra in agro-climatic condition of Satna (MP)

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Plant height (cm)</th>
<th>Number of branches / plant</th>
<th>Days to 50% flowering</th>
<th>Fruit colour</th>
<th>Fruit length (cm)</th>
<th>Fruit diameter (cm)</th>
<th>Yield (q / ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pusa Sawani</td>
<td>99.50</td>
<td>3.40</td>
<td>46</td>
<td>Light green</td>
<td>14.50</td>
<td>1.90</td>
<td>140.26</td>
</tr>
<tr>
<td>Parbhani Kranti</td>
<td>118.00</td>
<td>4.00</td>
<td>45</td>
<td>Light green</td>
<td>15.80</td>
<td>2.15</td>
<td>180.75</td>
</tr>
<tr>
<td>Punjab Padmini</td>
<td>122.45</td>
<td>3.25</td>
<td>35</td>
<td>Medium green</td>
<td>16.25</td>
<td>2.25</td>
<td>178.36</td>
</tr>
<tr>
<td>Varsha Uphaar</td>
<td>92.75</td>
<td>3.50</td>
<td>38</td>
<td>Dark green</td>
<td>17.55</td>
<td>2.20</td>
<td>181.00</td>
</tr>
<tr>
<td>Arka Anamika</td>
<td>124.80</td>
<td>3.25</td>
<td>44</td>
<td>Light green</td>
<td>18.00</td>
<td>2.30</td>
<td>190.00</td>
</tr>
<tr>
<td>Arka Abhay</td>
<td>123.25</td>
<td>3.16</td>
<td>41</td>
<td>Dark green</td>
<td>20.15</td>
<td>2.25</td>
<td>185.50</td>
</tr>
<tr>
<td>Co-1</td>
<td>115.00</td>
<td>3.00</td>
<td>42</td>
<td>Scarlet red</td>
<td>22.50</td>
<td>2.25</td>
<td>186.20</td>
</tr>
<tr>
<td>Pusa Makhmali</td>
<td>91.80</td>
<td>3.00</td>
<td>40</td>
<td>Medium green</td>
<td>12.00</td>
<td>1.85</td>
<td>138.80</td>
</tr>
<tr>
<td>Hisar Naveen</td>
<td>121.00</td>
<td>2.50</td>
<td>37</td>
<td>Light green</td>
<td>15.00</td>
<td>2.28</td>
<td>177.95</td>
</tr>
<tr>
<td>Sharda</td>
<td>135.00</td>
<td>3.75</td>
<td>42</td>
<td>Scarlet red</td>
<td>24.50</td>
<td>2.48</td>
<td>215.55</td>
</tr>
</tbody>
</table>

preparation however, urea will be applied in two split doses at 25 and 40 days after sowing of crop.

6. Seed rate –
   • For summer season crop 18-20 kg/ha
   • For rainy season crop 10-12 kg/ha.

7. Spacing –
   • For summer season crop – 60 cm × 25 cm
   • For rainy season crop – 75 cm × 30 cm

8. Irrigation – Irrigate the crop after every second or third day in summer only.

9. Yield –
   • Summer Season Crop – 125 q/ha
   • Rainy season Crop – 200 q/ha

10. Seed yield – From rainy season crop only 12 q/ha

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Healthy crop of Okra variety Sharda
Single plant of Okra Variety Sharda
Indian Horticulture

Scientific cultivation of *kharif* onion

Onion (*Allium cepa* L), an important commercial bulb vegetable crop, comes under family Alliaceae. It has originated in central Asia and is extensively cultivated all over the world, mainly in China, India, Netherlands, Pakistan, Bangladesh and Australia. India is the second largest producer of onion. As per monthly report of the Horticulture Statistics Division, Department of Agriculture, Co-operation and Farmers Welfare, Government of India, New Delhi (March, 2020) the total onion production of India is 228.19 lakh tonnes out of which share of *kharif* onion is 48.41 lakh tonnes, late *kharif* onion 21.50 and *rabi* onion 158.28 lakh tonnes. The major onion producing states in India are Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Bihar, Gujarat, Andhra Pradesh, Haryana, West Bengal and Uttar Pradesh. *Kharif* onion is mainly grown in Maharashtra, Karnataka, Gujarat with new emerging areas in parts of Madhya Pradesh, Rajasthan and Uttar Pradesh. These states account for almost 90% of the total onion production of the country. Maharashtra is the largest producer of onion with about 8,047 thousands tonnes having share of 35.26% in 2018-19.

In India, onion is produced in three seasons i.e. *kharif*, late *kharif* and *rabi*. About 21.21% production comes from *kharif* crops. The *kharif* onion is transplanted during July to August and probably harvested during October to November. The major portion of the *rabi* season onion crop can be stored throughout the India. This stored onion becomes available during May to October but there may be critical gap in supply of onion during October to December in the country. So the *kharif* onion crop plays key and vital role in fulfilling consumers’ demand in the country and hence, there is a need to popularize *kharif* onion cultivation which will also help to regulate the onion prices.

**Soil**

Soils for onion cultivation should be light, deep friable and highly fertile. Sandy soil needs more and frequent irrigation along with additional supplement of FYM or compost. In general, sandy loam to clay loam soil is more suitable. The optimum pH range required is between 6.0 and 7.5. Highly alkaline and saline soils are not suitable for onion cultivation. Addition of well decomposed organic manure helps in improving fertility status of soil besides improving the soil physical conditions and availability of microorganisms. Onions are very much sensitive to the effects of high water table, so well drained soils are best.

**Selection of suitable onion varieties for *kharif* season**

An ideal variety should have characters like early bulking, thin neck, resistance to pest, diseases and tolerance to water logging. Generally variety having 90 to 105 days duration with thin neck is to be preferred for *kharif* season. Some suitable varieties of *kharif* onion are as below.

**Agrifound Dark Red:** This variety, developed by National Horticultural Research and Development Foundation (NHRDF), is very old. It is recommended as *kharif* variety in all over the country.

**Arka Kalyan:** This variety, developed through vigorous mass selection from ICAR-IIHR, Bengaluru, is also among old variety suitable for *kharif* season.

**Baswant -780:** *Kharif* and late *kharif* variety was developed by Mahatma Phule Krushi Vidyapeet, Rahuri, Maharashtra.

**Bhima Dark Red:** This variety was developed by ICAR-DOGR, Rajgurunagar, Pune, Maharashtra. It is recommended as *kharif* variety for Gujarat, Maharashtra, Rajasthan, Delhi, Haryana, Karnataka, Madhya Pradesh, Tamil Nadu and Punjab.

**Bhima Raj:** Variety developed by ICAR-DOGR, Rajgurunagar, Pune, Maharashtra. It is recommended as *kharif* and late *kharif* variety for Gujarat, Maharashtra and Rajasthan and as *rabi* for Delhi, Gujarat, Rajasthan and Haryana.

**Bhima Red:** Variety developed by ICAR-DOGR, Rajgurunagar, Pune, Maharashtra, is recommended as *kharif* variety for Gujarat, Maharashtra, Rajasthan, Delhi, Haryana, Karnataka, Madhya Pradesh, Tamil Nadu, Punjab and as *rabi* for Maharashtra and Madhya Pradesh.

**Bhima Safed:** It is recommended for *kharif* season for Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Tamil Nadu.
Bhima Shubhra: The variety was developed by ICAR-DOGR, Rajgurunagar, Pune, Maharashtra, is recommended for kharif season for Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Tamil Nadu. It can be also cultivated during late kharif season.

Bhima Shweta: This variety was developed by ICAR-DOGR, Rajgurunagar, Pune, Maharashtra. It is recommended as kharif variety for Chhattisgarh, Karnataka, Maharashtra, Rajasthan, Madhya Pradesh, Odisa and Tamil Nadu and as rabi for Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Odisa, Uttar Pradesh and Punjab.

Bhima Super: Variety developed by ICAR-Directorate of Onion and Garlic Research (DOGR), Rajgurunagar, Pune, Maharashtra, is recommended as kharif and late kharif variety for Delhi, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Punjab and Odisha.

Line-883: This variety was developed by National Horticultural Research and Development Foundation (NHRDF). It is recommended as kharif and early kharif variety in all over the country.

N-53: It is very old kharif variety developed by Agriculture Department of Maharashtra, but now breeder seed is not available.

Phule Samarth: A kharif and late kharif variety developed by Mahatma Phule Krushi Vidyapeet, Rahuri, Maharashtra.

Pusa Riddhi: This variety was developed by IARI, Delhi. It is suitable for kharif and rabi crop storage and export.

Nursery management and transplanting

Well drained sandy loam soil rich in organic matter with sufficient land slope is preferred for nursery raising of kharif crop onion. Water stagnation during nursery stage in kharif season favours fungal diseases infection. The land should be prepared well in advance with repeated ploughing and harrowing to obtain a fine tilth. Areas where nursery is severely affected by damping off or soil borne diseases needs soil solarization treatments. Such nursery area should be irrigated lightly and covered with 200 gauge transparent white polythene during March to May where soil temperature rises up to 50°C for about 6-7 weeks. After 6-7 weeks, polythene sheet cover is to be removed and prepare the beds for kharif onion crop nursery. For raising nursery, raised bed of about 2-3 m length, 1-1.5 m width and 15-20 m height to be prepared. Apply 8-10 kg well decomposed farmyard manure (FYM) and 150 g 19:19:19 (NPK fertilizer) and copper oxychloride at 50 g per bed at the time of bed preparation and mix well with soil or apply well decomposed farmyard manure (FYM) @ 1 kg, 0.5 g nitrogen, 5 g phosphorus and 5 g potassium per m² area as basal dose and rest 0.5 g nitrogen per m² area is to be top dressed at 20 days after sowing. *Trichoderma harzianum* (30 g) is to be applied into the bed through well decomposed organic manures or application of *Trichoderma* @ 1.25 kg/ha is also recommended to manage damping off and raise healthy seedlings. Raised bed is recommended for nursery because as in case of the flat bed, water moves from one end to the other and there is a possibility of washing away of seeds as well as water logging in heavy soils. In sandy soils, however, sowing can be taken up in flat beds. For transplanting one hectare area, about 8-10 kg seed is required for nursery raising. If the nursery is raised using drip or sprinkler irrigation system, the seed rate of about 5-7 kg/ha is sufficient. Before sowing, the seeds are to be treated with captan or carbendazim @ 2-3 g/kg of seed. Treated and packed seeds do not require treatment again. The seed should be sown into line with spacing of about 5 to 7.5 cm in the lines at depth of 1-1.5 cm. The seeds after sowing to be covered with fine powdered farmyard manure or compost followed by light watering. Then the beds should be covered with dry straw to maintain optimum temperature and moisture. Watering should be done by a water can as per the need till germination is completed in small areas. In case of bigger areas it can be irrigated through flood if drip or sprinkler is not available, by filling the water in canals on both sides of the nursery raised beds. Nursery of onion can also be successfully raised on drip or sprinkler irrigation on raised beds. Dry straw or grass to be removed immediately after germination is completed in about
6 to 8 days after sowing. Delay in removal of dry straw and grass may result in lanky growth and yellowing of seedlings. Two hand weeding found effectively controlling the weed population in onion nursery during kharif season. In case of weedicide, it is advised to spray only pendimethalin @ 2 ml/l of water before onion seed germination followed by hand weeding at 20-25 days after sowing. The nursery should be protected by green shed net (above 2 m height) during hot summer and rainy season. Onion seedling in nursery can be attacked by different insect pests and diseases. So some control measures are to be taken for getting healthy, pest and diseases free seedlings. Thrips is a major pest of onion. Spray with fipronil 5 SC @ 1 ml/l of water or carbosulfan 25% EC @ 2 ml/l of water is effective to control thrips. Sticker is to be used during rainy season. Cloudy weather and dew formation favours fungal diseases like root rot, damping off, wilt etc. Spray the seedlings with mancozeb @ 2.5 g or hexaconazole 1 g/l of water to control black and brown blight diseases. Stagnation of water and inadequate drainage favours seedling root rot (fungal disease) in nursery. Root rot can be controlled by drenching of copper oxychloride @ 3 g/l of water. Drenching of metalaxyl 4% + mancozeb 64% @ 2 g/l of water between the rows controls wilt and damping off fungal diseases. Seedling may becomes yellow due to heavy nutrient loss through leaching therefore, foliar spray of 19:19:19 and micronutrients mixture (Zn 3%, Fe 2.5%, Mn 1%, Cu 1% and B 0.5%) at 20 days after sowing as per the recommended dose or scientists advise can control the deficiencies.

Kharif (rainy) season onion crop should be always transplanted on raised bed. About 40-45 days age old seedlings should be transplanted in the main field at spacing 15 × 10 cm. Seedlings of 0.8-0.9 cm in stem diameter and 20-35 cm height are optimum for transplanting. One third top portion of the seedlings is to be cut at the time of transplanting.

Over-aged seedlings if planted results in more bolting, more double bulbs, thick neck bulbs or small size bulbs. In case of younger seedlings, establishment seems poor. It is recommended for dipping of onion seedling roots into solution of fungicide carbendazim @ 1 g/l of water and insecticide carbosulfan @ 2 ml/l of water before transplanting for 2 h to control pest and diseases. The duration of seedlings root dipping may be changed as per recommendations of State Agricultural Universities and can be confirmed by the experts.

