INDIAN Horticulture
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Karonda
THE summer squash (Cucurbita pepo L.), known as Chappan Kaddu in Hindi is a very popular and important vegetable grown in hills and plains of India. It is an easy-to-grow, short-season crop best adapted to temperate and subtropical regions. Fruits are generally consumed immature as vegetable. Its tender fruits can be served fresh in salad and cooked (stuffed with meat, fried squash, baked squash). Growing tips and flowers are also consumed. It fits well in multiple cropping systems. No improved and heat tolerant round fruited variety of summer squash for spring summer season is available so far for North Indian plains. The available variety/hybrid Australian Green and Pusa Alankar developed by IARI are long cylindrical in shape. The only local oblong round variety available is very shy bearer and is less preferred by the consumers. The consumer preference in North Indian plains is of flattish round and medium size (70-80 g) fruits. Keeping in view the above facts, an early, heat tolerant, high yielding flattish round shaped variety Pusa Pasand has been released, notified and recommended for commercial cultivation during spring summer season for NCR Delhi. It is also suitable for growing during off season in winter under naturally ventilated polyhouse (Mid October - Mid February) and under plastic low tunnel (November end – Mid April) in North Indian Plains.

Pusa Pasand (DS-8)

It is developed from highly heterozygous local material collected from Malerkotla, Dist: Sangrur in Punjab. Selfing and individual plant selections were carried out to purify the material and develop the variety. Plants are annual, bushy, monoecious, and pubescent with an upright and open habit, hence ensuring multiple harvest, easy picking and shelters the fruits from the sunburn. Leaves are ovate-cordate without white spots and with serrate denticulate margins. Young fruits are attractive light green, shiny, uniform, flattish round in shape, 70-80 g with tender flesh. Fruits are easy to pick with minimal breakage. It has continuous and concentrated fruit setting. It is ready for first harvesting in 45-50 days after sowing during spring summer season. It has good heat tolerance and can produce seeds from April to May under open condition in North Indian plains. Average yield is 16.0 t/ha under open field condition, 24.5 t/ha under naturally ventilated polyhouse and 22.8 t/ha under plastic low tunnel.

Performance of Pusa Pasand

Pusa Pasand has been tested in yield trial under open field condition at IARI, New Delhi from 2010 to 2014 during spring summer season along with round fruited local check (Table 1). The results indicated that Pusa Pasand yielded 16.01 t/ha which was 40.93% higher than the local check. At Centre for Protected Cultivation (CPCT), IARI, New Delhi it showed 62.15% higher yield over local check under naturally ventilated polyhouse during off-season i.e. winter season (mid October to mid February) from 2011 to 2013 (Table 2). Pusa Pasand yielded 22.8 t/ha with 64.38% higher yield than the local check under plastic low tunnel during off-season i.e. winter season (November end – Mid April) from 2011 to 2013 (Table 3). At multilocation testing from 2012 to 2014, it showed 36.97% higher yield over local check under open field condition during spring summer season at IARI Regional Station, Karnal (Table 4).
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Potential of Underutilized fruits

India has a rich and varied diversity of underutilized fruits by the virtue of wide spectrum of habitats from tropical rainforests to temperate forests. Several fruit plant species have originated in Indian subcontinent. India is centre of origin of jack fruit, bael, aonla, ber, jamun, mahua, phalsa, lasoda, karonda, wood apple, bilimbi, kokum, etc. Some of these fruits have gained popularity in past few decade but majority are still not grown in large area. Apart from indigenous fruits, several fruits were introduced in India from South America, Africa, south east Asian countries during last four centuries. Some of them adopted to climatic conditions of India and became major fruits. But some remain confined to specific locations or backyard gardens due to several reasons. Several minor fruits such as Rambutan, mangosteen, longan, avocado, water apple, hog plum, macadamia nut, kiwifruit, longsat, durian, passion fruit, dragon fruit, pulasan, carambola, etc. were introduced during last few centuries. These fruits are slowly making place in our food baskets.

Some of these fruits are not as stay as the commercial fruits but most of these fruits are rich in mineral and vitamins. Many of these have medicinal and therapeutic values. The medicinal values of aonla, jamun, bael and kaith has been mentioned in the Ancient ayurvedic literatures. The area and production of aonla, bael increased several fold in last 40 years and they became major fruits. Several fruits processed products such as aonla are now exported as vitamin supplements apart from their use in several health supplements. Some of these fruits like kokum, malabar tamarind, durian, jackfruit, bilimbi, jamun are getting popularity due to their therapeutic value. The export of kokum and Garcinia products has increased rapidly in last one decade due to the anti-obesity properties. The dried rind, rind powder, drinks are exported to several countries. Kokum is exported to over 44 countries. In the year 2020-2021 (Apr-Nov), India has exported Kokum worth of 0.06 USD million. The total volume of export in 2020-2021 (Apr-Nov) was around 37460. Similarly jackfruit seed powder is extensive used in treatment of gastro-intestinal disorders and gaining popularity in global market. Jackfruit exports from Kerala grew to 500 tonnes in 2018 and was expected to reach 800 tonnes by 2019. Although these figures are very low as compared to export of grapes and mango but slowly these are making space in our fruit export. Passion fruit is a exotic fruit in India but grown in sizable area. In the year 2020-2021 (Apr-Nov), India has exported Passion fruit worth of 2.3 USD million. The total volume of export in 2020-2021 (Apr-Nov) was around 2293890. New World trade regime increase the import of several exotic fruits such as rambutan, avocado and dragon fruits to fulfil domestic demand. There is steep increase in the popularity of these fruits and import has also increased. Recent data has suggested that India imports 1000 tons of avocados annually. The area and cultivation of avocado, dragon fruit has taken a quantum leap in last decade. The increase in domestic production will be helpful in fulfilling the domestic demands and import substitution import.

Most of the underutilized fruits are cultivated by small and marginal farmers and considerable quantity of these fruits are collected by forest dwellers. The increased popularity of these fruits may provide income and employment and act as a livelihood security to these communities.

P C Tripathi
ICAR-IIHR, Bengaluru
Fig: A fruit for health

Fig is grown in many parts of the world with moderate climate. Figs are eaten dry and fresh both, as fresh figs are highly perishable, so fresh figs are consumed only in nearer market but dry figs are exported for long distance markets. Fresh and dry both fruits are rich in fibre; potassium, calcium, and iron. Fresh figs are highly sensitive to physical damage, and susceptible to disease and infections. Preharvest and postharvest conditions are very important to improve fruit quality and postharvest life. Due to its nutritional quality, fresh fruit breeders are taking it as a challenge for development of new improved varieties for long shelf life of fresh fruits.

Fig is botanically called *Ficus carica* (synonyms – forbidden fruit), it comes under family Moraceae, originated in the southern parts of Arabian Peninsula, Italy and USSR and its cultivation spread through Asia minor and into all countries of the Mediterranean region. It has 26 chromosomes and inflorescence hypanthodium with terminal bearing habit on current season growth. Fruit is tasty and sweet with total soluble solids 17 °Brix with good processing quality for export use as a dry fruit. Fig is one of the oldest fruit crops, morphologically it is called as “syconium” which is a vegetative fleshy tissue, with tiny true fruits enclosed inside. Fig is a gynodioecious species and some female types need pollination, while others set fruits parthenocarpically. Pollination is mostly performed by a wasp (*Blastophaga psenes*). Fig is grown as a subtropical and temperate crop. It is one of the most salt and drought tolerant fruit tree. Oldest crop well grown in Spain followed by Italy, Iraq, Syria, turkey and other Mediterranean countries. Spain and Italy once produced 2/3rd of world’s harvest. In India, its cultivation is confined to western parts of Maharashtra and Gujarat and small areas in Bengaluru (Bellary, Sreerangapatnam, Chitrdurga) and Tamil Nadu. In North India, most of the cultivation is concentrated in U.P. At present Turkey and Greece are the leading producers of fig, grown in an area of 600 ha in Maharashtra and 120 ha in south India (NHB, 2019).

**Nutritional value**

Fig is a highly nutritious fruit with high sugar and low acid content, rich in calories (269), protein and calcium (higher than milk), iron and highest fibre content among fruits. Fig fruits are often consumed as fresh, dried or canned. The nutritional index of dry fig is 11 as compared to 9 of apple, 8 of raisin and 6 of date and pear. The chemical composition and flavor of fig vary with the cultivar. Fresh and dehydrated figs both are rich in nutritional and biochemical content.

**Uses**

Fig fruits are consumed as fresh, preserved and dried or canned form. This is very much reputed as a dried fruit; and is processed into jelly and paste. Latex is used to coagulate milk. The latex of the unripe fruits and of any part of the tree may be severely irritating to the skin if not removed promptly. Fig leaves are used for fodder in India. In southern France, there is some use of fig leaves as a source of perfume material called “fig-leaf absolute. Dried latex powder use in coagulating milk to make cheese and junket. From it can be isolated the protein-digesting enzyme *ficin* which is used for tenderizing meat, rendering fat, and clarifying beverages. In tropical America, the latex is often used for washing dishes,
pots and pans.