Nutrient management

Ideal nutrient requirement depends upon soil type, available nutrient status of the soil and removal of nutrients by crop, etc. A nutrient management practice differs as per soil nutrient availability status. For normal

**Oxyfluorfen 23.5% EC @ 1 ml/l of water with quizalofop ethyl 5% EC @ 1 ml/l of water @ 25 DAT +1 hand weeding at 45 DAT.**
soil, well decomposed organic manure @ 25-30 t/ha to be incorporated into the soil 15 days before transplanting. Application of 250 kg neem cake per hectare can be applied as basal. Biofertilizers viz. PSB, Azotobacter @ 5 kg/ha each and Trichoderma 1.25 kg/ha can be applied through well decomposed organic manure or biofertilizers in liquid form can be preferred for easy application through drip irrigation. Bio-agents should not be used with chemical fertilizers or any agrochemicals. As per normal soil nutrient availability status, NPK @ 100:50:50 kg/ha is to be applied. First dose of NPK @ 50:50:50 kg/ha is to be given at the time of transplanting whereas remaining N @ 50 kg/ha to be given in 2 or 3 equal splits at 30 and 45 or 30, 40 and 50 days after transplanting, respectively. Sixty days after transplanting, no nitrogen containing fertilizers should be applied. Apart from major nutrients application through soil application, water soluble fertilizers and micronutrients can be given to enhance growth and yield in onion crop. About 30 and 45 days after transplanting (DAT), 0.5-1% spray of 19:19:19 (NPK) and one spray of 0.5-1% 13:00:45 or 00:00:50 during 60 DAT can give good results. If soils are deficient in micronutrients and plant show deficiency symptoms of particular micronutrients then particular micronutrients to be given as correction measure. Foliar application of micronutrients mixture (Zn 3%, Fe 2.5%, Mn 1%, Cu 1% and B 0.5%) to be done at 30 and 45 days after transplanting based on soil test reports or when plant show deficiency symptoms.

**Weed management**

As onion plants are closely spaced and shallow rooted crops, it is essential to keep the crop weed free, especially 30-45 days from transplanting. Crop weed competition is recorded higher from transplanting till almost 45 days, it may reduce yield up to 60%. Application of weedicide oxyfluorfen 23.5% EC @ 1.5 ml/l of water before transplanting or 8-10 days after transplanting using flat nozzle sprayers followed by one hand weeding at 30 days after transplanting efficiently controls weeds in onion.

Spray of oxyfluorfen 23.5% EC @ 1 ml/l of water with quizalofop ethyl 5% EC @ 1 ml/l of water at 25 days after transplanting followed by one hand weeding at 45 DAT can also give good results.

**Harvesting**

In **kharif** season, since tops do not fall, bulbs are harvested soon after the colour of leaves changes to slightly yellow and tops start drying and red pigmentation on bulbs develops. Developed true shape bulbs to be harvested and kept for drying the tops. The leaves are cut leaving about 2-2.5 cm tops above the bulb after complete drying. In **kharif** season, late harvesting results in doubled bulbs and bolting. The average yield of 10-15 t/ha can be obtained in **kharif** onion crop.

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A practical guide for successful orchid cultivation

Commercially grown orchids are mostly epiphytes. Thus they require different growing conditions as compared to other normal flower plants. As a result of this, domesticating them as a potted plant is quite difficult. They require special management practices and special care. In this article we will discuss about the good agricultural practices for orchids that can make orchid cultivation as a potted plant easier and help the growers to overcome the difficulties faced during growing orchids.

Orchids generally require good aeration for their roots, at the same time, scarcity of water will hamper the growth and vigour of the plant. So someone growing orchids should be careful about providing good aeration to the orchid roots and at the same time sufficient moisture. For that, orchid growing media need to be porous with good water holding capacity. ICAR-NRCo recommend brick piece/stone, leaf mould, coconut husk and semi rotten logs in the ratio of 1:1:1:1 for potting of orchids. They supply proper aeration, and will retain good quantity of moisture. Thus help proliferation of roots and support the plant to stand erect. With this combination repotting will be done once in every two years.

Potting comprises of two parts, viz. Unpotting the plant from the old container and grooming the plant; Re-potting the plant and staking it if necessary.

Unpotting the plant from the old container and repotting
1. Water the plant first as it makes it easier to remove the old potting material.
2. Retrieve the plant from the pot and remove all the old potting material.
3. Trim dead roots with sterilized shears or scissors.
4. Repot the plant.

Potting monopodial orchids
In contrast to horizontally growing sympodial orchids, monopodial orchids grow vertically. These types of orchids have a single main stem that produces a series of leaves; leaves grow alternately on either side of the stem, like Vanda.
1. Orchid roots will be placed in the pot. The plastic pot size should be just large enough to accommodate the roots. To use a clay pot, use a one size larger pot than the plastic pot, a little more to use clay orchid pot.
2. The plant will be centred and held in the pot, so that the junction of roots and lower leaves flush on the top of the pot.
3. For best results potting media will be well moist (but not dripping wet).
4. When done the base of the plant should be just a little higher so that leaves do not touch the potting media and the top of the roots are just a little bit exposed.
5. Yellow, shrivelled leaves and parts of leaves with spots need to be removed.
6. If necessary, the plants should be staked so that it does not wobble.
7. After two to three months, the stakes should be removed without disturbing the plant.
Potting sympodial orchids

These orchids have a rhizome (main stem) at the base (usually horizontal, at least when they are grown in pots), with a series of growths developing upward from it. On some sympodial orchids such as Cymbidiums, Jumeleas, Paphiopedilum, Phragmipedium, etc., the new growths will be very close to the base of the old growth[s], forming sort of a circle around the older growths. The potting procedure for these type of young plants is similar to monopodial orchids, but for many sympodial orchids, such as Cattleyas, Dendrobiums, Oncidiums, etc. the new growths develop along a rhizome and usually tend to grow in the opposite direction of the old growths. The procedure for potting these is the same as for monopodial orchids except that instead of centring the plant in the pot, one should place it close to one edge of the pot, leaving room on the opposite side of the pot for the new growths.

Care after repotting of orchids

Re-potting is similarly shocking to plants as major surgery is to humans. So for a few weeks after re-potting a plant it is required to nurture it a bit.
1. Their leaves should be sprayed (misted) lightly twice a day for two weeks for healthy plants, up to four weeks for weak and ailing plants. The plant should be sprayed early in the day and again not later than mid-day. Plants should not be watered after 12 noon in the winter.
2. Addition of 2 or 3 drops of superthrive and 2 or 3 drops of a rooting solution to misting water will be very beneficial. If the grower do not have rooting solution, he or she may add a pinch of phosphorus rich fertilizer to the misting water.
3. The newly re-potted plants need to be placed at less light than what they usually get; for 3-4 weeks. The lower light levels will reduce the stress caused by the repotting shock and will help the plants recover better and faster.
4. Plants should be watered lightly (just enough to get the potting material moist, for one week), grower should not add enough water to run through the drainage holes. After one week, the plants will be watered thoroughly once a week. Rooting solution should be used instead of fertilizer for the first 3 or 4 watering after repotting.
5. Plants should not be fertilized just after repotting.

Light requirement for growing orchids

The foliage of the orchids will provide the information regarding light, whether the available light is sufficient for the plant or not or if it is too high?
1. If the leaves of the orchids stay green, crisp and firm, then the light is most probably optimum.
2. If the foliage is dark green, then the light availability is too low.
3. If the foliage shows purplish coloration, then the light is probably too high. Sometimes if the light is too high, the leaves tips will dry up.
   Most orchids will not tolerate direct sunlight, except maybe for an hour or two after sunrise and an hour or two before sunset. Orchids should be provided with some shade, at least for the brightest part of the day. Surrounding trees or tall buildings may provide enough shade. There is a substantial reduction in the light from summer to winter. More light and less shade should be provided at winter (from mid of October to mid of February) to compensate for this natural reduction of light. Although the plants will adapt to changing environments, they will adapt better with less stress, if the plants gradually ease into the new conditions (such as summing them in bright outdoors light). Orchids will adapt to the environment, to some degree. Orchids will tolerate higher levels of light (of their respective light range) if they are provided with more water [more frequent watering], more fertilizer and better air movement [if possible] to keep their leaves a little cooler. More frequent watering means, the orchids will be watered on every five days or so instead of every seven days. This does not mean growers should subject their plants to excessive light. If orchids get too much light but not enough water and fertilizer, they will be stressed. Stressed plants have less deficiencies against pests and diseases, they will be easily attacked by the insects and pests, finally the reproductive growth will be hampered.

Signs of stress

Plants will show several symptoms when they are stressed, like-shrivelling pseudobulbs and/or leaves, drying buds, prematurely wilting flowers, yellowing of leaves etc. This kind of stress can also be resulted from improper potting, decaying potting material and insufficient watering.

Temperature for orchids

Orchids are classified into three basic groups, on the basis of their temperature requirement. Their classifications and favourable temperature are given in the table below:

<table>
<thead>
<tr>
<th>Orchid group</th>
<th>Day time temperature (°C)</th>
<th>Night time temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter</td>
<td>Summer</td>
</tr>
<tr>
<td>Warm growing orchids</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Intermediate temperature growing orchids</td>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td>Cool growing orchids</td>
<td>15</td>
<td>25</td>
</tr>
</tbody>
</table>

Orchid may adapt and acclimate to grow pretty well a few degrees outside of these ranges. Some of the examples of orchids of each group are provided below:

Examples of warm climate orchids

Phalaenopsis (with 60% shade cloth should be provided), Phragmipedium (50% shade cloth should be provided), Cattleya (40% shade cloth should be provided), Catsetum (50% shade cloth should be provided), Vanda and Ascocenda (20-30% shade cloth should be provided), Angraecum and Aerangis (20-30% shade cloth should be provided), Calanthe (40% shade cloth should be provided).
Examples of intermediate climate orchids  
*Oncidium* (20-30% shade cloth is required), *Warm tolerant Cymbidium* (30-40% shade cloth is required), *Miltonia* and *Miltoniopsis* (30% shade cloth is required), *Paphiopedilum* (50% shade cloth is required), *Lycaste* and *Angulola* (50% shade cloth is required), *Bulbophyllum* (50% shade cloth is required).

Examples of cool climate orchids  
*Cymbidium* (30-40% shading should be provided), *Odontoglossum alliance* (60-70% shade cloth should be provided), *Disa uniflora* (50-70% shade cloth should be provided), *Pleione* (50-60% shade cloth should be provided), *Zygopetalum* (40% shade cloth should be provided), *Dendrobium* (30% shading should be provided), *Masdevallia* (70% shading should be provided), *Coelogyne* (50% shading should be provided).

Shed cloths of green colour are generally preferred.

Humidity for growing orchids  
Most of the orchids require 60% to 80% humidity. These humidity levels are necessary for the plants for best flowering and increasing longevity of the flowers. Even, these levels may be slightly higher; they are in fact well within the comfort zone for human, which are 40% to 70% of relative humidity. In the summer time, the natural humidity is usually sufficient to meet the needs of orchids, except on bright, sunny, dry days. Air conditioning in the summer and artificial heat in the winter, especially from forced air heating and electrical baseboard heating, will dry the air well below the need of orchids. Plants placed in the path of air conditioning or in the path of forced air heating or next to a radiator or next to a heat source can get quickly desiccated and lose their buds and even their leaves in just few days. A hygrometer can help to evaluate humidity of the air of the orchid poly house.

Procedures to increase humidity around orchids  
If the humidity levels are consistently too low, growers need to buy a humidifier to increase the humidity level. Another way of increasing humidity is by setting orchid pots on trays filled with pebbles or gravel and with water, but plants should not be in contact with the water. The trays must be wide enough so that the leaves of orchids are over the tray (from where the humidity will raise). A tray for a single plant will not be of much help as the little humidity rising from it will disperse very fast. It is better to have have a dozen or more plants grouped together, they will create a micro climate with higher levels of humidity. The humidifier is the better solution. But mist should not blow directly on your plants as this will eventually wet them and promote bacteria and fungus growth that may kill the infected plants.

Methods of watering your orchids  
The quality of water is extremely important for good culture; rain water is acceptable for watering orchids. Well water or underground water is acceptable if its content of total dissolved Solids (TDS) is below 120 ppm. Hard water (water with mineral contents TDS above 120 PPM) will create hard deposits on the leaves of plants. This may clog the pores on the leaves of plants. If your water is hard it may be beneficial to periodically (once to twice a year) clean the leaves with distilled water. The best water is water processed through a reverse osmosis system which will remove most of the minerals from the water.

Some general rules for watering potted orchids  
1. While watering, grower should be careful to look after the matter that, the potting material should never be soggy. Potted plants must be sufficiently watered to prevent them from becoming bone dry.
2. In general, watering once in a week is optimum, but small pots (5” or less) need more frequent watering than large pots (6” or more).
3. Different potting materials and different sized potting materials will dry at different rates. Clay pots will evaporate more water than plastic pots when other factors are constant, so clay pots will dry faster than plastic pots. Clay orchid pots, because of their openings, will dry out faster than regular clay pots.
4. Finally, temperature, light, air conditioning and heating will influence the drying rates of potting material. Watering habits should be adjusted, as the season changes.
5. By a thumb rule method, one can insert his/her finger an inch or two in the potting media and feel the moisture condition of it, it should be moist not soggy, if not moist, need to add water to moisten it, and if it is soggy; it should be kept for drying.
6. During watering, some water may get in between leaves or new growth. If this water stays there overnight, it may promote the growth of bacteria and fungi that may harm or kill orchids or the new growth of the orchid. To reduce this risk, sound watering practices should be adopted, like
   - Orchid should be watered only on sunny days. If the weather is cool, cloudy or rainy, wait for a day or two before watering.
   - Watering should be done early in the day. This will allow water (that got in between leaves or new growth) to evaporate before nightfall. Watering should be stopped before 2 PM in the summer, before 12 noon in the winter and before 1 PM in the spring.
   - Orchids should be watered with room temperature water or lukewarm water. Because a difference of 10 degrees or more between the temperature of the water and the room temperature may cause injuries to the plants.
7. Watering should be done from the top, and it should continue till the water runs freely through the drainage holes, or the plant may be immersed in water up to 1/2” or so below the rim and it may be allowed to absorb water for 10 minutes or so.
8. Water splashed on the leaves or in between the leaves should be wiped out. Using a straw is a convenient way to flow air and blow out water from in between leaves.
In a 30-10-10 fertilizer formulation, 30% of the total content is nitrogen, 10% phosphorous, and 10% potassium. Nitrogen derived from urea is not readily available to orchid plants, so urea should not be used as an N source to orchids. Also, organic fertilizers are not well suited for orchids. Application of silicon to orchids improves heat and drought tolerance. Orchid requires a higher amount of Ca and Mg as compared to common plants. For young plants, N application is high, for intermediate growth stages, N, P, K applied at a balanced and equal rate, before flowering the rate of P and K need to be increased as compared to N.

1. For young plants (1st year) 30:10:10 @ 0.05% should be applied; dissolving 0.5 g fertilizer having N:P:K composition as 30:10:10 in one litre water will prepare the solution. The prepared solution should be sprayed on the plant and potting materials at an interval of 15 days.

2. For intermediate growth stage (2nd year), 20:20:20 @ 0.05% should be applied; dissolving 0.5 g fertilizer having N:P:K composition as 20:20:20 in one litre water will prepare the solution. The prepared solution should be sprayed on the plant and potting materials at an interval of 15 days. Also, calcium nitrate @ 0.05%, magnesium sulphate @ 0.1%, Iron sulphate @ 50 ppm, boric acid @ 50 ppm, zinc sulphate @ 50 ppm should be applied, at 60 days interval. For this, 0.5 g calcium nitrate, 0.5 g magnesium sulphate, 1 g iron sulphate, 50 mg boric acid, and 50 mg zinc sulphate should be dissolved in one litre water and sprayed on the plant and potting materials at an interval of 60 days.

3. At late growth stages (3rd year on word), N, P, K will be applied as 15:25:25 @ 0.1%; for this 1g of fertilizer having N:P:K composition as 15:25:25 or 10:26:26 should be dissolved in one litre water and sprayed on the plant and potting materials at an interval of 15 days.

Insects and their management

Scale insects are very small organisms (1–2 mm), they secrete a waxy coating for defence and resemble scales. Hard scale looks like tiny turtles. Soft scales may be found in dried sheaths at the base of pseudobulbs of Cattleya or similar plants. Hard scale will usually be under the leaves of Phalaenopsis or Cattleya, sometimes hiding in the pot. Those insects should be removed as much as one can see, then an insecticide may be applied.

Mealybugs are white and look sort of cottony, may be 1/4” in size. They can be on or under the leaves, on flower stems, on buds, behind flowers, in the pot. Those insects should be removed as much as one can see, then an insecticide may be applied.

Aphids are most persistent, reproduce on a 3 day cycle, small sap-sucking insects, varies in colour and they can fly too. They are found on new growth, new leaves, on flower stems and flower buds. In warm sunny weather the plant should be taken outside and shaken by garden hose to remove them from plants. Then the plant may be treated with an insecticide.

Fungus gnats look like small black flies. They will remain hiding in the pot, and get attracted by potting material that stays damp, decaying plant material (dead roots, leaves). They may attack roots, especially those of Cymbidiums. They may be treated by immersing the pot in an insecticide solution.

Spider mites are very small and cannot be seen individually without a magnifying lens. They are found under the leaves, in tiny silvery pits, where they suck the plant juices. They can be managed by maintaining proper humidity, and treating them with an insecticide or miticide. The pot may be immersed in an insecticide/miticide solution.

Thrips are minute slender insects with fringed wings. They are having length of 1 mm or less. They are found in deformed or spotted flowers. They are difficult to eradicate because they tend to lodge in the flower buds and under sheaths where they are protected from insecticide sprays. Deformed or spotted flowers should be removed and destroyed.

For sucking insects stated above, insecticides like, acephate, dimethoate, imidacloprid etc insecticides could be used @ 1 g /l solution.

Slugs are known to emerge at night. They may be found anywhere. Sluggo available in liquid or granular form, may be used to control them. Or they may be removed physically and destroyed.

Treating insects with an insecticide

1. While using commercially available insecticides, one should always follow the directions on the label, and take all possible precautions to avoid poisoning him or herself and others around them.

2. One should never use more than the recommended doses of the pesticide.

3. Safe and effective insecticide may be prepared at home. Soap solution prepared by mixing one teaspoon of a mild liquid dishwashing detergent to a litre of lukewarm water.
4. Many insecticides kill only the adult insects, not necessarily the eggs or the larvae (immature insects). Insects may also develop resistance to insecticides. That means, some of the insects are not affected by the insecticide and they will reproduce again. Treating those insects with the same insecticide will not kill them. To avoid resistance, one can rotate insecticides, that is-first application with one insecticide, the second application with another and the third one either with the first insecticide or with a third one.

5. Rotating is not necessary with the insecticidal soap solution prepared in home, because this insecticidal soap works by suffocating the insects. Only thing is that, the soap solution need to apply frequently so that insects coming out of eggs are also controlled.

6. If the infestation is not excessive, insecticide solution will be sprayed thoroughly on the new growths, leaves (both sides), flower stem, back of buds and flowers. If the infestation is widespread the plant should be dipped in insecticide solution for 15 minutes.

7. For the treatment to be effective one should treat the plants (spraying or immersing) at least three times, at an interval of one week (at an interval of 3-4 days for aphids). More than one application should be made, because the insecticide will kill the adults and a few days later the eggs will hatch and the cycle will restart, unless treatment is repeated again to kill them too.

There are lots of insecticides available on market, some of them are- Chlorpyrifos-methyl, Imidaclorpid, Acetamiprid, Dinotefuran, Thiamethoxam, Malathion, Pirimicarb, Carbosulfan, Lambda-cyhalothrin, Esfenvalerate, Pymetrozine and Diazinon.

**Precaution**

- Plants should be immersed in a solution only on sunny days; if the weather is cool, cloudy or rainy, the day must be avoided.
- It should be done early in the day. This will allow any water that got in between leaves or new growth to evaporate before nightfall.
- The solution should be prepared with room temperature water or lukewarm water.

**Diseases of orchids**

**Viruses**

- Occasionally the growers may come across a plant that has a virus. This may manifest itself by concentric or elongated black or brown or discoloured circles on the leaves or black streaks on flowers and leaves.
- These will be repeated on all leaves / flowers. New leaves / flowers will appear free of it at first, but as they age the virus will manifest itself.
- Unfortunately nothing can be done to manage viral diseases. The plant must be discarded. The plant or infected plant part should be removed and burned or destroyed.

**Bacterial and fungal diseases**

- These will appear if water stays in between leaves or if the potting material stays soggy, especially when the night temperatures are cooler (winter, spring).
- Grower can treat these with fungicides (Ridox, Phentom, Compass, etc.), but the best way is to avoid these problems by practicing proper cultural practices.
- Copper oxychloride (blitox) @ 3 g/l solution can be used against fungus as well as bacteria. Carbendazim @ 1 g/l solution can be used against fungus.

**Cultural problems which are common to most of the orchids and their probable remedies**

**Leaves**

1. *Leaves are dark green, look very healthy, but plant does not bloom:* Probably due to insufficient light, shade should be decreased and the light level must be increased.
2. *Leaves are not as lustrous, eventually they shrivel:* Plant is not absorbing enough water. The root system must be checked. If roots are abundant, healthy, firm and white, then the plant is being under watered. If the root system is not healthy, the plant should be repotted as soon as possible.
3. *Yellowing of leaves (chlorosis), it may be due to excessive light and/or deficiency of nitrogen and/or sulphur, shade must be provided, nutrient should be applied.*
4. *Clear or watery spots on leaves, usually result from fungal/bacterial infection. The plant should be repotted, the plant may be treated with fungicide (Ridox, Phentom, Compass, etc.), and it should be kept relatively dry for a few weeks.*
5. *Discoloured area on top of curled leaves on leaf area exposed to light, it appears most probably due to sunburn or excessive light. Sufficient shade should be provided.*

**Leaves or new growth**

1. Soft, rapid growth may appear due to excessive nitrogen, the application rate of N should be adjusted and reduced.
2. New growths are smaller and stunted, not as plump than previous ones, not growing upright, one should understand that the plant is under stress, either because of weakened root system or insufficient light or too extreme temperatures, deficiency in nitrogen, or a combination of these. Light, temperature levels and fertilizer dosage should be checked. If needed repotting should be done. Sufficient shade and humidity should be provided to the stressed orchids.
3. No or limited new growth may result from nitrogen and/or phosphorous deficiency, or damage / rotting of growth or setback if the plant was divided and left with only one growth. N and P fertilizer should be applied.

**Buds, flowers and flower spikes**

1. Buds become yellow and drop, reasons may be extreme temperature, extreme or insufficient light, too dry air, inadequate watering, micronutrients deficiency or weak root system. Temperature and light should be adjusted at optimum level, and proper fertilizer
management practice as specified earlier must be followed. If root system got too weak due to decaying potting materials then the plant should be re-potted as soon as possible.

2. Flowers do not open up fully, this condition may appear due to genetics, or by too low temperature, or may be due to too low humidity or thrip damage. The humidity and temperature should be adjusted. If it is thrip damage, treat the plant with an insecticide as described earlier.

3. Flowers are too small; colours are not as strong as before, this type of flowers comes most probably due to insufficient light, and or too extreme temperatures. The light and temperature should be adjusted.

4. Flowers fade too fast, this situation may be caused by too high or too low temperature, exposure to direct sunlight, too low humidity, micronutrients deficiency, inadequate watering or poor condition of the root system. Adjusting temperature and light at optimum level, following proper fertilizer management practice as specified earlier may manage the situation. If root system got too weak due to decaying potting materials then the plant should be re-potted as soon as possible.

5. Too few flowers may appear due to weak plant, too low light, phosphorous deficiency. Adjusting the light and following proper fertilizer application procedure will solve the problem.

6. Brown streaks or mosaic patterns on flowers, may be due to presence of a virus.

7. Poor display of flowers reduce the attractiveness of orchid flowers, when buds start to form on the flower spikes, one should not change the orientation of the flower spike so as to get the best possible display of flowers.

Roots

1. Black or brown roots indicate damaged or rotten roots (root rot fungus). Damaged and rotten roots should be cut. Plant may be re-potted, and kept a little drier for few weeks. If rotten roots are many in number, fungicide may be applied.

2. Chewed or missing tips appear due to chewing by pests (millipedes, sowbugs, snails or slugs), an insecticide should be used to control those insects.

3. Dead root tips may be caused by salt built-up due to too hard water or excess fertilizer application or due to not leaching medium regularly. Regular leaching of the media, good quality water application, maintaining proper fertilizer doses can solve this problem.

4. Deformed root may appear due to chlorine deficiency. Stunted roots may appear because of micronutrients deficiency. Proper fertilizer management may solve these problems.

For further interaction, please write to:
Siddhartha Sankar Biswas (Scientist), ICAR-National Research Center for Orchids, Pakyong, Sikkim 737 106. Corresponding author email: siddssac20475@gmail.com
Patchouli cultivation – A boon for resource poor farmers

Patchouli has been identified as one such essential oil bearing aromatic plant with immense export potential. Patchouli oil production could be a rural based, labour intensive, low cost agro-base cottage industry, which will give large-scale employment in rural and hilly areas. Being a shade loving plant, it can easily be grown as an intercrop amidst fruit trees, arecanut and coconut plantation etc. It can also be easily cultivated in flood free fallow or wastelands. This will provide some extra income for the farmers. India can be a key player in the production of this essential aromatic oil. CSIR-CIMAP has done vast research to develop suitable varieties and agro-technology for patchouli farming.