The latex is widely applied on warts, skin ulcers and sores, and taken as a purgative and vermifuge, but with considerable risk. In Latin America, figs are much employed as folk remedies. A decoction of the fruits is gargled to relieve sore throat; figs boiled in milk are repeatedly packed against swollen gums; the fruits are much used as poultices on tumors and other abnormal growths. The leaf decoction is taken as a remedy for diabetes and calcifications in the kidneys and liver also. Fresh and dried figs have long been appreciated for their laxative action.

Plant description

Fig is moderate sized deciduous tree in subtropics but performs as evergreen in tropics. Branches are irregular, shoots develop at base of trunk, leaves are very broad, ovate and long stalked. Fruits mostly long stalked, pear shaped with a velvety or glabrous skin, purplish or black in color. Fig is a multiple fruit, botanically a ‘Syconium’ which consists of a hollow receptacle with a narrow aperture at the tip and numerous small tiny fruits lining in inner surface.

Table 1. Biochemical parameters in fresh and dehydrated fig

<table>
<thead>
<tr>
<th>Biochemical Parameter</th>
<th>Fresh Fig (Irfan et al. 2013)</th>
<th>Dehydrated Fig (Naikwadi et al. 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total soluble solids</td>
<td>17.43 %</td>
<td>35.0 %</td>
</tr>
<tr>
<td>Total sugar content</td>
<td>17.55 %</td>
<td>26.3 %</td>
</tr>
<tr>
<td>Reducing sugar</td>
<td>13.35 %</td>
<td>24.1 %</td>
</tr>
<tr>
<td>Non – reducing sugar</td>
<td>5.70 %</td>
<td>2.2 %</td>
</tr>
<tr>
<td>Titratable acidity</td>
<td>0.35 %</td>
<td>0.09 %</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>0.85 mg/100 g</td>
<td>1 mg/100 g</td>
</tr>
</tbody>
</table>

Leaf shape of fig

Table 2. Some popular varieties of fig and their characteristics

<table>
<thead>
<tr>
<th>Type</th>
<th>Popular varieties</th>
<th>Flower type</th>
<th>Mode of pollination</th>
<th>No. of crops</th>
<th>Listed var.</th>
<th>Other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edible or common fig</td>
<td>Poona</td>
<td>Long styled pistillate flowers</td>
<td>Fruits develops parthenocarpically</td>
<td>1</td>
<td>470</td>
<td>Seeds are hollow without kernals and the embryo. Some varieties produce a small Breba or first crop in addition to main or second crop</td>
</tr>
<tr>
<td></td>
<td>Conardia</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Mission</td>
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<tr>
<td></td>
<td>Kadota</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Brown</td>
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<tr>
<td></td>
<td>Turkey</td>
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<tr>
<td></td>
<td>Smyrna</td>
<td>Long styled pistillate flowers</td>
<td>Female wasps emerging from the spring Caprifig enter Smyrna fig for oviposition and in the process effect pollination</td>
<td>1</td>
<td>116</td>
<td>Originated from the caprifig. The fertile seeds contribute to the excellent quality</td>
</tr>
<tr>
<td></td>
<td>Calimyrna</td>
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<td>Zidi</td>
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<td>Taranimt</td>
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</tr>
<tr>
<td></td>
<td>San Pedro</td>
<td>Long styled pistillate flowers</td>
<td>First crop (Breba) fruit develops without pollination but not second crop(main)</td>
<td>2</td>
<td>21</td>
<td>Commercially not well important, some while, large fruited types are grown in Mediterranean countries for drying</td>
</tr>
<tr>
<td></td>
<td>King</td>
<td></td>
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<td></td>
<td>Gentile</td>
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<td></td>
<td>Sanpedro</td>
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<td></td>
<td>Dauphine</td>
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<td></td>
<td>lampeiria</td>
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<tr>
<td></td>
<td>Wild or caprifig or goat fig</td>
<td>Short styled pistillate flowers and functional staminate flowers near the Ostiole</td>
<td>Self-fertile (persistent) syconia</td>
<td>3</td>
<td>20</td>
<td>A primitive type. Fruits have almost no edible value, but serves as an abode for fig wasp and Smyrna and Sanpedro figs</td>
</tr>
</tbody>
</table>
Varietal diversity of Fig

Nearly 700 varieties of fig have been listed in the world. Based on pollination pattern and sex of flower, there are four types of fig.

Based on the colour, figs are classified into three types:
1. Fruit green or yellow - Adriatic, Kadota
2. Fruit shaded with bronze or copper colour - Brunswick
3. Fruit dark violet or purplish black - Patridge eye

Poona fig is most popular cultivar grown in India. It is bell-shaped, medium size, weighing about 1.5 oz (42 g); thin-skinned; light-purple with red flesh, of sweet, good flavour. Some well-known fig hybrids from California have performed well in comparison to Poona fig under Bangalore conditions, they produce parthenocarpic fruits. Adriatic fig is commonly grown. Most common varieties grown are Black Ischia, Brown Turkey, Turkish white, Kabul, Marseilles, Lucknow and Poona figs. A type of Adriatic fig of high quality introduced at Coimbatore and locally known as Coimbatore fig is reported to be highly superior than Poona fig. There are many cultivated varieties in each class of figs. In fact, over 700 varietal names are in use but many are synonyms. Here we need only present those that are suited to warm areas and do not require pollination. Most popular among these are ‘Celeste’ and ‘brown Turkey’, followed by ‘Brunswick’ and ‘Marseilles’, but some hybrids from California have reportedly performed better over Poona Fig.

Harvesting indices

Fresh figs should be harvested when they are soft, slightly wilted at the neck and drop; no milky latex flow at the cut end of the stalk; sudden increase in fruit size and opening of ostiole. Figs are handpicked from the trees by twisting the neck at the stem end. Harvested fruits are spread out in the shade for a day so that the latex will dry a little. In India, a fig tree bears 180 to 360 fruits per year.

Grading

- After picking, figs are carefully stored. Diseased and damaged ones are culled.
- Fruits are graded for size as 50 g, 40-50 g and 30-40 g.

Packing

Fig fruits packing should be done in a corrugated box (CFB) carton of 3 ply having 12 holes for ventilation and arrange in the carton in 2 layers, each of 28 (4 rows of 7 figs in a line). Fig leaves are used for cushioning material.

Storage

Fresh figs are very perishable so, for storage needs very much care and fresh fruits can be stored at 40° to 43°F (4.44°-6.11°C) and 75% relative humidity. Figs remain in good condition for 8 days but have a shelf life of only 1 to 2 days when removed from storage. At 50°F (10°C) and relative humidity of 85%, figs can be kept no longer than 21 days and fruits remain in good condition for 30 days when stored at 32° to 35°F (0°-1.67°C). If frozen whole, they can be maintained for several months.

Conclusion

As discussed above, fig is very nutritious and delicious in taste as fresh and processed both but needs cultivation of some improved varieties for longer shelf life like Poona and Black Ischia figs. Some improved technology like modified atmospheric storage, cold storage and controlled atmospheric storage conditions are required for increasing shelf life of fresh fruits.

For further interaction, please write to: Pradeep Kumar Vishwakarma (Horticulturist), ICAR–Indian Institute of Horticultural Research, Bengaluru 560 089. Corresponding author e-mail: pradeepkumar5953@gmail.com
Sustainable transformation of oil palm recyclable biomass into organic manure through vermicomposting

The increasing global demand for edible oils has resulted in the increase of oil palm cultivation but there are concerns over the large amount of waste that are being generated in the field. The ability of vermicomposting process to utilize organic waste and bio-convert them into higher value added products makes it an attractive technology. The aim of this study was to investigate the characteristics and physico-chemical changes of vermicompost during composting of palm oil processed by epigeic earthworm (*E. eugeniae*).

**PALM oil**, edible oil, is derived from the fleshy mesocarp of the fruit of oil palm (*Elaeis guineensis*). In India, an area of 19.33 lakh ha in 18 states is identified as potential area for oil palm cultivation. Oil palm is one of the leading oil yielding perennial crop that produces 4 to 6 tonnes of crude palm oil and 0.4 to 0.6 tonnes of palm kernel oil per ha per year from 4th to 30th year of its productive life span. There is an urgent need to increase the production and productivity of vegetable oils to meet the increasing per capita consumption along with the population growth and reduce the dependency on import of edible oil.