Prospects

Scope and market potential of patchouli cultivation

Patchouli belongs to family Lamiaceae and its botanical name is *Pogostemon cablin*. It is an aromatic herb. This crop is mainly cultivated for its oil and oil is used in manufacturing of perfumes, cosmetics, medicines etc. Patchouli has many species but *Pogostemon cablin* is the only superior species which is grown for oil purpose. It is perennial and erect plant. Leaves contain aromatic oil which is an essential component in the plant. In patchouli oil approx. 40-45% cablin alcohol is present. Mainly two important compounds are present in the oil of patchouli i.e patchoulol and norpatchoulenol.

Patchouli oil is one of the best fixatives for heavy perfumes with long lasting qualities. It is a perfume and is highly valued in perfumes, soaps, cosmetics and flavour industries. It is also used as a scent in several products like paper towels, laundry and air fresheners. In many countries like Japan and Malaysia, patchouli oil is also used as an antidote against venomous snakebites. Oil's scent is also used for inducing relaxation. Some Chinese medicines with its oil are used in headaches, cold, nausea, diarrhoea and abdominal pain. Patchouli oil is a vital ingredient and used as a ‘base’ material in perfumery business. There is no other substitute for patchouli oil, which increase its worth and in demand within the perfumery market. Consumption of patchouli oil within the world is approximate at 2000 t each year. The present consumption of patchouli oil in the world is about 800-1000 metric tonnes per annum. In India, consumption has gone up to regarding 300 tonnes each year whereas the production is below 50 tonnes. Hence, the country principally depends on imports primarily from other countries like Indonesia. India has a vast scope to enter the world market.

Improved varieties

There are some important varieties which are developed and recommended by CIMAP, Lucknow.

1. **CIM-Samarth**: It is fast growing variety, can be grown in shady as well as open field. It is tolerant to several diseases.

2. **CIM-Utkrisht**: It is a new developed variety of patchouli. Production potential of this variety is more than CIM-Samarth. It’s cultivation can be done in shady area as well as in open field without much effort.

Soil requirement

For patchouli crop, the soil should be medium type, loamy and fine texture. Soil should be in well drained condition. Water logged soil should be avoided due to more nematode attack problem and root rot disease. It is a partial shade loving plant so can be easily grow in partial shady areas as well as an intercrop or main crop.
Climate

It grows well under humid condition of 70-75% humidity. Generally, coastal areas are more suitable for this crop. Beside this plenty of sunlight is required. For good growth of the crop, temperature should be in between 25 to 30°C, it is an ideal temperature for its growth. The crop can be successfully grown in fairly heavy and evenly distributed rainfall form 150-300 cm per annum.

Field preparation

Two deep ploughings are recommended to make soil fine texture for good crop establishment. Level the field properly so that water logged condition should not be there and another advantage of land leveling is that it helps in saving of water by uniform distribution of water in the field whenever irrigation is applied.

Propagation

It is usually propagated by rooted cuttings grown in the nursery. Patchouli cuttings are made from healthy main stem of 10-12 cm length with 3-4 nodes. Leaves should be removed. These cuttings are planted in the nursery in the month of April-May. Cuttings can be grown in soil as well as in poly bags. Soil of polybag or in nursery area; it should be well mixed with FYM. Fillings in the polybag should be prepared in the ratio of 1:1 (one part of soil and one part of FYM). Before planting of cuttings in nursery area or in polybags, cutting should be well treated with fungicide like Bavistin/Dithane M-45/Captan and basal portion must be treated with rooting hormone such as Rootex and then planting is to be done in nursery beds with 2-3 cm spacing as well as in polybags. 200 sq.m. area is sufficient for raising plants for one hectare area. Cuttings become ready for transplanting in about 8-10 weeks.

Transplanting

Transplanting of rooted cuttings is always recommended during monsoon season because of maximum establishment of crop and to minimise the cost of irrigation. Transplanting should be done at a spacing of 50 cm × 50 cm.

Manures and fertilizer

At the time of field preparation, about 10-15 ton of FYM/ha or 7 tonne/ha vermicompost should be applied and thereafter fertilizer application schedule should be started on soil test basis. Fertilizer application depends upon soil fertility status. In general, patchouli crop requires high dose of urea and potassium and lesser phosphorous. The NPK requirement is in the ratio of 150:50:50 kg/ha. Apply phosphorous and potassium at the time of field preparation and nitrogen should be applied in 4 splits at equal intervals.

Weed management

For proper growth and to get maximum yield potential of crop, the crop should be weed free, weeding should be done whenever it is required. During first 40 days, weed management is an important step, if not done, production potential of the crop is reduced.

Irrigation

First irrigation just after transplanting and rest as per need. Water logging should be avoided. Irrigation is done for 3-4 days for the first 15-20 days after planting in the field and later done at 8-15 days interval. Water logging should be avoided. Under conventional method, number of irrigation per year will be around 60 (no watering during monsoon) with each irrigation lasting for 3 hours with 5 HP motor. Under drip system of irrigation, irrigation is provided by a drip with nozzles at a distance of 45 cm from each other, which discharge water at a rate of 2 L water/hour. Irrigation for 30 minutes per day is adequate. In hot and dry season, it should be up to a maximum of 60 minutes in two installments.

Pests and diseases

Pests: Major pests of patchouli crop are leaf caterpillar and white fly. To control these, may use Dichlorophos or Monocrotophos etc. After 2-3 years of cropping of patchouli, nematode problem also arises in the field. To control nematode problem in the field, use Carbofuran @ 15-20 kg/ha.

Diseases: Leaf blight, root rot and wilt are the major fungal diseases in the crop. To control these, may apply any fungicides such as Bavistin/Captan/DithaneM-45 @ 2 ml/lt. of water or sometimes may drench in case of soil borne diseases at 3-4 days interval.

Harvesting

The crop is ready for first harvesting after transplanting in 5-6 months, when the leaves turn pale green in colour. Subsequent harvests can be done in every three months interval. Crop should be harvested with sharp cutting tool. Crop cutting should be done 20-25 cm from the apex with a sharp cutting tool. The new shoots come from the nodes and if the cutting is done at too low level, the next harvest will be affected. In rainy season, after each cutting, spray of fungicides is recommended to minimise the incidence of any fungal disease in future crop. The right time for harvesting is when the plants are about 1 m high, leaves turn pale green or slightly brown in colour. Subsequent harvests can be done every three months. Once planted,
Post harvesting

After harvesting, the biomass is dried under shade for 4 to 5 days. Drying shed with thatched roof and mud floor is constructed with a drying area of 100 sq. m. Essential oil is extracted by steam distillation, requiring the cell walls of the leaves to be ruptured. This can be achieved by steam scalding, light fermentation, or by drying. After harvesting, biomass should be dried under shade for 3-5 days. Essential oil is extracted by steam distillation.

Yield

The yield under drip irrigation is nearly 2 times that of conventional method. Under conventional irrigation, the average yield of green leaves is 20 t (3 cuttings) per ha p.a. while it is 40 t (3 cuttings) per ha under drip irrigation. As an intercrop, 4 t dry biomass per year can be expected. It has 2.0-2.5% essential oil and average oil yield is 60-75 kg/ha.

Economics

The cost of cultivation is ₹ 50,000 (per ha) while the income is ₹ 1,50,000 (per ha) giving a net profit of ₹ 1,00,000 (per ha).

SUMMARY

The current production of patchouli oil in India is not sufficient to fulfill domestic demand and the country has to depend upon massive import. Hence, to meet the country’s demand and realizing the export potential of oil, increase in area of cultivation and production of patchouli oil has to be stressed. Large-scale production of good quality patchouli oil is quite possible in India, which may provide an economically viable option to the traditional agriculture and shifting cultivation practices. Patchouli oil production could be rural based labour intensive, low cost agro-based cottage industries that will generate huge employment opportunities for resource poor farmers.

For further interaction, please write to:
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Production technology

Pusa Safed Baingan-1 can be grown in sandy loam to clay loam soil rich in organic matter with a pH of 6.5 to 7.5. A temperature range of 25-30°C is most favourable for obtaining good crop growth and yield. In North Indian plains, particularly Delhi and its adjoining areas i.e the states of Haryana, Rajasthan and Uttar Pradesh, the summer crop can be grown from the months of February - May and during the kharif it can be grown from June - November. About 350-400 g seed is sufficient for raising seedlings for one hectare. The seeds are sown in raised beds in nursery at 1 cm deep and 5-7 cm apart in rows. Prior to sowing, the seeds are treated with Captan @ 2 g per kg seeds. Seeds can also be treated with Trichoderma viride @ 5 g/kg before sowing. The nursery beds can be treated with a mixture of 1 kg Trichoderma and 25 kg of cow dung manure which was kept in the shade for one week. Before sowing 10 kg FYM, 1 kg neem cake, 50 g VAM, 100 g Superphosphate, 10 g furadon per square meter should be mixed. After sowing, the beds are covered with dry grass immediately followed by irrigation. Precautions should be taken in the nursery to avoid water stagnation by providing proper drainage facilities to prevent water logging and damping off disease. The seeds germinate within 4-5 days; therefore, dry grass should be removed immediately after seedling emergence. To avoid disease infestation, the beds are drenched with Captan @ 2.5 g/litre and can be repeated after 7 days interval. Watering should be done for proper growth. Irrigation should be withheld 4-5 days before transplanting for hardening of seedlings. Fruit and shoot borer infestation can be managed by placing the pheromone traps in nursery area or by spraying of Spinosad @ 4 ml/10 l of water.

Transplanting and fertilizer management

The field is prepared well in advance with repeated 4-5 times ploughing followed by pre-planting spray of Pendimethalin 30% a.i (2.5-3 litre in 600 litre/ha) after giving light irrigation. About 30-35 days old seedlings are transplanted when they attain 12-15 cm height and have 3-4 leaves. Once the seedlings are uprooted, they are first soaked for 15 minutes in Captan solution (2 g/l) and then transplanted in the field. About 25-30 tonnes FYM, 50-55 kg urea, 325-350 kg SSP and 75-100 kg MOP/ha should be mixed in the soil during field preparation as basal dose. The seedlings are planted in ridges and furrows at a spacing of 75 cm (row to row) × 60 cm (plant to plant) during the kharif season. Nitrogen in the form of urea @ 50 kg each is applied two times, once after one month of transplanting and again 3-4 weeks later. Irrigation should be given at 10-15 days interval or depending upon the weather condition.

Plant protection

The main pests of brinjal are fruit and shoot borer, jassids, epilachna beetle and mites. Fruit and shoot borer occur throughout the crop growing season however, jassids and epilachna beetle cause more damage during the vegetative growth. The major damage to the crop is caused by fruit and shoot borer which is the most damaging pest of brinjal. This pest can be managed by setting up pheromone traps at 10-12/ha or by cutting and removing the infested shoots, i.e half inch below the bore point and burying them deep into the soil. However, the lure of the trap should be changed regularly at an interval of 15-20 days. Spraying with Spinosad @ 4.5 ml/10 litre of water before flowering or at fortnightly interval will help in managing the pest. The main diseases are Fusarium wilt, little leaf and Phomopsis blight. The crop is also being attacked by a complex virus and the only way to manage is to uproot the infested plants and bury deep in the soil to avoid further spread. Spraying of Confidor @ 1 ml/l of water...
Table 1. Mean performance of Pusa Safed Baingan-1 at IARI, New Delhi during 2013-14, 2014-15 and 2015-16

<table>
<thead>
<tr>
<th>Variety</th>
<th>2013-14 Total fruit yield (t/ha)</th>
<th>% Increase over best check</th>
<th>2014-15 Total fruit yield (t/ha)</th>
<th>% Increase over best check</th>
<th>2015-16 Total fruit yield (t/ha)</th>
<th>% Increase over best check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pusa Safed Baingan - 1</td>
<td>34.80</td>
<td>11.50</td>
<td>36.78</td>
<td>9.85</td>
<td>35.41</td>
<td>14.63</td>
</tr>
<tr>
<td>DBOR-94</td>
<td>31.20</td>
<td></td>
<td>33.48</td>
<td></td>
<td>30.89</td>
<td></td>
</tr>
<tr>
<td>Pusa Bindu</td>
<td>26.78</td>
<td></td>
<td>27.89</td>
<td></td>
<td>28.14</td>
<td></td>
</tr>
<tr>
<td>Aruna</td>
<td>24.32</td>
<td></td>
<td>24.64</td>
<td></td>
<td>23.52</td>
<td></td>
</tr>
<tr>
<td>Pusa Ankur</td>
<td>21.12</td>
<td></td>
<td>23.52</td>
<td></td>
<td>21.60</td>
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</tr>
<tr>
<td>CD at 5%</td>
<td>4.28</td>
<td></td>
<td>1.03</td>
<td></td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>8.23</td>
<td>1.88</td>
<td>1.72</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Mean performance of Pusa Safed Baingan-1 at different locations during 2013-2014