As oil palm is a highly nutrient demanding crop using waste from palm oil processing unit as fertilizer supplement in place of inorganic nutrients is an environmentally friendly option. The waste products from oil palm processing consist of oil palm trunks (OPT), oil palm fronds (OPF), empty fruit bunches (EFB), palm pressed fibres (PPF) and palm kernel shells, less fibrous material such as palm kernel cake and liquid discharge palm oil mill effluent (POME). One hectare of oil palm produces 10 to 35 tonnes of fresh fruit bunches (FFB) per year. The production of 1 tonne of crude palm oil requires 5 tonnes of fresh fruit bunches.

If cut fronds are left over in the field it hinders harvesting and other cultural operations as it takes longer period for decomposition. There is a need of appropriate waste minimization or recycling technology which should be easy to operate and cost effective. In this regard ‘Vermicomposting’ has been reported to be a viable, cost effective technique for the efficient management for disposal of recyclable biomass. Recycling of organic recyclable biomass from oil palm gardens by converting them into stabilized decomposed products could be the base for sustainable crop production. As oil palm leaves and fronds are hard containing high amount of lignin and polyphenols, natural decomposition under field conditions takes place at slower rate, vermicomposting under artificial shade could be the best choice. Hence, study was conducted for utilization of oil palm fronds for vermicomposting under All India Coordinated Research Projects on Palms (Oil Palm) at College of Horticulture, Mulde Tal: Kudal Dist: Sindhudurg (Maharashtra).
Composting by Earthworms

Vermicomposting is a composting processing (recyclable biomass) involving the interaction of earthworms and microorganisms. Earthworms have the capacity of feeding on any organic debris and converting them into quality manure. Species like *Eisenia fetida* and *Eudrillus euginiae* are common for preparing vermicompost from coconut and oil palm waste. However, species *Eudrillus euginiae* had a wide adaptability under humid tropical conditions of India and potential to convert the oil palm leaves into the value added products. Vermicompost is a final peat-like material with excellent structure, porosity, drainage and moisture holding capacity.

Preparation of compost bed

The experiment was performed in compost beds of plastic, Kaddappa and lateritic stones in open condition of the shaded yard. Readymade plastic unit having dimensions of 3” × 3” × 10” were used for preparation of vermicompost. Dimensions, cost of construction, quantity of chapped fronds and quantity of vermicompost are given below.

<table>
<thead>
<tr>
<th>Particular</th>
<th>Dimensions/ bed (cm)</th>
<th>Cost of Construction/ bed (₹)</th>
<th>Quantity of dry material with cow dung (25%) (kg)</th>
<th>Quantity of Vermicompost (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readymade plastic bed</td>
<td>300 × 120 × 60</td>
<td>1200/-</td>
<td>600</td>
<td>210</td>
</tr>
<tr>
<td>Kaddappa</td>
<td>420 × 75 × 90</td>
<td>9800/-</td>
<td>400</td>
<td>150</td>
</tr>
<tr>
<td>Lateritic stones</td>
<td>420 × 75 × 90</td>
<td>9100/-</td>
<td>400</td>
<td>140</td>
</tr>
</tbody>
</table>

Table 1. Dimensions, cost of fixing, quantity of chapped fronds and vermicompost

Dried as well as partial green oil palm leaves and fronds were chopped into pieces with the help of tractor driven mechanical shredder. Chopped material was spread in a single vermicompost unit layer by layer mixed with fresh cow dung slurry at 25% of biomass. Final layer was covered with thick slurry of cow dung and after filling the bed it was covered with weed mat to protect the entry of Rhinoceros beetle and excess sunlight and heavy rains during monsoon. The beds were incubated for 4-5 weeks and moistening was done through the two foggers. Besides, the moisture content was maintained at 60–80% by periodic sprinkling of adequate quantity water on the bed throughout the study. After 2-3 weeks turning of waste at weekly interval was done. After 5 weeks when material started decomposing, earthworm species *Eudrillus euginiae* were introduced at a rate of 1,000 worms/ bed. Compost was ready after 7 months when chopped oil palm waste was used while dried un-chopped oil palm fronds took 12 months for decomposition and final vermicomposting. After the trial, watering was stopped one month prior to harvesting of bed. The product was air-dried and collected in polythene bags for further analysis.

Nutrient value of vermicompost

After 7 months of vermicomposting process using *E. euginiae* the final produce of vermicompost was analyzed. The colour of vermicompost was also darker with granular grain size of 1 to 1.5 mm with black colour, pH 6.6, organic carbon (13.50%), nitrogen (0.75%), phosphorus (0.39%) and potassium (0.89%). In short, this study suggests that the chopped oil palm wastes which were mixed with an appropriate ratio of cow dung could be easily vermicomposted by *E. euginiae* when compared to dried un-chopped oil palm fronds and the vermicompost produced could be utilized as an efficient organic fertilizer for sustainable land restoration practices.

For further interaction, please write to:

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Chamomile cultivation – Step towards rural prosperity

German chamomile (*Matricaria recutita* L.) is one of the most ancient herbs known to mankind. Essential oil of chamomile is used extensively in cosmetic industry and aroma therapy. Besides these, chamomile preparations are used for many human ailments and as herbal tea. It is also an ingredient of several traditional unani and Homeopathic medicines. It is an introduced crop in India and is mainly grown in Kashmir, Uttar Pradesh and Assam, and much credit goes to CSIR-CIMAP and Aroma Mission. Suitable agro-techniques have been developed by scientists so that farmers can grow chamomile and diversify existing cropping systems. Aromatic crops like chamomile can prove to be a milestone in doubling farmers income for sustainable agriculture.

The German chamomile (*Matricaria recutita* L.) is mainly cultivated for essential oil. It is well-known medicinal plant species from the Asteraceae family often referred to as the “star among medicinal species”. Chamomile is a native of Europe and adjoining Asian countries. The essential oil is produced mainly in Argentina, Egypt, France, Germany, Hungry and Yugoslavia. In India, seeds were brought from France in early 1950s for experimental field trials in Regional Research Laboratory in Jammu and later All India Coordinated research Project on Medicinal and aromatic crops at Solan centre and agro-techniches were developed. Today, CSIR-CIMAP is the leading institute working on this crop for developing improved varieties and agro technology. Today the main centres of the crop are Jammu and Kashmir, Uttar Pradesh and Assam. The oil of chamomile is known as Blue oil in market. About 40 different compounds were identified in chamomile essential oil that the most important ones included sesquiterpenes, chamanzulene, b-farenzn, bisabolo oxide A, and bisabolo oxide B. In chamomile oil, there are 120 components which are identified by different researchers but only two major components are for our use i.e. α-bisabolol and chamazulene (17-18%). They directly involve in reducing inflammation and both are mild anti-bacterial.

Nowadays it is a highly used medicinal plant in folk and traditional medicine. It's multitherapeutic, cosmetic, and nutritional values have been established through years of traditional and scientific use and research. Blue oil of chamomile is used in perfumery industries as well as having medicinal importance like face creams and sun burn and flavouring fine liquor. Extract of chamomile is useful in stomach disorders, to cure ulcer problem and wounds healing. Flower of chamomile is used as herbal tea and it is very common in China. Chamomile oil is also used as baby massage oil, for promoting gastric flow secretion and in treatment of cough and cold. Due to it's high pharmacological and pharmaceutical properties, plant has great economic value and is in great demand in the Asian and European countries.

Improved varieties

CSIR-CIMAP has released many improved varieties of chamomile like Vellari, Prashant, CIMAP-Sammohak and CIM-Ujjwala.
The cultivar Prashant is superior to Vallary in all respects like plant height (85 cm), diameter of the capitulum (1.5) and gross oil production (22%).

Climate
It can be grown as winter crop in plains of North India and as summer crop in the hills of J&K, Himachal Pradesh and Uttar Pradesh. Chamomile plant grows well when the temperature is in between 30-32°C with a humidity of 40-50%. If the temperature exceeds 38°C or above, the plant growth and flower bud formation is affected.

Soil requirement
It can be cultivated in wide range of soils but light texture and low water holding capacity soil should be avoided. Chamomile cultivation is possible on medium and heavy texture soil. For good establishment of plants, soil should be well drained, crumby, levelled and slightly slopy in nature. Sometimes chamomile plant can be grown in sodic soil as it can tolerate the sodic condition up to some extent.

Propagation
Chamomile is propagated through seeds during Oct-Nov in north Indian plains and March-April in the hills. Plants can be transplanted after 6-8 weeks.

Direct sowing: Sowing should be done in lines but in this method more seed is required.

Nursery raising and transplanting: For commercial production of chamomile plant, raising of seeding in nursery is recommended. Raised bed of 4 × 1 m² or 5 × 1 m² are prepared by mixing good amount of FYM or compost in the soil. About 0.501 kg seed is required for raising nursery for 1 ha area. Sowing of nursery is done in the month of October-November and in the mid of November, transplanting of seedlings is done at a distance of 50 × 30 cm.

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 levelling is that it helps in saving water by uniform distribution of water in the field whenever irrigation is applied. Drainage facility should be there in the field.