<table>
<thead>
<tr>
<th>Variety</th>
<th>IARI Regional Station, Karnal, Haryana Total fruit yield (t/ha)</th>
<th>% Increase over check</th>
<th>IARI-KVK, Shikohpur Total fruit yield (t/ha)</th>
<th>% Increase over check</th>
<th>Seed Production Unit, IARI, New Delhi Total fruit yield (t/ha)</th>
<th>% Increase over check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pusa Safed Baingan - 1</td>
<td>34.88</td>
<td>28.23</td>
<td>31.36</td>
<td>23.07</td>
<td>30.88</td>
<td>25.63</td>
</tr>
<tr>
<td>Pusa Bindu</td>
<td>27.20</td>
<td>-</td>
<td>25.48</td>
<td>-</td>
<td>24.58</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3. Nutritional composition of Pusa Safed Baingan-1

<table>
<thead>
<tr>
<th>Variety</th>
<th>Total phenol (mg GAE/100g)</th>
<th>Antioxidant CUPRAC (μ moltrolox/g)</th>
<th>Antioxidant FRAP (μ moltrolox/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pusa Uttam</td>
<td>21.57</td>
<td>2.03</td>
<td>1.13</td>
</tr>
<tr>
<td>Pusa Anupam</td>
<td>24.48</td>
<td>1.89</td>
<td>1.14</td>
</tr>
<tr>
<td>Pusa Kranti</td>
<td>19.67</td>
<td>1.97</td>
<td>1.03</td>
</tr>
<tr>
<td>Pusa Bindu</td>
<td>24.02</td>
<td>2.61</td>
<td>1.68</td>
</tr>
<tr>
<td>Pusa Upkar</td>
<td>31.59</td>
<td>2.67</td>
<td>1.49</td>
</tr>
<tr>
<td>Pusa Safed Baingan - 1</td>
<td>31.21</td>
<td>3.48</td>
<td>2.58</td>
</tr>
<tr>
<td>Pusa Hara Baingan - 1</td>
<td>33.50</td>
<td>4.31</td>
<td>3.07</td>
</tr>
<tr>
<td>G-164</td>
<td>24.31</td>
<td>1.69</td>
<td>0.85</td>
</tr>
<tr>
<td>Pusa Purple Round</td>
<td>21.50</td>
<td>2.25</td>
<td>1.40</td>
</tr>
<tr>
<td>Pusa Purple Cluster</td>
<td>29.23</td>
<td>2.75</td>
<td>1.77</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>4.58</td>
<td>1.26</td>
<td>0.14</td>
</tr>
<tr>
<td>CV (%)</td>
<td>14.25</td>
<td>2.36</td>
<td>3.62</td>
</tr>
</tbody>
</table>

Table 4. Minimum seed standards for foundation and certified seeds of Pusa Safed Baingan-1

<table>
<thead>
<tr>
<th>Seed standard</th>
<th>Foundation seed</th>
<th>Certified seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure seed (minimum)</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Inert matter (maximum)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Other crop seeds</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Weed seeds</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Objectionable weed seed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Germination (minimum)</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Moisture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Normal container</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>b) Vapour proof container</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>
water to control vector is useful. Fruit rot or phomopsis blight can be managed by pre-sowing treatment of the seeds with Captan @ 3 g/kg seeds (dry dressing) and spraying the affected plants with Dithane-M-45 @ 2.5 g/l of water. Little leaf can be managed by removing the affected plants in the early stages and spraying the affected plants with Acetamiprid 20% SP @ 100 g/ha to control the vector.

**Harvesting and yield**

The fruits are ready for first picking 50-55 days after transplanting when they have become shiny white in colour, have attained the marketable size but are still immature, soft and tender to touch and when cut, the seeds have not turned brown. The average fruit yield is 350 q/ha.

**Seed production**

The seeds of Pusa Safed Baingan-1 can be carried out during the *kharif* season from June to mid-December and it should be noted that the maturity of fruits should not coincide with the rainy season. Brinjal is an often cross pollinated crop which requires an isolation distance of 400 m and 200 m for the production of foundation and certified seeds, respectively. The flowers are light purple in colour. A minimum of three inspections is needed for rouging out the off types and unwanted plants i.e. a) before flowering or vegetative stage; b) at flowering and fruit setting stage and c) at fruit maturing stage. The diseased infected plants should be removed from the seed production field to avoid further spread. The matured and ripened fruits are ready for harvest when they have turned yellow in colour. The seeds are extracted the next day either manually by beating with a stick, seed extractor or with the help of a seed extracting machine. The seeds are then washed in clean water and dried in the shade till the moisture content of the seeds reaches 8% or below followed by sun. The average seed yield is 150-200 kg/ha. The minimum seed standards for foundation and certified seeds of brinjal are given in Table 4.

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For further information, please write to: Partha Saha (Scientist), Division of Vegetable Science, ICARI-IARI, New Delhi 110 012. Corresponding author e-mail: hortparth@gmail.com
Soursop – A wonder fruit

Soursop (Annona muricata L.) which belongs to Annonaceae family is an evergreen tree species known for its anti-cancer properties, due to its annonaceous acetogenins content. It is a native of Central America and bears the largest fruit among Annonas. It is mostly distributed in tropical and subtropical regions of the world. In regions where sweet fruits are preferred, as in South India and Guam, the soursop has not enjoyed great popularity. Soursop grows on a limited scale in Southern India, in states like Tamil Nadu, Karnataka, Andhra Pradesh and Kerala. It also thrives wild throughout the Southern Sub-tropical India.

THe soursop is truly tropical. It does not tolerate frost and grows well in well-drained and semi-dry soil up to an elevation of 300 msl. The optimal range of latitude is between 27°N and 22.5°S. It grows and produces well at 21 to 30°C, being very sensitive to severe changes in temperature, especially if the limit of 12°C is reached. Young trees in exposed places are killed only by a few degrees of frost. Temporary defoliation and interruption of fruiting occurs when the temperature drops near freezing. However, good productive orchards are found at altitudes of up to 1,100 m.

Soursop (Annona muricata) has three general classification: sweet, sub-acid and acid and then subdivided as round, heart-shaped, oblong or angular and finally classed according to flesh consistency which varies from soft and juicy to firm and comparatively dry. Some popular annonas are the true custard apple, or bullock’s heart or Ramphal (A. reticulata Linn.), the sugar apple or sweetsop or Sitaphal or Custard apple (A. squamosa Linn.) and the cherimoya (A. cherimola Mill.). The tree is low-branching and bushy but slender because of its upturned limbs, and reaches a maximum of 7.5-9 m in height. Young branchlets are rusty-hairy. The leaves, normally evergreen, are alternate, smooth, glossy, dark-green on the upper surface, lighter beneath; oblong, elliptic or narrow-ovate, pointed at both ends and highly aromatic when crushed. The flowers, which are borne singly, may emerge anywhere on the trunk, branches or twigs. They are short-stalked, 4 to 5 cm long, plump, and triangular-conical, the three fleshy, slightly spreading, outer petals yellow-green, the three close-set inner petals pale-yellow. Soursops are more or less oval or heart-shaped, sometimes irregular, lopsided or curved due to improper carpel development or insect injury. They range in size from 10-30 cm long and up to 15 cm in width, weight ranges from 0.3 kg up to 6 kg compound and covered with a reticulated, leathery-appearing but tender, inedible, bitter skin from which protrude few or many stubby, or more elongated and curved, soft, pliable “spines”. The tips break off easily when the fruit is fully ripe. The skin of the immature fruit
is usually dark-green, becoming slightly yellowish-green before the fruit is soft to the touch. The inner surface of the skin is granular and separates easily from the mass of snow-white, fibrous, juicy segments much like flakes of raw fish surrounding the central, soft-pithy core. In aroma, the fruit is somewhat pineapple-like, but its musky, sub-acid to acid flavor is unique. Most of the closely-packed segments are seedless. In each fertile segment there is a single oval, smooth, hard, black seed, 1.25 to 2 cm long; and a large fruit may contain a few dozen to 200 or more seeds. The fruit consists of about 67.5% edible white pulp with a pleasing fragrance and flavor. It is a good source of vitamins B and C with some calcium and phosphorus.

Food and medicinal uses

It has numerous uses. The young green fruits with seeds are still soft can be cooked as vegetable. When ripe, the flesh can be eaten off hand or as dessert, or processed into candies, jams and jelly. Its juice is used for flavoring or packaged into refreshing guyabano drinks. The leaves are used as herbal medicine. Because the tree is small and tolerant of partial shade, it can be intercropped with coconut or with large fruit trees like mango, durian, avocado and jackfruit. Soursop leaf contains annonaceous acetogenins which exhibited significant inhibitory effects against six human cancer cell lines: lung, breast, colon, pancreatic and kidney carcinoma. It has also been found to contain compounds which were responsible for inhibiting uric acid formation in hyperuricemic induced lab wistar rat and it shows potential for developing medicine to cure gout. Soursop Leaves Crude Extract (AMCE) exhibited cytotoxicity toward breast cancer cell lines and reduced the tumor’s size and weight in lab mice. Thus it is a promising candidate for cancer treatment especially in breast cancer as an alternative to conventional drugs. Extracts of *Annona muricata* and *Annona reticulata* inhibited the growth of *Plasmodium falciparum*, a malaria causing organism. The aqueous extract of *Annona muricata* (Graviola tea) has shown considerable antioxidant potentials. The bark, leaves, fruit, roots and seeds are known since long for various medicinal uses. The fruit and juice is used against worms and parasites, to cool down fevers, to increase lactation after childbirth. The seeds can be crushed and then used against internal or external parasites, head lice and worms. The tea prepared from the leaves is used as a sedative and a soporific (inducer of sleep) in the West Indies and Peruvian Andes. This infusion is also used to relief pain or for antispasmodic purposes. For liver problems, leaf tea is used in the Brazilian Amazon. Traditionally it is used in medicinal herbal drugs to cure various diseases such as for diarrhoea (fruit), cough, hypertension, rheumatism, tumours, cancer, asthma, childbirth, lagtagogue (fruit), malaria, tranquilizer, skin rashes, parasites (seeds), worms (seeds), liver problems, arthritis (used externally), etc. The leaf decoction is lethal to head lice and bedbugs. The wood is pale, aromatic, soft, light in weight and not durable. It has been used for ox yokes because it does not cause hair loss on the neck. The roots of the tree are employed as a vermifuge and the root bark as an antidote for poisoning. Nowadays people are more aware of the detrimental effects of Allelopathic medicine. So, they are starting to look for alternative medicine, which is eco-friendly and gives no side effects. Moreover, taking delicious fruits as medicine also gives an immense pleasure to the patient thereby giving an added psychological push to the healing process. People are willing to pay any amount for a side-effects-free alternative medicine. Tea prepared from soursop leaves and stem has recently been gaining wider popularity and shade dried leaves and stem fetches very premium prices in e-commerce vendors. It is more convenient to store and transport dried leaves and stem as opposed to fruits which are highly perishable and may not ripen properly in fluctuation of storage temperature. Therefore, due to changing market demand, leaf production of soursop would be a lucrative business since the leaves contain annonaceous acetogenins.

Propagation and planting

Soursop can be propagated from seed and by budding. The height of the plant is not greatly affected by budding and the majority of producers prefers using grafted
seedlings rather than seeded seedlings. Propagation by seed or graft is done in plastic bags in a growth medium that varies from region to region. The constituents in the growth medium in the nursery phase are very important. Depending on the material and quantity used, there is the possibility of interfering with seed germination and of phytotoxicity burning the young leaves and causing the death of the seedlings. Poor emergence of soursop seedlings is a result of poor storability of the seeds. Soursop seeds lose viability easily and do not store for a very long time and are, therefore, best sown without delay. Soursop has thick black seed coat that reduces water inhibition during the first stage of germination and therefore requires some pre-sowing treatments to enhance germination and seedling emergence. It is preferable to select only the sunken seeds when soaked in water and sowing right after extraction. The land planting field should be deep ploughed and leveled. In normal practice a spacing of 4 to 6 meters is recommended depending on climate and soil type. In high density planting, 2.4 × 2.4 m of spacing is adopted in Puerto Rico. Pit of 60 × 60 × 60 cm size are dug and filled with a mixture of 3:1 top soil and compost. It is preferable to plant in early evening or on cloudy days. Plants should be 8-12 months old and 50-90 cm in height. Plants should be watered immediately after transplanting.

Training and pruning
Soursop trees usually attain symmetrically conical shape and are adapted to the central leader system. The fruits are borne on the lateral branches and hangs down for ease of harvesting. Little pruning is not required after training of the trees. Branch pruning is done to promote uniform air movement and light penetration. Diseased, interlocking and weak branches should be removed.

Flowering and pollination
In India, soursop flowers and fruits during the months of April to October. It require 27-35 days for flower bud development from initiation to anthesis. Flowering can extend from 3-6 months. The flowers exhibit both dichogamy and a protogynous nature. Anthesis takes place between noon and 8 PM and 4 AM to 8 AM with pollen release occurring between 4 AM to 8 AM.

Manuring
Adequate fertilization of the planting pit is a basic condition for excellent seedling growth that will result in a productive adult plant producing good quality fruit. The amount of fertilizer to apply is based on soil analysis and on the volume of pit. It is recommended to apply 40 g nitrogen and 60 g potassium to one year old plant. Four and onwards, 180 g nitrogen, 120 g phosphorus and 180 g potassium should be applied to each tree. In addition adequate quality of organic manure should be applied. Fertilizer should be applied around the plant but only lightly incorporated into the soil to avoid damaging the developing root system. The required quantity of N and K fertilizer should be divided into three doses. First dose should be applied at onset of rainy season, second in the middle and third at the end of the rainy season. Water stress should be prevented to produce good crop.

Harvest and yield
The fruit is picked when full grown and still firm but slightly yellow-green. If allowed to soften on the tree, it will fall and crush. It is easily bruised and punctured and must be handled with care. Firm fruits are held a few days at room temperature. When eating ripe, they are soft enough to yield to the slight pressure of one’s thumb. Having reached this stage, the fruit can be held 2 or 3 days longer in a refrigerator. The skin will blacken and become unsightly while the flesh is still unspoiled and usable. Studies of the ripening process in Hawaii have determined that the optimum stage for eating is 5 to 6 days after harvest, at the peak of ethylene production. Thereafter, the flavor is less pronounced and a faint off odor develops. The sour sop is a shy-bearer, the usual crop being 12 to 24 fruits per tree. In Puerto Rico, production of 5 to 8 tonnes per ha is considered a good yield from well-managed orchard. A study of the first crop of 5 year-old tree in Hawaii showed an average of 42.5 kg fruits per tree. Yield was slightly lower during next year. The 3rd year, the average yield was 78 kg per tree. At this rate, the annual crop would be 16 t/ha.

In India, though soursop has been introduced long back, it is grown very limited scale in the plantations. The average productivity of soursop in India is about 25-40 kg per tree. A cost and return analysis prepared by the Bureau of plant Industry for guyabano planted at 5 m × 5 m spacing shows a progressive increase in yield starting 4 years after planting with a fruit yield of 4.8 tonnes per hectare and a net profit cost ratio of 47.56% in the seventh year. In the 10th year, net profit cost ratio is
about 200% with a projected yield of 11.8 tonnes per hectare. Data obtained from Hawaii, however, disclosed that with 215 trees per hectare fruit yield in the 6th year was 18 tonnes per hectare.

**Post-harvest handling**

High temperature can cause premature fruit ripening and fermentation of the fruit. Fruit is harvested when fully mature and firm. The skin colour changes as the fruit approaches maturity. The immature soursop is dark green and shiny and becomes slightly yellowish green at maturity. Sour soup respiration begins to increase within a day after harvest and reaches its peak at the sixth to eighth day. Total soluble solids increase from around 10-16% during the first 3 days of ripening. The major titrable acids are malic and citric acids. After day 5 to 6 titrable acidity, produce a bland flavour and even slight odour. The optimum edible stage is at days 6-7, which coincide with ethylene production. Fruit is hand harvested and put into boxes or baskets. Harvested fruit should be handled with care to prevent bruising of the skin. Firm fruit are held after harvest for 4-7 days at room temperature before softening begins, optimum quantity processing occurring 5 and 6 days later. The skin of ripening soursop gradually turns dark brown to black, but the flesh is unspoiled. Storage below 15°C causes chilling injuries and failure to develop full flavour. At lower temperatures, skin discolouration rapidly occurs. It can be used as fresher for processing after removal of outer skin and seeds.

**Export potential**

In the large cities of tropical America, there is a good demand for the fruits at all the times of the year. This demand is not yet adequately met. Hence there is larger scope for exporting soursop fruits to tropical America.

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**HANDBOOK OF AGRICULTURAL ENGINEERING**

Agricultural Engineering interventions have led to significant improvement in agricultural productivity by timeliness of operations, reduction in drudgery, prevention of post-harvest losses and achieving higher cultivation intensity. Timely farm operations with efficient use of inputs, post-harvest processing and value addition to agricultural produce and conservation and sustainable use of natural resources are essential for ensuring higher returns to the cultivators. This is the maiden attempt of the Indian Council of Agricultural Research to publish the *Handbook of Agricultural Engineering*. The handbook comprises 50 chapters under four sections, namely Farm Machinery and Power, Soil and Water Engineering, Energy in Agriculture and Agro-Process Engineering. This publication would be useful to farmers, students, researchers, extension workers, policy makers, entrepreneurs and other stakeholders.

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With the changing lifestyle, people are aware that diet and consumption pattern plays a major role in preventing diseases and thus demand convenient food products with higher functional nutrition. Fresh fruit is one of the easiest ways to give our body the essential nutrients required for a healthy life. Studies on fruits have progressed from the discovery of essential nutrients and prevention of dietary deficiency, to the promotion of a state of well-being and health with reduction of the disease risk. Among them, banana is a globally popular fruit, which is a package of nutrients and bio-active compounds. Banana being rich in many essential nutrients and dietary fibre has the capability to cure many diseases. Some of the specific diseases known to be cured by banana are: anaemia, blood pressure, constipation, depression, hangovers, heart burns, morning sickness, PMS, Seasonal affective disorder (SAD), ulcer, stroke, stress and age related disorders. It is good to enhance brain power, and provide instant energy.

India is the largest producer of banana with the production of 30.6 million tonnes from an area of 8.02 lakh ha, contributing 17% of world production. About 90% of banana produced is consumed domestically as fresh fruit. Merely 5% is consumed in processed form providing a good potential for future processing. About 2.5% is only processed purely as banana products and the rest as an ingredient in other foods. The primary product of banana in market is ‘fried chips and candy’ which constitute around 31% with production capacity of 2.0 lakh tonnes valued at ₹ 500 crores per annum, rest as banana puree 9%, banana pulp 3%, banana beer 3%, banana wafers 3%, banana powder 6% and others. Banana contains considerable amount of resistant starch (non-digestible starch) and non-starch polysaccharides, which have low glycemic index. This property makes it an appropriate ingredient for different functional and convenience foods like cookies, bread, cake, extruded foods and chips, etc. Conventional products like chips, jam, jelly, banana fig, ready to drink juice are very familiar products from banana and loads of blogs are available online that detail the protocol for its utilization.

Recently, at ICAR–National Research Centre for Banana, Tiruchirappalli has developed handful of technologies which are not only innovative and low cost but also provide better entrepreneurial opportunities under PMFME and other government schemes which orient towards Atmanirbhar initiatives. Product like banana syrup and glucose are unusual but remarkable products. Similarly, unripe banana powder is a customary product, but ripe banana powder is an exceptional item. The future innovation can also include prebiotic and probiotic foods, function specific targeted micro-encapsulated healthy foods from banana.

Low glycemic resistant starch rich green banana flour based nutri-products

Banana flour prepared from mature unripe banana with high starch content (available and resistant) can be blended with other cereal flours and can be used as a potential ingredient for bakery products. Consumption of unripe banana flour incorporated products can confer beneficial effects for human health, a fact often associated with its high resistant starch content. 5-15% of incorporation of banana flour as a substitution for Maida in bakery products like bread, bun, biscuits, muffins, cakes and pizza base and deep fried products like doughnut imparts better nutritional value with low gluten, higher resistant starch, dietary fiber and lower glycemic index.

Banana bread
Modified banana starch for nutraceutical/pharmaceutical and other industrial applications

The present invention relates to starch modifying (RS-III) process by occupying of C2, C3 and C5 positions of sugar in starch through physical (autoclaving and cooling), enzymatic debranching (using pullulanase), chemical (cross-linked phosphate, oxidized, acetylated, acid thinned and hydroxypropylated) methods. After the modified process, the starches were specifically analyzed for resistant starch content and degree of substitution. The purpose of this modification is to introduce new functional group in native starch and enhance its properties particularly in specific applications such as to improve the increase in water holding capacity, heat resistant behaviour, reinforce its binding, minimized syneresis of starch and improved thickening. We preferred three modifications like autoclaving and cooling, enzymatic debranching, Acetylation and oxidation depending upon its use, easiness and versatility. Enzymatically modified starches could be acted as a pre-biotic for making functional food formulations whereas while oxidized form of starch can be used as edible film in food industry and pharmaceutical companies.

Low cost, easy to make, foam mat dried ripe banana powder

The natural matrix of ripe banana usually contains a high amount of carbohydrates and sugar and takes long time to dry in convective drying due to its sense physical structure. Making the pulp porous by whipping, followed by drying can minimize the above mentioned negative effects. The ripe banana powder obtained by this method will be rich in bioactive compounds with potential pre-biotic beneficial effects on human health and can be used as functional ingredient in food preparation. With intense, sweet and indulgent natural flavours the product will be a healthier ingredient. Ripe banana power can be used in food product formulations like pudding, fudges, pan cakes, bakery fillings along with refined wheat flour. It can also be used as a flavouring ingredient for making low fat yogurt, ice cream, fruit toffee and fruit bar. It can also be suggested for compaction into tablet forms for nutraceutical consumption.

Tailored low Glycemic foods with banana starch: Optimization of extraction procedure and elucidation of functional characteristics

Starch is the second most abundant biopolymer, vital for both human/animal nutrition as well as non-food applications. With an annual starch production is around 70 million tonnes worldwide, it is used in thickening, gelling, imparting consistency, shelf-life stability and varied applications in food processing industries. Starch with relatively slow and incomplete digestion has lower glycemic load and insulin demand. This may lead to increased satiety and higher levels of resistant starch (RS); both are physiologically useful. Resistance starch (RS), with its functional food characteristics, is one such food ingredient, has the potential for not being digested quickly in the digestive system, make them essential food with the changing lifestyle. Banana, with its higher quantity of starch and resistant starch offers a greater extraction of starch other than conventional sources.

Basil seed suspended banana based ready to serve drinks

Commercially banana RTS with basil seed suspension is not available. Basil seeds are used as diuretic, antipyretic, antispasmodic and stomachic. The complication in suspending basil seeds is that, due to density differences with beverage, it is common tendency for seeds to either settle at the bottom or to float at the top. The proper suspension of soaked basil seeds in the beverage requires addition of suspension agents. The process involves slicing and pulping edible portion of banana followed by enzymatic treatment to get the clarified juice, standardization and pasteurization, to which soaked basil seeds were suspended. Technology was identified to keep them suspended uniformly in banana based ready to serve (RTS) drink. With the technology the seed were in suspended state in banana RTS for more than 6 months without any contamination.

Glucose/Glucose syrup from banana

Glucose is a type of sugar, that we get from foods (especially starchy foods) and our body uses it for energy. Usually corn is major plant source for starch extraction, which can be further converted into glucose (Liquid or powder). On exploration of other starchy biological sources for glucose extraction, unripe banana turned out to be a promising source. Green banana pulp
contains up to 70–80% starch on a dry weight basis, a percentage comparable to that in the endosperm of corn grain and the pulp of white potato. Banana starch has a great potential, both from its digestion and functional properties, to have application in processed foods and become a commercially viable starch product. Further, by conversion of the obtained starch from unripe banana into glucose by acid/ enzymatic digestion can supplement the commercially available liquid and powdered glucose in the market. Additionally, the availability of banana glucose in market shelves can give a choice of versatility to the consumers.

**Banana fruit concentrated syrup as natural sweetener**

Fruit syrup from dates, lemon, orange, grape etc., is a common product in shelves of Indian market. Being the leading producer of banana, banana syrup can also find its place in super market. By simple concentration of enzyme clarified banana juice, can yield us banana syrup with 65°Brix. Being an energy source and a natural fruit sweetener, banana syrup can be designed for the natural food market, so that the terms ‘fruit sweetener’, ‘sweetened only with fruit’ can be used to popularize it. It can be used as a flavouring agent in yoghurt, milkshakes or stopping for pancakes, ice cream, ice slushes, etc. Additionally, it can also give a caramel flavour and tinge of browning of the products in baking, as a result of partial degradation. Since, it has its inherent preservative ability to reduce water activity and to increase osmotic pressure to a level where the growth of even the most spoilage microorganisms is no longer possible, banana syrup, will not require addition of any chemical preservatives to extend its shelf life.

**Low fat chips**

Snack industry is expected to witness stellar growth in accord with the changes in lifestyle and food habits. Endowed with unique savour, banana chips are gaining popularity as a deep fried product. Owing to high incidence of health issues, with consumption of deep fried products, consumers nowadays are more inclined towards healthy products, which are low in fat and calories. Banana chips are produced by deep frying of thin slice of mature, unripe banana from Nendran and Saba variety in India and Philippines, respectively. Owing to high starch content, banana chips from popoul variety is also preferred by people. Studies have proved that modification of product surface can reduce oil uptake during deep fat frying. Hence, by employing surface modifying agents, the oil absorption during deep fat frying of banana slices can be reduced up to 25%. Pairing low-fat with deep frying technology can yield healthy and appetizing banana chips that will be well suited for calorie conscious people.