Irrigation
First irrigation is applied just after transplanting and rest irrigations are to be done as per need. Normally, the crop requires 2-3 irrigation in it’s crop duration.

Manures and fertilizers
Apply 10-15 tonnes of well rotten FYM or apply 5 tonnes of Vermicompost at the time of field preparation. Synthetic fertilizer should be applied on soil test basis but in general, apply nitrogen, phosphorous and potassium in the ration of 80:40:40 Kg/ha. Full dose of phosphorous and potassium at the time of transplanting and nitrogen dose should be applied in 4 splits in equal quantity at equal interval and 3 splits before flowering and 4th dose after first picking of flowers.

Weed management
To control weeds in the early crop growth stage is an essential interculture operation otherwise the crop yield may get affected. The uncontrolled weed growth caused about 35% reduction in the dry flower yield as compared to weed free condition. Generally 3-4 hand weedings are required for good crop. Chemically, there are so many herbicides for weed control in chamomile crop such as 2,4-D, atrazine, trifluralin and oxyfluorfen. Application of oxyfluorfen @ 0.6 kg/ha give better result.

Pest and diseases
Insects: Aphids, mealybugs, spider mites cause severe damage to the chamomile plants. To control the insect attack and their infestation, (may) use natural bio-control agent like lady bird beetle or wasp and for mealybug control, spray neem oil which is an effective agent.

Diseases:
Powdery mildew: Formation of white powder growth on the foliage parts of the plant. To control this, spray any of the following fungicide such as captan/bavistin/Dithane M-45 @ 0.2-0.3%.
Damping off: Plant wilts and dies. To control this disease, drain out the excess moisture from the field and reduce the nitrogen dose.
Root or crown rot: It cause yellowing of leaves and then branches to turn brown and death of the plant. To control this, reduce too much irrigation, standing water is the main cause.
Flower picking
This is an important and laborious operation in chamomile crop. So for picking purpose, sufficient labour should be available. Only fully developed flowers should be picked. Flowers are ready for first picking after 65-70 days of transplanting and then subsequent picking should be done at 15 days interval and last and second last picking should be done only for seed purpose.

Drying of flowers
As the fresh flowers of chamomile contain about 70-80% water. Picked flowers should be immediately transferred to the drying shed and spread over ground in very thin layers of 1-2 cm and allowed them to dry till flowers loose 45-65% moisture.

Distillation
Steam distillation method is an appropriate method for oil extraction from dried flowers of chamomile.

Oil content and yield
The flowers yield a blue oil containing 1-15% azulene. It is used in pharmaceutical industry, to flavour high quality wine, tea and in perfumes. Oil percentage- 0.80%, oil yield- 7-8 kg/ha, dry flower- 7-8 quintal/ha. Flower yield may vary because it depends on soil fertility status, management practices and number of pickings.

Benefit: Cost ratio
Cost per hectare: ₹ 75,000/- per annum; income per hectare: ₹ 1,70,000/- per annum; net benefit per hectare: ₹ 95,000/- per annum.

SUMMARY
There is good potential for chamomile cultivation as commercial crop in India. Since it is a valuable crop for aroma industries and has high export value, it is necessary to promote this crop among small and marginal farmers, to secure their livelihood. CSIR-CIMAP with all other leading scientific institution is working hard to increase its area, its inclusion in existing cropping systems and adoption on large scale for bringing rural prosperity and self reliant India.

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Sweet lime cultivation for increasing the productivity, profitability and sustainability

Sweet lime (Citrus limetta) popularly known as Mosambi is an important citrus fruit that has plenty of health benefits. The fruit is directly consumed as raw or more commonly in the form of juice. It is a rich source of vitamin C, helps in detoxification of body, boosts immunity, regulates digestion keeping the bowels healthy and prevents constipation. The juice is also rich in vitamin B complex and carotene which enhance the body immune system, improve eye sight and skin health. In India, it is grown in an area of 20.65 M hectares with a production of 33.15 M tons. The important states growing this crop are Andhra Pradesh, Maharashtra, Telangana, Madhya Pradesh, Punjab and Rajasthan. Andhra Pradesh ranks first in the area, production and productivity followed by Maharashtra, Telangana and Madhya Pradesh.

The sweet lime crop is grown under tropical and sub-tropical conditions with moderate rainfall i.e. 750 mm. A well-drained loamy soil of uniform texture up to a depth of 2 – 3 meters having good fertility is considered as the best for its cultivation. The red sandy loam soils are also ideal for sweet lime cultivation.

Varieties
There are three popular varieties which are extensively grown in different parts of the country.
Sathgudi: It is a high yielding (1,000 – 2,000 fruits/tree) variety popular in south India. The fruit weighs about 150 g. The fruit skin is thin and the no. of segments are 10-12. The brix ranges from 8.5 to 9 degree. Juice content is about 50% with 0.65% acidity.
Batavian: Batavian variety (Bathayee) closely resembles Sathgudi except for the green and yellow patches that develop due to basking. It is mostly grown in coastal districts of Andhra Pradesh.
Mosambi: It is grown in some parts of Telangana. The fruit develops prominent furrows on skin and a circular groove at the stylar end. It has hard and thick skin. It tastes sweeter and has more number of seeds compared to Sathgudi. It lacks flavour and has inadequate blending of acidity with sugars. The fruit is spherical, smooth and weighs about 200 g; it has 14 segments; 8.5° brix; 0.44% acidity and 43% juice content.

Propagation
Healthy and vigorously growing buds from desired sweet lime variety are selected and budded on Rangapur lime root-stock.

Planting
The plants selected should be free from virus, pest and disease. While planting the bud joints should not go into the soil. The plants have to be staked immediately to avoid wind damage. An intra-row spacing of 4 – 5 m and inter row spacing of 6 – 8 m will be sufficient depending upon the fertility status of the soil. This will facilitate
operating tillage machinery and taking up plant protection measures. Pits of 1 meter cube are dug and filled with mixture of tank silt, red earth and farm yard manure in equal proportions. 2 – 3 kg bone meal or super phosphate per pit to be applied. Planting may be done preferably after the rainy season to avoid water stagnation.

Manures and fertilizers
Nitrogen is applied in the form of FYM and oil cakes each at 25% and the remaining 50% as chemical fertilizer while P₂O₅ is applied in the form of superphosphate and K₂O in the form of sulfate of potash. Manures are applied in 2 – 3 equal doses i.e. first dose in December-January, 2nd dose in June-July and 3rd dose in September.

A mixture of Zinc sulfate 0.5%, Manganese sulfate 0.2%, Boric acid 0.1%, Urea 1% and lime 0.4% has to be sprayed two or three times in a year to control chlorosis in leaves.

Pruning and training
The plants should be trained to grow straight and to build a strong framework. Rootstock sprouts, water suckers and dead wood should be removed periodically and Bordeaux/Copper fungicide paste to be applied at the cut ends.

Intercropping
Short duration rainfed crops like green gram, black gram, cowpea or horse gram can profitably be raised in the inter-row spaces during the rainy season as the crop canopies of sweet lime are shorter.

Weeding and interculture
The interspaces can be kept weed free by operating cultivator. Power weeders are now a days used for weeding and hoeing in the basins. After weeding and manuring, application of dry leaf mulch or paddy husk to a thickness of 6–8 cm in the basin keeps down the weed growth and decreases the number of irrigations.

Irrigation
Scheduling of irrigation depends upon the climatic conditions, soil type and available soil moisture in the root zone. Normally drip irrigation is recommended to save water and labour. Young trees need to be watered regularly during the dry season.

Control of fruit drop
Early and pre-harvest fruit drop is very common. Planofix 10 ppm solution can be sprayed thrice at flowering, after fruit set and one month before harvest. It minimizes the fruit drop and increases yield considerably.