**Low sodium stem and flower pickles**

Large amount of wastes like stem, flower, etc. with higher nutritive values are available in banana production system after harvesting bunches. The impact on utilization of low sodium salts on sensory properties of banana stem and flower pickles has proved to be a promising methodology and technology to introduce new, innovative product to the ever growing pickling industry. Without the worry of an enormous amount of salt content being present in the conventional pickle, diet conscious people and people with certain medical conditions, including heart problem, high blood pressure and kidney disorder can dine with this product as banana inherently rich in potassium and the process involves the use of lesser sodium. Low sodium salt had no negative impact on nutritional properties of banana flower and stem pickle but decreased the sodium content. Pickles sodium content less than 23% is considered to be a suitable alternative for preparation of banana stem and flower pickle. The pickle produced can be stored up to 45 days in room
condition, without any changes in comparable differences in physiochemical components and sensory attributes.

**Low calorie stem juice**

Central core stem from banana which is often considered a farm waste is traditionally known for its rich nutrient content. The inner part of tender pseudostem from banana plant is edible and contains macro and micro nutrients in high concentration. It is also a rich source of potassium and vitamin B6 which helps in the production of insulin and haemoglobin. When consumed, it reduces high blood pressure and can also maintain fluid balance within the body. The extract from tender portion, is an excellent diuretic and helps to detoxify the body, useful for stomach disorder and diabetes. The central stem extracts is an excellent antiurolithiatic agent and is considered to be useful in dissolving the stones in kidney and urinary bladder. Blending of banana central core juice with sweeteners were the most effective with high acceptability, low calorie and high-quality attributes and the storage at 7°C can provide acceptable level of sensory temptation to the juices. No sugar, no preservative alternatives were developed to capture the health conscious population and to bring them into consuming healthy processed food products.

**Fibre rich, designer food products using central core stem powder**

Process for the production of banana central core stem powder and its incorporation in the preparation of designer foods were evaluated. Banana pseudostem, is regarded as waste, are rich in minerals such as potassium, calcium, sodium, magnesium, phosphorus, copper and iron. The central core stem was washed, sliced, and ground to powder. The dried samples were powdered in a grinder and sieved (sieve no 60 mm). Cookies were prepared by incorporating the prepared banana central core stem powder with different ratio of substitution. It may have immense potential for commercialization in food industry considering its high nutrient content with antioxidant property and rich in dietary fibre.

**Functional enrichment of value added product with banana peel powder**

The post-harvest losses in banana have been estimated in the range of 20-25%. Recently, the use of banana as an ingredient for functional foods has gained significant interest. This is particularly due to the banana carbohydrates (starch and non-starch) having low digestibility, which makes it an excellent ingredient for consumption. The peel has been found to contain high levels of dietary fibre and phenolic compounds. Moreover, the material has been demonstrated to exhibit potent antioxidant capacity, antimicrobial and antibiotic properties. As such, it is a promising material for further applications in the nutraceutical and pharmaceutical industries. The left out in chips industry or the peel from immature banana could be used for making different functional products.

**Strategies to promote banana based processing industries**

- Unlike developed countries, the food processing sector in India is dominated by the unorganized sector, contributing more than 80% share. Brining them into the MSME bracket is pre-requisite to boost the processing of horticultural produces especially the crops like banana.
- Creation of cross functional convergence with development agencies, cluster formation in production points by converging Farmer producer organizations (FPOs), market linkages and assessment of the impact through technological incubation and cross cutting initiatives are primary step for the successful establishment of processing industry.
- In the end, bigger players like ITC, Britannia, Parle-G, Horlicks, Boost, Bournvita, Pepsi, Coca Cola, Dabur, etc. should come up with the plan to utilize the banana flour, fruits and juices in their product portfolio to scale up the industrial use and to market it effectively.
- The share of processed industries in agricultural employment has to be enhanced from the present 0.5% to at least 10% with the enhancement of productivity of workers by retaining the youth in agriculture by giving better remuneration and allotting them higher productivity work. With that we can eradicate the dependency of workers in low productivity agricultural activities and shift them to higher remuneration agri-based industrial activities.
• Developing methodologies based on input-output models which provide information about the cluster wise production of banana and could identify the major catchments for supplying the fresh produces. This will allow in calculating the impact of any change in the supply chain. Using AI/ IoT/ App based platforms to provide and generate real time data points.

• In order to sustain the production and growth potential, it is essential to make value added products based on banana, so that farmers get an assured price for their produce all the time. India is the land of more than 30 ethnic varieties in different states with different taste, flavor and nutritional advantages. For example, Nendran is rich in vitamin A and thus could be used for making functional powders to alleviate malnutrition among the rural masses. Likewise, the enormous processing potential could be tapped by developing and commercializing variety dependent technologies.

• Building right infrastructure for converting raw banana into flour, ripe banana into health powder and making banana puree need to be prioritized. All these products have a greater nutritional potential and could be used in functional food markets with its pre-biotic characters. The low glycemic, sugar controlling capability of banana flour has to be rightly marketed to enhance the demand for banana based products.

• Ripe banana could also be used for making dehydrated fruits popularly known as “banana fig” with its fig like taste. This product is highly stable and energy packed thereby could be promoted through giving them to kids in noon meal schemes and to defence personnel other than improving the export market.

• Using banana wastes for the production of innovative products like nutraceuticals, bio colourants, fructans and developing synbiotic foods could pave way for the secondary agriculture. Exploitation of banana wastes and fibre for non-food applications like bio film, edible film, personal hygienic products, handicrafts, and textiles, composite boards will add additional income besides reducing the environmental pollution and carbon foot prints.

Conclusion

Banana being a very popular fruit in the world market has a great diversity of health benefitting nutrients. Not just the fruit, every part of banana plant is endowed with high value bioactive compounds. Banana is world’s widest-known fruit and it’s harvesting, processing and transportation generates lots of waste. With high crop production projected in the future, there is a vital need to complement this production with proper utilization of the product and its waste, which is rich in nutrient resource, therefore, the volume of processed banana products has developed slowly. Fresh-fruit operations, though continuing year-round, are still affected by seasonality and by supply and demand. With the tremendous growth in food processing and nutraceutical industries as an aftermath of Covid-19 pandemic, banana can play a pivotal role in its further escalation. Being a climatic fruit, with diversified varieties and variety specific preference by consumers the acceptability of its processed products will be much easier, as consumer find potential advantage of products from tropical fruits over fruit flavoured or substituted products and equate such items with better nutritional outcome. However, any pertaining lag to accomplish its acquiescence can be compensated by developing commercial processes with techno-economic feasibility. Smallholder farmers need to improve their position in food value chains in order to improve their margins and as a strategy for coping with agricultural food price volatility through innovations within the chains. Processes endowing high value processed products (starch, antioxidants and pigments) have huge application in food, pharmaceutical and cosmetic industry. Through the combination of farmer’s cooperation, technological upgradation, reduction in postharvest loss, establishment of processing industries and favourable policies, the banana trade from India could make more impact and foot print in the world trade. Ultimately, branding and boosting the entrepreneurship through providing incubation platforms, providing marketing intelligence and handholding for technological backup are prerequisite in the coming days to sustain the banana production and promotion of value addition.

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Flowers always make people better, happier, and more helpful; they are sunshine, food and medicine for the soul.

– Luther Burbank
Reinventing potato breeding through true potato seed based technology

Potato is the major staple food in many countries of the world. It has a long history of cultivation in its area of origin i.e. Andean region of Peru. It is propagated through tubers to maintain the purity of cultivars due to high heterozygosity and polyploid genome. The cultivated potatoes are auto-tetraploid and self-compatible. But upon selfing they show high inbreeding depression due to high heterozygosity in parental lines and may be expression of lethal alleles on selfing. The homozygous lines therefore could not be developed in tetraploid potato and the varieties as well as advanced breeding material are maintained in the form of tubers only. Maintenance of varieties and other breeding lines through clonal propagation in the form of tubers lead to accumulation of pests and diseases particularly viruses, which keep on multiplying in each cycle of clonal propagation. This leads to diminution of varieties productivity and acceptance. Moreover, the potato breeding programme takes more than 12 years to develop a new variety and is based on clonal propagation of tubers. The seed of the variety is also multiplied clonally through tubers with a seed multiplication rate of approximately 1: 8 tubers per year. There are two approaches which have been envisioned at the global level for using TPS as the propagation material in potato.

POTATO propagation through diploid hybrid TPS is a completely new breeding method, developed in Netherland and is being adopted in all potato growing countries including India. The new diploid hybrid breeding technology works by sexual propagation. The method is based on identification, evaluation of diploid cultivated species and dihaploids of Solanum tuberosum for selection of desired clones with acceptable tuber and other plant traits. Diploid potatoes are naturally self-incompatible. The sli gene for inducing self-compatibility is introgressed in diploid clones and selfing is done for few generations to get homozygous diploid lines. The diploid homozygous inbred lines are evaluated for various tuber, plant and adaptation traits and potential lines are selected for hybrid combinations to accumulate desirables genes from both the parental lines in F1 hybrid. Development of homozygous diploid lines with desired traits is a step by step process which require many crossings and selection cycles. Thereafter, the hybrid combinations are tested to produce new hybrid offspring which share...
the best features of both parental lines. This sexual crossing of the two parent lines results in thousands of true potato seeds per plant instead of only a few potato tubers. So multiplication of a new variety can occur much faster. Since the offspring of a sexual cross is a pristine true seed, these are completely free of diseases and therefore make excellent seed material for potato growers around the world. These hybrid true potato seeds can be sown and grown into seedlings, and these seedlings will be transplanted into the field for commercial crop. The technology provides the opportunity to quickly develop new varieties to meet specific requirements. By improving the elite parent lines we can improve their offspring variety for the target trait more easily, quickly and in a targeted way. The genetic gains in potato breeding will be much higher using TPS based diploid hybrid breeding in potato.

b) Variety specific TPS through meiotic genes editing

Another way to use TPS as propagating material is by fixing the heterozygosity. This involves the production of unreduced gametes (2n) and thereafter use of haploid inducer lines to get the normal parental type tetraploid plants without segregation. This can be done by deploying the CRISPR-Cas genome editing tools to disrupt the expression of major genes involved in meiosis so as to develop apomeiotic seeds. The process involves targeting of meiotic process in potato by modifying the 3 genes having role in recombination and segregation phases of cell division which leads to the production of unreduced gametes. The plants producing unreduced gametes will be hybridized with haploid inducer lines to get normal ploidy parental type true potato seeds. This novel hypothesis could result in fixation of heterozygosity in TPS production.

TPS propagation technology could revolutionize the potato cultivation, industry and research across the globe. The true potato seeds (TPS) i.e. botanical seed is never used in propagation of varieties which otherwise is easy to maintain, easy to transport, easy to store, amenable to genetic manipulations and is free from viruses, diseases and pests inoculums.

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Ploidy analysis through flow cytometry for confirmation of diploids a) Diploid b) Tetraploid

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Vegetable grafting for combating stresses and to increase productivity

Vegetable production faces many challenges of biotic and abiotic stresses. Gene introgression for stress resistance is time consuming and laborious and limited by crossability barriers as well as linkage drag. Vegetable grafting is seems to be an easy and successful alternative to face these challenges.

**Grafted** vegetable plants are ‘physical hybrids’ resulting from combining at least two genotypes/varieties, a rootstock and at least one scion; the first used to provide important traits and the second used to produce fruit. Grafting is a surgical technique to facilitate fusion of two sets vascular tissue of two different plants. It serves as a rapid alternative approach to combat stress. This technique is becoming popular in the members of Solanaceous and cucurbitaceous crop to reduce infection by soil-borne pathogens and increase survival and to induce vigour, precocity, better yield and quality.

The process is analogous to organ transplantation in that rootstock and scion varieties and seedlings must be compatible, the operating room and patients clean and disease-free, the grafter using appropriate methods, and the newly-grafted plants allowed to recover under specific conditions.

Objective of vegetable grafting are to reduce dependence on agrochemicals for organic production and to impart tolerance against biotic and abiotic stresses as well to increase the production and productivity.

**Vegetable grafting history and Indian perspective**

Grafting of vegetable seedlings is a unique horticultural technology practiced for many years in East Asia to overcome issues associated with intensive cultivation using limited arable land. This technique was first practiced by grafting watermelon (*Citrullus lanatus*) onto pumpkin (*Cucurbita moschata*) rootstock in Japan and Korea in the late 1920s. A serious crop loss caused by soil-borne diseases aggravated by successive cropping was avoided by production of vegetables with grafted seedlings. In many fruit-bearing vegetables such as watermelon, cucumber, melon, tomato, eggplant and pepper, the use of grafted seedling has become increasingly popular. Grafting is an environment-friendly approach which is used to control soil borne diseases and increasing the yield of susceptible cultivars. This technique is eco-friendly for sustainable vegetable production and by using resistant rootstock, it reduces dependence on agrochemicals. To induce resistance against low and high temperatures, grafts were generally used. Grafting increases the yield and promotes biotic/abiotic stress tolerance. Grafting is also used to induce tolerance to abiotic stresses *viz.* flooding, drought and salinity. In Japan (92%), Korea (98%) and China (20%), major share in watermelon production is from grafted seedlings. In Europe, Spain is leading in grafted seedlings production with 129 million grafted seedlings followed by Italy (47 million grafted seedlings) and France (28 million grafted seedlings). Grafting as a technology for the commercial production of vegetables was later on adopted by many countries in Europe, Middle

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**Step-wise One cotyledon grafting (OCG) method followed in cucurbits**

**Step-wise Hole insertion graft (HIG) method followed in watermelon**

March–April 2021
East, Northern Africa, Central America and other parts of Asia.