Table 1. Area, Production and productivity of sweet lime crop in major growing states (3 years’ average data 2015-18)

<table>
<thead>
<tr>
<th>State</th>
<th>Area (lakh ha)</th>
<th>Production (M tons)</th>
<th>Productivity (tons/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>80.93</td>
<td>163.57</td>
<td>20.13</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>32.71</td>
<td>57.23</td>
<td>12.03</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>0.64</td>
<td>0.74</td>
<td>16.68</td>
</tr>
<tr>
<td>Telangana</td>
<td>50.20</td>
<td>73.75</td>
<td>14.56</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>7.22</td>
<td>11.86</td>
<td>16.05</td>
</tr>
<tr>
<td>Karnataka</td>
<td>1.65</td>
<td>2.63</td>
<td>15.95</td>
</tr>
<tr>
<td>Mizoram</td>
<td>2.22</td>
<td>0.48</td>
<td>2.85</td>
</tr>
<tr>
<td>Tripura</td>
<td>1.24</td>
<td>0.20</td>
<td>2.12</td>
</tr>
<tr>
<td>Punjab</td>
<td>2.84</td>
<td>2.36</td>
<td>8.29</td>
</tr>
<tr>
<td>All India*</td>
<td>206.54</td>
<td>331.45</td>
<td>16.23</td>
</tr>
</tbody>
</table>

(Source: ICAR Data Book, 2019) * including all growing states

Table 2. Nutrient requirement of sweet lime crop

<table>
<thead>
<tr>
<th>Age of plant</th>
<th>Plant nutrient to be applied (g/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>1st year</td>
<td>300</td>
</tr>
<tr>
<td>2nd year</td>
<td>600</td>
</tr>
<tr>
<td>3rd year</td>
<td>900</td>
</tr>
<tr>
<td>4th year</td>
<td>1200</td>
</tr>
<tr>
<td>5th year &amp; above</td>
<td>1500</td>
</tr>
</tbody>
</table>

Sweet lime tree bearing fruits in the orchard block of NAARM
Plant protection measures

Leaf minor, leaf weevil, citrus butterfly, bark and stem borer, mungo mite, fruit sucking moth are common pests. The orchard to be kept clean and weed free. Integrated pest management involving suitable insect traps, pheromones, biological and chemical methods to be followed.

Diseases

Quick decline or dieback: Tolerant rootstocks such as sweet orange, trifoliate orange and Rangapur lime have to be used for propagation. Virus free plants to be planted. Best management practices to be followed and the crop should not experience deficit or excess moisture stress.

Greening disease: Insect vector to be controlled by spraying systemic insecticide.

Root rot: Care must be taken to prevent irrigation water coming in contact with tree the trunk. Bordeaux paste has to be painted on trunks up to 65 cm above the ground level. For effective management of dry root rot, soil drenching with Mancozeb is recommended.

Harvesting and post-harvest technology

The bearing starts from third year onwards. The sweet lime produces 2 – 3 crops in a year in South India. First harvest will be from December to February, second from March to May and third harvest from June to September. The fruits have to be picked at fully matured stage when they develop their characteristic flavor to the maximum and the green colour of the fruit gradually changes to light greenish yellow colour. The fruits after harvest may be treated with ethylene gas to obtain uniform ripening. Sweet lime yields about 1,000 to 2,000 fruits per tree. The fruits are eaten raw and squashes and juices are also prepared. The fruits can be preserved in cold storage at 7 – 8°C for 4 – 8 weeks.

Mosambi based intercropping system

Fruit based Agri-horticulture system mainly focuses on higher income per unit area. The farmer can practice intercropping during the early stages of the fruit trees. The system is helpful in generating more employment especially during the off-season when the crops are not cultivated.

The sweet lime crop canopy is comparatively shorter. It offers good scope for intercropping of short duration and short statured crops like green gram, black gram, cowpea and horse gram. Wherever there is good irrigation facility, crops like groundnut, soybean and vegetables can also be grown in the inter-row space of sweet lime trees.

Economics

One hectare orchard accommodates about 310 plants with a spacing of (8 × 4 m).

- Cost of cultivation per hectare: (Planting material + planting expenses+ fertilizers and manures+ other maintenance expenses) = ₹1,00,000=00 (Approx.)
The planting material and planting expenses will be in the first year. However, the maintenance expenses will be increasing as the trees grow and it will be approximately ₹ 1, 00,000=00 from 5th year onwards.

- Expected yield/ hectare/ year (Approx. from 5th year): (No. of trees/ha x fruit weight/tree) = 310 × 100 kg = 31 tons .................(B)
- Market price of sweet lime = ₹20,000/ ton (Approx.)....... (C)
- Gross returns/ha/year = B × C = ₹6,20,000=00........... (D)
- Net returns/ha/year = (D) – (A) = ₹5,20,000=00

Thus, growing sweet lime is sustainable and profitable under suitable soil and climatic conditions. Short duration intercrops can also be raised in the inter-row spaces which increases the productivity and profitability.

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Intercrop green gram grown in the sweet lime orchard during rainy season.
Nutrient management strategies to enhance Litchi production

Litchi is known as ‘Queen of Fruits’ due to their attractive pericarp colour and possesses a rich source of nutraceutical, therapeutical and medicinal properties; taste and aroma. It is in a great demand in both domestic and global markets and has emerged as one of the most remunerative and lucrative enterprises. It is commercially grown in the states of Bihar, Jharkhand, Uttar Pradesh, Uttarakhand, West Bengal, Punjab, Haryana, Union Territory of Jammu & Kashmir etc. The litchi industry has expanded rapidly during the last 10 years; wherein, area has increased substantially from 74,400 ha in year 2009-10 to 95,000 ha in the year 2018-19 (IIIrd Advance Estimate, NHB) to the tune of about 27.6%, fruit production over 47.1% and fruit productivity by 17.8% in the country. The litchi fruit industry is growing rapidly in sub-mountainous regions of Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir due to favourable soil and unique agro-climatic conditions. The establishment of litchi-oriented state sponsored projects such as ‘Litchi Niche’ area in the Jammu region, and Litchi estate in Punjab also further give momentum to litchi cultivation in Northern regions of India.

A N adequate supply of nutrients to litchi plants is the main criterion which contributes significantly for the higher production of quality fruits. Besides, the potential yields are reduced drastically due to the poor availability of nutrients. New vegetative flushes in litchi depend upon the reserved or availability of photosynthates/carbohydrates rather than the annual application of recommended fertilizers. The visual symptoms of nutrients deficiency occur due to the lower availability of nutrients, antagonistic soil nutrient interactions, soil pH, etc. According to estimates, one tonne of litchi fruit annually removes about 2.2 kg N, 2.2 kg P$_2$O$_5$, 6.6 kg K$_2$O, 1.6 kg CaO and 1.1 kg MgO from the soil. In India, an average fruit productivity of about 7.65 MT/ha has been documented; thus, on an average, fruits remove about 16.8 kg N, 16.8 kg P$_2$O$_5$, 50.5 kg K$_2$O, 12.2 kg CaO and 8.41 kg MgO nutrients from the soil system. To compensate the nutrients loss, growers are applying the organic and inorganic fertilizers regularly for the sustainable fruit production. The plants of litchi produce higher yields of good quality when applied with optimum level of nutrients even under soils inherited low fertility level. Fertilizers contribute about 50-70% towards the fruit yield and the drastic reduction of fruit yield and quality has been witnessed due to improper fertilizers schedule. At the same time, excess application of fertilizers especially N, P, K contents not only results in economic loss but also causes environmental pollution and higher incidence of insect-pests and diseases. The litchi crop needs micro-nutrients in addition to N, P and K fertilizers. Thus, growers should add organic and inorganic fertilizers to sustain fruit yield, quality and soil health. Hence, risk of fruit yield and economic losses resulting from nutrients deficiency may be mitigated. The aim of the nutrient management is to maintain the optimal nutrients level, good plant health and production of maximum fruiting shoots.

Soil and leaf analysis

The soil and leaf analysis are considered as reliable norms and should be linked to ascertain the nutritional status of orchards, nutrient disorders and to guide/develop fertilizers scheduling in fruit crops. The soil samples at the depth of 0-15 cm and 15-30 cm from the orchards should be tested after 2-3 years so that nutrient status may be judged well in advance before the appearance of any nutritional deficiency. Recent studies also revealed that 4-5 months old leaves from autumn flush should be collected from 2nd and 3rd pair of leaflets from the apex of terminal litchi shoots at the advent of panicle initiation (February-March) to assess the nutritional concentrations of litchi orchards. Leaf samples should be collected from North, South, East and West directions from healthy shoots at the workable height of approximate 6-7 feet from the ground level.

Diagnosis of deficiency symptoms

Nitrogen: Nitrogen is a mobile nutrient in plant system; thus, it is translocated easily from older leaves to younger
Deficiency symptoms of Nitrogen in litchi

Deficiency symptoms of Phosphorus in litchi

Deficiency symptoms of Potassium on litchi

Deficiency symptoms of Calcium in litchi

Deficiency symptoms of Magnesium in litchi

Deficiency symptoms of Zinc in litchi

Deficiency symptoms of Iron in litchi

Deficiency symptoms of Boron in litchi

Deficiency symptoms of Manganese in litchi
leaves under low soil nitrogen content. The deficiency of N nutrient causes yellowing of older lower leaf and mostly entire plant foliage shows light green colour appearance. Under severe deficiency conditions, a pale-yellow chlorosis starts from the tip of older leaf and gradually whole leaf portion becomes pale brown in colour. The N deficiency also leads to poor branching, reduces fruit yield by increasing the proportion of undersized fruits and defoliation throughout the year. In litchi, N deficiency generally retards the leaflet size, new growth, emergence of panicles and root growth. The deficiency of nitrogen generally appears in the soils with lower organic carbon content, light textured soils, intensive cropping system and water logged conditions.

**Phosphorus:** The deficiency of phosphorus causes stunted vegetative growth, smaller leaflet size and lower fruit production. Older leaves develop a characteristics dark to light green colouration that tends to change towards the reddish-brown or purple tinge. Interverinal leaf necrosis and leaf dropping are also visualized. As the deficiency becomes severe, brown necrosis starts to appear on leaf tip and proceeds further to midrib, leaves curl and premature leaf drop. The P deficiency generally appears in the regions with low soil organic carbon content, soils exhausted by intensive or inter cropping, acidic soils and soils where topmost soil has been removed.

**Potassium:** The deficiency of K content causes reduction of internodal length, and generally losses its healthy and dark green leaf growth. The K being a mobile nutrient in plant system, the actively growing younger leaves translocate K from older leaves, while younger leaves generally remain green. The deficiency symptoms include the appearance of pale-yellow chlorosis on the tips of old leaves and finally cause necrosis of leaf margins. The deficiency of K is also responsible for the poor fruit set, fruit size, pericarp colour and pulp/stone ratio. The deficiency of K nutrient generally appears in the soils with light texture, lower in organic content and soils higher in Na, Mg, Ca concentrations, soils irrigated with high bicarbonate content and soil with pH < 6.0.

**Calcium:** The branches of the litchi remain stunted, short and yield is also reduced drastically due to Ca deficiency. The Ca nutrient is relatively immobile in the plant system; thus, its deficiency first appears on the younger leaves. The newly emerged leaves usually malformed and gives plant a shabby appearance. The deficient leaf shows necrotic patches in the interveinal tissues which grow towards leaf margin. The deficiency appears in sodic soils with high exchangeable sodium percentage, low calcium content, and highly leached acidic sandy soils.

**Magnesium:** The magnesium is a mobile nutrient and it is easily mobilised from older leaves under lower soil moisture conditions. Older leaf becomes pale green and the develops into pale yellow interveinal chlorosis, low branching, necrotic leaf margins and leaf dropping. The plant doesn't grow vigorously and shows dull appearance. The deficiency symptoms generally appear in the soils with high Ca or K content, acidic soils with low cation exchange capacity and leaching due to heavy rainfall.

**Zinc:** Zinc deficiency causes stunted vegetative growth, pale, smaller leaflets; bronzing, smaller fruits with lower pulp/stone ratio and sugars content. The deficiency of Zn content generally appears on fully mature newly emerged leaf as irregular interveinal chlorosis where veins remain green. It has also been observed that the fruit does not develop its characteristic colour under severe Zn deficiency. Deficiency appears in soils with pH >7.5, leached sandy soils, soils with excessive application of phosphoric fertilizers and high bicarbonate content. The deficiency of zinc intensifies under higher application of nitrogen fertilizers.

**Iron:** The iron nutrient is immobile in the plant system; thus, it is not transferred from older to younger leaves so its deficiency appears as chlorosis of young leaves, spread to older leaves and die back of branches take place under severe conditions. The iron deficiency appears in the soils with low organic matter and high pH, calcareous soils with high bicarbonates reduces the solubility and uptake and soils with excessive application of phosphatic fertilizers.

**Boron:** Leaf becomes short, bloom show wilting and necrotic symptoms, reduction in pollen viability, poor fruit set and causes fruit cracking due to boron deficiency. The boron deficiency also causes flower and fruit drop, produces misshapen fruits. The deficiency symptoms appear in light textured leached soils, calcareous soils, soils excessive fertilizes with potassic fertilizers, etc.
Copper: The copper deficiency symptom appears on older leaves due to its immobile nature in the plant system. Leaf remains short with symptoms of interveinal pale greenish to pale yellow colour. New emerging branches shows die back symptoms and downward bending of leaf margin under severe deficiency. The copper deficiency appears in alkaline and calcareous soils, leaching in acidic soils, higher organic matter that binds the copper nutrient and reduces its availability. The availability of Cu to plant reduces due to excess soil N, P and Zn levels.

Manganese: It is an immobile nutrient in plant, so retranslocation from older leaves and woody parts is very slow. The symptoms are characterized as development of pale-yellowish interveinal chlorosis in the middle portion of the older leaves that proceeds towards the tip and further to leaf base. The purplish lustre may also develop on the upper surface of the leaves. The Mn deficiency is not common but it may appear in the light textured soils.

Nutrient management through fertilizer applications
Fruiting is an exhaustive process that removes a large amount of nutrients from the soil. To prevent the adverse affects of nutrient deficiency in the plant, fertilizer is applied according to the tree age.

Time of fertilizers application
The proper fertilizers schedule needs to be followed with the plantation of the litchi seedlings in the orchard. In the early phase of orchard establishment, the goal of the farmers should be to establish health plantation, instead of realizing any yield from the plants. Generally, the newly established plantation doesn’t require the substantial quantity of fertilizer; however, FYM is applied in sufficient quantity under low fertile soils. This practice not only provides nutrients to the growing plant but also improves soil health and water and nutrients holding capacity of the soils. During the pre-bearing stage, Urea should be applied in three equal split doses in February-March, June-July and August-September. During bearing stages, urea should be applied in two equal splits, half in the mid-February and other half dose after fruit set during April. FYM, SSP and MOP should be applied in the month of December. If plant shows any symptom of the micro-nutrient that nutrient may be sprayed as and when it is required.

Method of fertilizer application
The roots of the litchi do not penetrate deep in the sub soil and remains concentrated in the top 60-90 cm soil layer. The fertilizers should not be applied near the base of the plants to avoid any injury to the plant. The manures and fertilizers should be applied in the circle about one metre inside the canopy of the plant and be mixed in the soil. If the soil moisture is low at the time of fertilizer application, light irrigation may be applied. A pit of 1 m × 1 m × 1 m should be dug to facilitate better root penetration. Pit is exposed to sunlight for at least 15 days to disinfect the soil. Add 15 ml Chlorpyriphos 20 EC after mixing in about 2 kg of soil to each pit for protection against white ants. The soil in pit for litchi plantation should be mixed with soil collected from the root zone of litchi orchards as it contains Mycorrhiza fungus which helps in the improvement of nutrients uptake and roots development. The pits must be filled to the height of about 2-5 cm above the ground level with the mixture of well rotten farmyard manure, silt and top soil in equal proportions. Irrigation is then applied thoroughly, so that the loose soil settles down properly.

SUMMARY
The widespread nutrient deficiencies can be managed with the application of the recommended dose of fertilizers that will be helpful in realizing higher litchi production in the country.

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Onion is a high valued bulb crop cultivated commercially all over India for its medicinal, aromatic and food plant since ancient times. It is also called as Queen of Kitchen due to its unique characters like aroma, flavor, and taste. It is widely used throughout the year in curry preparation and in the form of processed foods. India is one of the major onion producing country. 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 are Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Bihar, Gujarat, Andhra Pradesh, Haryana, West Bengal and Uttar Pradesh in the country. These states account for almost 90% of the total onion production in the country. Maharashtra ranks first in onion production (8047 thousands tonnes) with a share of 35.26% in 2018-19. In India there are several factors like biotic (Insect pests and diseases) and physiological constraints which affect the yield of onion adversely and reduce productivity.

**Onion maggot (Delia antiqua): A destructive pest of onion**

**Onion maggot (Delia antiqua; Anthomiidae: Diptera),** which is one of the major constraints in the onion production causes rotting of the onion stem in the field and secondary storage, rots in storage leading to heavy losses.

**Biology of onion maggot**

**Egg:** The onion fly deposits white elongated eggs of about 1.25 mm in length on the soil near the stem, occasionally on the young leaves and neck of the onion plant. Eggs hatch in 2-3 days.

**Maggot:** The legless maggots are tapered, creamy-white in colour and reach a length of about 8 mm. Maggots develop through three larval stages in 2 to 4 weeks depending on the temperature. Most newly hatched maggots crawl below the soil surface and feed upon the roots or burrow into the basal plate of the bulbs. Some maggots may enter into the sides of bulbs rather than through the basal plate, after undercutting has occurred. Any injury site on the bulb facilitates the maggot’s entry.

**Pupa:** When full-sized, the maggot leaves the bulb and enters the soil to pupate at a depth 5-10 cm. The pupa is chestnut brown and 7 mm long. First and second generation pupae remain in the soil for 2-4 weeks before adult emergence. Larvae of the third (fall) generation develop into pupae and pass the winter in that stage. Flies emerging the following spring constitute the spring flight.

**Adult:** Onion flies are slightly smaller than houseflies. They have longer legs are more slender and overlap their wings when at rest.

**Symptoms of damage**

- If the maggots bore into the stem, it rots and it is expected to break just below the roting stem of the seedling.
Cultivation
Summer squash requires mild climate for its growth, flowering and fruit-set. The optimum temperature requirement for successful growing of summer squash is 24-27°C. It is sensitive to frost and low temperature and its cultivation is difficult in northern plains from December to February because of the prevailing low temperature during this period. However, Pusa Pasand being heat tolerant can be successfully grown during spring summer season under open condition. It can be grown successfully on all types of soils but prefers well-drained loam and sandy loam soils rich in organic matter.