In India, vegetable grafting work was first started in IIHR Bengaluru by Dr RM Bhatt and his associates. Their work was on identification of rootstocks for waterlogged conditions. For this purpose they have imported semi-automated grafting machine. IIHR Bengaluru organized first ever short course on vegetable grafting during the year 2013. Later on at many places work on vegetable grafting was started in a scattered manner. NBPGR regional station, Thrissur, Kerala have done work on Cucurbit grafting by taking *Momordica cochinchinensis*, a dioecious plant. The female plants were grafted on to the male plants to increase its production. Graft success was 98%. SAUs and ICAR institutes like CSKHPKV, Palampur; ICAR-IIVR, Varanasi; ICAR-CAZRI, Jodhpur also initiated work on grafting and identified more than 22 rootstocks of brinjal, chilli, tomato and cucurbits for importing resistance to bacterial wilt and nematodes. Some private players are also involved in vegetable grafting. One of them is ‘VNR Seed Private Limited’ in Chhattisgarh which is supplying grafted brinjal seedlings resistant to bacterial wilt to farmers. The other seed company is TAKII SEED INDIA PRIVATE LIMITED and very recently CCSHAU has also established a vegetable grafting nursery in public private partnership with VNR Seeds at Hisar, Haryana. Recently Center for Protected Cultivation Technology, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi has started working on evaluation of different rootstocks and their suitability for vegetable grafting and in near future grafted plants will be made available to the farmers also.

**Grafting techniques**

**One-cotyledon grafting**

This method is common method used for watermelon and melons in Korea, Europe and North America. This method is also known as the splice graft, and was originally developed by Japanese engineers for use with automated grafting. The splice graft is used in greenhouse production of vegetable crops for grafting disease-resistant rootstocks. The graft can be performed manually or with sophisticated, robotic grafting machines. Grafting machines can be used to graft watermelon and melons using this method, but high initial cost for equipment and strict requirement for uniformity of seedlings present obstacles for wider adoption of grafting automation of cucurbit crops. Rootstock seedlings should have one true leaf, and scion seedlings should have two true leaves. Cut the rootstock at a 60° angle so one cotyledon remains and one is removed. Cut carefully so as to keep the remaining cotyledon firmly attached to the rootstock stem. The angled cut should also remove the apical meristem in the remaining cotyledon.

**Merits**

- Most simple and rapid technique for grafting watermelon.
- Grafting automation can be conveniently accomplished.

**Demerits**

- Requires careful control of humidity, light, and temperature after grafting.
High losses and possible diseases or physiological disorders may occur if the healing environment is not optimal.

Some meristem tissue may remain in the rootstock, requiring removal later in the production cycle.

Hole insertion grafting

The hole insertion method is the most widely used method for watermelon and melon grafting. Root-stock seedlings should have one small true leaf, and scion seedlings should have just the cotyledons or the first true leaf just emerging. The diameter of the scion stem must be smaller than the diameter of the rootstock stem so that the scion can be inserted into a hole made between the two cotyledons of the rootstock. With a pointed probe, remove the true leaf, the apical meristem, and the axillary buds from the topmost growing point of the rootstock plant. It is important to remove all of the apical meristem and the axillary buds to prevent future shoot growth of the rootstock. Use the probe to create a hole in the top of the rootstock where the tissue was removed; leave the probe inserted in the growing point while cutting the scion. Cut the scion below the cotyledons at a 45° angle on two sides to form a wedge and insert it into the rootstock as the probe is removed. Mist the grafted plants with water and place in healing chamber.

Merits

- A grafting clip is not essential, which saves time and labor involved in collecting grafting clips after healing.
- Tends to have a high success rate.
- Maximizes the contacting surface area between rootstock and scion which helps create a strong graft union.

Demerits

- Requires slightly more skill than most other grafting techniques.
- It may require more time to graft than some of the other grafting techniques depending on the grafter’s skill and the grafting operation.
- Regrowth of the rootstock will occur if not all the meristem tissue has been removed.

Prerequisites for grafting

Selection of compatible rootstock and scion.

- Grafting aids: Grafting clips, Tubes, Pins and Blade.
- Screening house: To grow seedlings prior to grafting.
- Healing Chamber: To provide 28-29°C temperature, 90-95% RH for 5-7 days, darkness for initial 1-2 days to promote callus formation and acclimatization of grafted seedlings.

Biotic stress management

- *S. torvum* rootstock confers resistance to *F. oxysporum* f. sp. *melongenae* in brinjal scion against *Verticillium* and bacterial wilt.
- Interspecific hybrid rootstock ‘Brigeor’ controls root knot nematode in brinjal.
- Resistant brinjal rootstocks: Good for bacterial wilt resistance in tomato.
- *Cucurbita moschata*: Tolerance to both *Fusarium* wilt and *Phytophthora* blight in cucumber.
- Burr cucumber and African horned cucumber: Best nematode tolerance to most cucurbits.
- Wild *Solanum* sp. rootstock: Reduces white-fly transmitted virus symptoms in tomato.
Table 1. Countries position of vegetable grafting in world

<table>
<thead>
<tr>
<th>Country</th>
<th>Watermelon</th>
<th>Cucumber</th>
<th>Melon</th>
<th>Tomato</th>
<th>Brinjal</th>
<th>Pepper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel</td>
<td>70%</td>
<td>--</td>
<td>5</td>
<td>15</td>
<td>5</td>
<td>---</td>
</tr>
<tr>
<td>Japan</td>
<td>93%</td>
<td>72</td>
<td>30</td>
<td>48</td>
<td>65</td>
<td>5</td>
</tr>
<tr>
<td>Korea</td>
<td>98%</td>
<td>95</td>
<td>95</td>
<td>15</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Greece</td>
<td>100%</td>
<td>5-10</td>
<td>40-50</td>
<td>2-3</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Spain</td>
<td>98%</td>
<td>--</td>
<td>3</td>
<td>4500 ha</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Morocco</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>75%</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Cypria</td>
<td>80%</td>
<td>--</td>
<td>--</td>
<td>170 ha</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Italy</td>
<td>30%</td>
<td>--</td>
<td>5-6 million</td>
<td>1200 ha</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>France</td>
<td>--</td>
<td>3</td>
<td>1000 ha</td>
<td>2800 ha</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Netherland</td>
<td>--</td>
<td>5</td>
<td>--</td>
<td>50</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Turkey</td>
<td>30%</td>
<td>5</td>
<td>--</td>
<td>25</td>
<td>10</td>
<td>---</td>
</tr>
</tbody>
</table>

Source: Histil South Africa (PTY), 2007 cited by Yassin and Hussen

Abiotic stress management
- Fig-leaf gourd: Low soil temperature tolerance to cucumber, watermelon, melon and summer squash.
- Bottle gourd imparts salt, alkalinity and flooding tolerance and improves water use efficiency in watermelon; increases nutrient uptake in melon.
- Sweet pepper recorded highest yield under high-temperature conditions on chili rootstock.
- Minimizes negative effects of boron, copper, cadmium, and manganese toxicity in tomato.
- Commercial rootstock (PS 1313: *Cucurbita maxima* × *Cucurbita moschata*): 60% more marketable yield in watermelon.
- Bitter gourd cv. New Known grafted onto sponge gourd showed flooding tolerance.

Higher yield and improved quality
- Pumpkin rootstock gave 27% more marketable yield on cucumber seedlings.
- Watermelon grafted onto the bottle gourd exhibited 27-106% more yield over the control, while, grafting on *Cucurbita* spp. resulted in 127-240% reduction in fruit yield.

Conclusion
Grafting is a method of plant propagation which is site specific management tool for soil borne diseases and nematodes by utilising selective rootstock and scion combinations. It has the potential to increase the area under vegetable cultivation in the disease hotspots or in non-traditional and fragile
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<td>₹ 1,000</td>
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Website: [www.icar.org.in](http://www.icar.org.in)
Table 2. Grafting methods and rootstocks used in vegetable crops

<table>
<thead>
<tr>
<th>Scion plant</th>
<th>Rootstock</th>
<th>Method of grafting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg plant</td>
<td>Solanum torvum</td>
<td>Tongue and cleft method</td>
</tr>
<tr>
<td></td>
<td>Solanum sissymbrifolium</td>
<td>Cleft method</td>
</tr>
<tr>
<td></td>
<td>Solanum khasianum</td>
<td>Both tongue and cleft methods</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum pimpinellifolium</td>
<td>Cleft method</td>
</tr>
<tr>
<td></td>
<td>Solanum nigrum</td>
<td>Tongue and cleft methods</td>
</tr>
<tr>
<td>Sweet pepper</td>
<td>Capsicum annum</td>
<td>Splice grafting</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Cucurbita moschata</td>
<td>Hole insertion and tongue method</td>
</tr>
<tr>
<td></td>
<td>Cucurbita maxima</td>
<td>Tongue method</td>
</tr>
<tr>
<td></td>
<td>Cucurbita ficifolia</td>
<td>Hole insertion and cleft method</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Benincasa hispida</td>
<td>Hole insertion and cleft method</td>
</tr>
<tr>
<td></td>
<td>C. moschata</td>
<td>Hole insertion and cleft method</td>
</tr>
<tr>
<td></td>
<td>C. melo</td>
<td>Cleft method</td>
</tr>
<tr>
<td></td>
<td>C. moschata × C. maxima</td>
<td>Hole insertion method</td>
</tr>
<tr>
<td></td>
<td>Lagenaria siceraria</td>
<td>Splice grafting</td>
</tr>
<tr>
<td></td>
<td>Sicyos angulatus</td>
<td>Hole insertion and cleft method</td>
</tr>
<tr>
<td>Bitter gourd</td>
<td>C. moschata</td>
<td>Hole insertion and tongue method</td>
</tr>
<tr>
<td></td>
<td>Lagenaria siceraria</td>
<td>Hole insertion</td>
</tr>
<tr>
<td>Bottle gourd</td>
<td>C. moschata, Luffa sp.</td>
<td>Hole insertion and tongue method</td>
</tr>
<tr>
<td>Pak-Choi</td>
<td>R. sativus var. longipinnatus</td>
<td>Splice grafting</td>
</tr>
</tbody>
</table>

Tomato grafting by Splice grafting

Table 2. Grafting methods and rootstocks used in vegetable crops

Indian Horticulture

Tomato grafting by Splice grafting

Brinjal grafted in Solanum torvum by Splice grafting

agro-ecosystems. It is a rapid alternative means to the moderately slow breeding methodology. In recent days, grafting application leads the limit use of harmful soil disinfectants which minimizes the toxic residues in vegetables and environmental pollution. Hence, it is suggested that, by adopting modern innovations and indigenous wild relatives, we can realize commercial use of grafting to attain the low input sustainable horticulture in future. Since it provides disease tolerance and results in better vigour of the crops, it will be useful in the low-input sustainable horticulture in near future.

For further interaction, please write to: Praveen Kumar Singh (Principal Scientist), Center for Protected Cultivation Technology, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi 110 012. Corresponding author e-mail: pksingh128@gmail.com
Malabar Tamarind at a glance

**Malabar Tamarind**

Indigenous to Western Ghats, rind of small pumpkin-like fruit is rich in a substance called hydroxycitric acid. Rind powder widely used in anti-obesity formulations.

**Botanical name**

*Garcinia gummigutta* Choicy

**Family**

Clusiaceae

**Commercial varieties/ lines**

CHES GG-IV-I

**Economic part**

Fruit, seed

**Propagation techniques**

Cleft grafting, seeds

**Nursery period**

14-18 months

**Grafting time**

June-July

**Spacing**

6 m x 6 m

**Climate and soil requirements**

Flourishes well up to an elevation of 1,200 m msl and over 250 cm rainfall. It comes up well in lateritic, alluvial soils, and well-drained soil.

**Leaf**

Simple, dark green, with entire margin

**Growth form**

Upright

**Flowering period**

Feb-March

**Pollination**

Cross pollination

**Pollinating agents**

Wind

**Economic yield**

After 15 years

**Yield/tree**

30-40 kg/tree

**First harvest**

6-8 years

**Harvesting method**

Individual fruits harvested by hand plucking

**Harvesting period**

3-4 month after fruit set

**Pests**

Leaf eating beetles

**Diseases**

Drying back of twigs

**Shelf life**

4-5 days under ambient temperature.

**Post harvest products**

Dried rind, powder, butter

**Chemical Composition of Malabar Tamarind Rind (100 g edible portion)**

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>0.9 g</td>
</tr>
<tr>
<td>Fat</td>
<td>1.4 g</td>
</tr>
<tr>
<td>Tannins</td>
<td>1.7 g</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>4.1 g</td>
</tr>
<tr>
<td>Water</td>
<td>80 g</td>
</tr>
</tbody>
</table>

**For further details, please contact or write to:**

Dr. P.C. Tripathi and Dr. G. Karunakaran

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