Growing under lowcost polyhouse and low plastic tunnel under North Indian plains
For direct sowing, seeds are sown on raised beds diagonally with a spacing of 90 × 60 cm. Sowing is done under low-cost polyhouse from 3rd week of October to 1st week of November when temperature is mild and conducive for summer squash. The seed rate is 3.0-5.0 kg per hectare. The seeds are treated with captan @ 2 g/kg of seed. Generally, 2-3 seeds are sown on pit prepared diagonally on the side of the raised bed and when the seedlings are established, thinning is done to keep only one plant per pit. It can also be transplanted by raising seedlings in plug tray (1.5 inch cell size) with soilless medium consisting of cocopeat, vermiculite and perlite in a 3:1:1 ratio. Single seed should be sown per cell. The 28 days old seedlings (two-leaves stage) should be transplanted @ 1 seedling/hill over raised bed. Earthing up is very essential which should be done at regular interval, whenever required to provide support to the plants. Drenching of seedlings with captan 2 g/litre of water should be done to prevent the seedlings from damping off.

A fertilizer dose of 250 kg FYM, 1.2 kg N, 800 g P and 600 g K was found to be optimum for 100 m² (20 × 5 m) polyhouse. A basal dose of 250 kg FYM, 600 g

<table>
<thead>
<tr>
<th>Selection</th>
<th>Yield (t/ha)</th>
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Management practices
- Avoid successive planting of onion in the same field and follow crop rotation.
- Use well decomposed cow manure.
- Field sanitation, removal of weeds, destruction of damaged onions to reduce population build up.
- Soils that are rich in un-decomposed matter should be avoided.
- Close planting of onions should be avoided to reduce movement of maggots in the nearby areas.
- Drenching of the chlorpyrifos with irrigation at 1.6-2 litre/acre should be done before transplanting or when infestation starts to appear. This will effectively control maggots infestation up to 8 weeks.
- After hand weeding, fipronil 80% WG should be applied in the soil at 1 kg/acre followed by irrigation.

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Pusa Pasand – First high...

Table 1. Mean performance of Pusa Pasand (DS-8) and local check under open field condition at IARI, New Delhi during spring summer season from 2010 to 2014

<table>
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Table 2. Mean performance of summer squash Pusa Pasand (DS-8) under naturally ventilated polyhouse during winter season (Mid October - Mid February) at CPCT, IARI, New Delhi from 2011 to 2013

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<td>16.69</td>
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N, 800 g P and 600 g K should be applied at the time of preparation of beds and rest of the N should be applied in two split doses, 300 g one month after sowing and another 300 g just before the initiation of flower. Summer squash is bushy in nature; hence, it does not require any trailing and pruning but earthing up is essential to cover the roots properly. The raised beds should be covered through black plastic as mulch. Otherwise, one or two hand-weeding are required. It requires 2-3 hoeing and weeding. Frequent irrigation at shorter interval is required. The older leaves should be removed at regular interval to prevent the plant from various diseases and pests and to provide the plant proper aeration and light. The application of one spoon Carbofuran per hill at the time of sowing/ transplanting of seedling can provide an effective control against cut worm. For control of white flies, aphids and viral diseases, spraying of imidachlorprid @ 0.3 ml/l is recommended. Mites are sometimes cause serious problem during spring summer season and can be controlled by spraying Spiromesifen (Oberon) @ 1.5 ml/l. The preventive spray of Karathane and Ridomil 2 g/litre of water at 8-10 days interval control powdery mildew and downy mildew, respectively. No synthetic plant protection chemical should be used fifteen days prior to harvesting.

Hand pollination is needed in summer squash. Pollination is comparatively easy in summer squash since flowers are large and solitary. Freshly open flowers are hand pollinated from 8-10 a.m. in the morning to enable fruit-set and fruit development.

For low plastic tunnel, seeds are sown on raised beds diagonally with a spacing of 90 × 60 cm during last week of December to first week of January. The sowing, planting, intercultural operation, fertilization and plant protection measures are same as mentioned above should be followed. During second fortnight of February when chance of frost is over, the polythene should be removed for open pollination by honeybees and other beneficial insects.

Growing under open field condition

Summer squash requires mild climate for its growth, flowering and fruit-set. However, Pusa Pasand being heat tolerant can be successfully grown under open condition during spring summer season under North Indian plains. The seeds are sown on raised beds diagonally with a spacing of 90 × 60 cm during third week of February to first week of March. Apply 15-20 tonnes of well-rotten organic manure per hectare before field preparation and 100 kg urea, 200 kg single super phosphate and 80 kg muriate of potash at the time of last ploughing. Another dose of 50 kg urea should be top-dressed at 20 days after planting. The intercultural operation, fertilization and plant protection measures are same as mentioned above should be followed.

Harvesting and yield

The fruits should be harvested at tender stage and graded according to size. The harvested fruits should be kept in plastic crates with fillers instead of gunny bags to avoid bruises and injury. The average fruit yield is 16.0, 24.5 and 22.8 t/ha during spring summer season under open field condition; naturally ventilated polyhouse and plastic low tunnel during winter season, respectively.

SUMMARY

Pusa Pasand is the first early improved flattish round heat tolerant variety of summer squash for spring summer season cultivation under open and protected cultivation during winter (offseason) developed by IARI for North Indian plains. It can set fruit and produce seed under high temperature condition. Apart from superior quality characters, it has an average fruit yield of 16.0, 24.5 and 22.8 t/ha during spring summer season under open field condition; naturally ventilated polyhouse and plastic low tunnel during winter season, respectively. Its continuous and concentrated fruit setting will be highly acceptable to the growers.

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Lakshamana: New tamarind selection for improving rural livelihood

Tamarind is a nutritious crop which has been growing in India since centuries. The tree is of widespread occurrence growing on marginal lands in semi-arid and sub-humid tropical climates, making it highly valuable in ensuring food security for rural poor. Given the great potential of this neglected and underutilized species to address global challenges such as hunger, poverty and climate change adaptation, there is a need to revisit research and development priorities in its favour and to develop strategies together with stakeholders to increase its use.

TAMARIND (Tamarindus indica) is an evergreen tree legume, distributed all over the world in tropical and sub-tropical countries. The tree produces fruits in pods which consist of a brittle outer shell encapsulating the pulp and enclosed seeds. Once established, the tree develops a large tap root which protects it from strong winds and cyclones, making it well suited to the region prone to such weather phenomena. It is also considered to be a suitable tree for inter-planting with other commercial forest species. Tamarind starts bearing from 6-8 years and has productive life of 50-70 years after which it declines. The normal life span of the tree is 150 years. A typical established tree yields between 50-100 Kg of collectable fruit which is harvested during multiple picks over an 8-10-week period between February and April. Apart from tamarind pulp other by-products such as seed, shell, fiber is also useful for various purposes. Tamarind comes in two main types; sweet and sour. Sweet tamarind is harvested ripe and usually consumed fresh, while the sour tamarind is processed into a range of value-added products. Some of the most common products produced from tamarind include juice, pulp, powder, chutney, pickles, sauces, sugar coated candies and tamarind kernel powder (TKP). TKP is an important sizing material for the jute and textile industry and tamarind seeds are gaining importance as a rich source of proteins and valuable amino acids. India is the world’s largest producer of tamarind; it is estimated that 300,000 tonnes are produced annually. It is also an exporter of tamarind, mainly to Europe and Arab countries.

Recently, there has been an increased interest in finding alternative, potentially high-value cash crops to improve the income of small farmers who are currently depending upon growing and selling traditional cereal crops. Tamarind has a wide range of genetic variation in India, which could facilitate identification of superior and desirable types. It has innumerable types, categorized according to the phenotype and genetic characteristics contributing
to diverse land races available in wild. Being a highly cross-pollinated crop, and propagated from time immemorial by seeds, considerable amount of variability exists in the trees growing in different regions. Selection is the crop improvement method widely adopted in tamarind and varieties are being released using this method in India. The consumer preference is for traits such as broad, brown pulp with good pulp recovery which is currently not being met by the few released varieties. The present study was undertaken keeping in view the emerging importance of the crop with the objective of identifying superior quality combined with higher pulp recovery. In this context, a survey was undertaken in Tumkur district of Karnataka to characterize the variability available for pod and tree characters and identify superior trees using horticultural traits. In situ analysis of the samples collected from this region was done at ICAR-Indian Institute of Horticulture Research, Bengaluru and an elite tamarind variety was identified having broad pods with good pulp colour and recovery. Farmer’s tamarind selection “Lakshamana” emerged from participatory breeding research having significantly better traits compared to local tamarind.

**Lakshamana**

This is an accession identified in Nandihalli village of Tumkur district of Karnataka, having coordinates latitude 13.52° N, Longitude-76.74° E and 860 m MSL growing in field of Shri Laxmannappa. It was found to be superior with better yield and pod characters compared to local and registered mean annual yield (4 years from 2016-2020) of 251.4 kg/tree as against 165.0 kg/tree in local trees.

| Table 1. Economic traits of promising selection Lakshamana |
|-----------------|-----------------|
| Sl. No. | Trait | Lakshamana |
| 1. | Fruiting season | Feb-March |
| 2. | Fruit bearing position | Terminal |
| 3. | Fruit clustering habit | Cluster of 2-3 or solitary |
| 4. | Fruit shape | Long, curved |
| 5. | Pod length (cm) | 25.4 |
| 6. | Pod breadth (cm) | 3.8 |
| 7. | Number of pods/kg | 24 |
| 8. | Number of seeds/pod | 8.2 |
| 9. | Shell wt. (g/kg fruits) | 250 (25%) |
| 10. | Pulp wt. (g/kg fruits) | 430 (43%) |
| 11. | Seed wt. (g/kg fruits) | 270 (27%) |
| 12. | Fiber wt. (g/kg fruits) | 50 (5%) |
| 13. | Yield per plant (kg per tree) | 251.4 |

Lakshamana is a 40-year-old, regular bearing tree. It commences flowering in September-October, matures in February-March and harvesting can be done in March-April under Tumkur conditions. This is a lean period in this region when there is less agricultural activity. The farmers can use this time to process and pack the tamarind to get better price in market. The pulp of “Lakshamana” is of superior quality having light brown colour, it is broader in shape which is desirable for marketing and has less fiber content. The inner cavity is silvery and this encloses the seeds. The pulp recovery is high (43%) as against 28% in local tamarind trees.

**Biochemical composition of promising selection identified**

The pulp of Lakshamana has been characterized for nutritional traits (acidity and sugars) and total acidity and total sugar was found to be 20% and 29.78%, respectively. It was also profiled for sugar through liquid chromatography with tandem mass spectrometry (LC-MS/MS) and organic acid by high-performance liquid chromatography (HPLC). Glucose and fructose are the major sugars and account for 96.8% of the total sugar content. Beside that small amount (<1%) of mannose, ribose, arabinose, rhamnose, myo-inositol, sucrose and maltose were also found. Among organic acid tartaric acid content was highest (18.61%). Although tartaric acid occurs in other sour fruits, but tamarind fruits are reported to be the richest natural source of tartaric acid. Tamarind is known to be simultaneously the most acidic fruit with the sweetest taste because of presence of high levels of reducing sugars (glucose and fructose) and tartaric acid. Combination of organic acid and reducing sugar gives sweet-sour taste to this fruit.

| Table 2. Sugar and organic acid profile of Lakshamana |
|-----------------|-----------------|
| S. No | Nutritional trait | Lakshamana (g/100 g) |
| i | Glucose | 20.53 |
| ii | Fructose | 10.64 |
| iii | Mannose | 0.66 |
| iv | Ribose | 0.06 |
| v | Arabinose | 0.05 |
| vi | Rhamnose | 0.02 |
| vii | myo-Inositol | 0.06 |
| viii | Sucrose | 0.004 |
| ix | Maltose | 0.006 |
| x | Tartaric acid | 18.61 |
| xi | Malic acid | 2.88 |

Harvesting and processing of Lakshamana pods starts from February and lasts up to mid-June. The tree has drooping architecture which makes harvesting easy. The pods fall down on own or the branches are shaken with help of long poles or a person climbs and shakes the branch to break free the pods. The pods are collected and left out to dry in sun for a few days. Processing which involves breaking the shell and removing seeds is carried out to secure better market value. One person can process 15-20 kg pods per day and earn around ₹ 400/day. The whole family of Shri Laxmannappa gets involved during this period for processing thus employment is generated.
After the shell is removed, the pulp is inverted to discard the seeds. It is stacked in ring shape in bamboo basket with capacity of 50 kg. Each basket fetches ₹1500. The seed is also sold at rate of ₹17/kg and the shell chips at ₹2.50/kg. The seeds of “Lakshamana” tamarind are bold type and 1 quintal of pulp produces approximately 40 kg seeds. Thus, primary processing and value addition activities have potential of improving livelihood. Collective marketing and little primary processing can significantly improve family income from this accession.

In recent decades, scientific and economic interest has emerged to promote and commercialize the tamarind products. The primary reason for this is that the crop is well suited for the backyard, dry and waste land farming. Hence, identification of this potential accession besides increasing the area and production could also address the issue of sustainability as the crop is climate resilient and profitable. Further, it also contributes towards rural livelihood security and employment for women when there is less agricultural activity. There exists ample scope for area expansion under tamarind with superior fruit types all over India.

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In last few decades, the market for fresh-cut fruits and vegetables has grown rapidly as a result of their freshness, convenience and human health benefits. However, fresh fruits and vegetables deteriorate very rapidly after processing, especially cut-surface browning resulting from wound induced physiological and biochemical changes. Browning of fresh-cut apples during post-harvest handling and processing degrades the sensory properties and nutritional value and discourages consumer purchase. Consequently, enzymatic browning results in significant economic losses for the fresh-cut industry. In respect of above background, the application of anti-browning agents is one of the most effective methods for controlling the enzymatic browning reaction in fresh-cut apple.

**Recent approaches to control enzymatic browning in fresh-cut apple**

The control of enzymatic browning is one of the most important issues in fresh-cut apple industry. Various approaches to inhibit browning of fresh-cut apples have been reported including a wide variety of chemical compounds, edible coatings, modified atmosphere packaging and temperature control which are discussed below.

**Browning inhibitors**

A dip treatment after slicing is the most common way to control browning phenomena in fresh-cut apples. A range of treatments have been applied to extend the shelf life of fresh-cut apples including use of natural browning inhibitors, salt and chemical treatments, edible coating agents and reduced oxygen atmospheres. A key approach used to avoid browning in apples has been the use of reducing agents, often with the addition of calcium chloride, in combination with modified atmospheres and low temperature storage. Calcium salts, particularly CaCl₂, are used as firming agents in a wide variety of whole, peeled and fresh-cut fruits.

**Ascorbate and calcium**

The most commonly used anti-browning agent is ascorbic acid which is recognized as a GRAS substance...
by the Food and Drug Administration for its use to control browning of minimally processed apples. Ascorbic acid is used to prevent polyphenol oxidases enzyme activity through its ability to reduce the o-quinones back to their phenolic substrates. Ascorbic acid has long been applied in combination with organic acids and calcium salts to control browning of minimally processed apple slices. A formulation containing ascorbic acid and calcium acts to prevent cell and membrane breakdown and also modulates polyphenol oxidase activity in ruptured cells where loss of compartmentalization has take place already. For instance, 4-hexylresorcinol in combination with ascorbic acid had a significant effect on maintaining the colour of fresh-cut apples.

Thiol-containing compounds

The N-acetylcysteine and glutathione are some thiol-containing natural substances having antioxidant properties and have been applied as browning inhibitors to prevent discoloration on fresh-cut apples. These thiol-containing anti-browning compounds react with o-quinones formed during the initial phase of browning reactions to yield colourless products or to reduce o-quinones to o-diphenols.

Carboxylic acids

Carboxylic acids have been widely used commercially due to their anti-browning activity. Citric acid exerts a double inhibitory effect by reducing pH and chelating copper in the active site of polyphenol oxidase and therefore, inactivating the enzyme. Acidulants are not often used alone because it is difficult to achieve efficient browning inhibition, and combination with a chemical reductant may have a major effect.

Resorcinols

Among several resorcinol derivatives, 4-hexylresorcinol has been proved to be effective in controlling browning on fresh-cut fruit such as apples and pears. 4-hexylresorcinol (4-HR) has a structural resemblance to phenol substrates and could have a competitive inhibitory effect on polyphenol oxidase activity. Hence, 4-hexylresorcinol may specifically interact with polyphenol oxidase, and render it unable to catalyze the enzymatic reaction. Its applicability on fresh-cut fruit has been proven especially when used in combination with reducing agents. Some combinations have been proven to extend the storage life of fresh-cut produce. A mixture of 0.01% 4-hexylresorcinol + 0.5% ascorbic acid + 0.02% calcium chloride maintained freshness of ‘Royal Delicious’ apple wedges for one week at 5 ± 2°C.

Modified atmosphere packaging

The rapid growth of the packaged fresh-cut fruits industry has been enabled largely by the development of modified atmospheric packaging technology. With modified atmospheric packaging the desired balance of O₂ and CO₂ is created through the control of gases transmission of the packaging film and the respiration rate of the produce. Modified atmospheres can retard the browning reaction. Among other benefits the use of modified atmospheres delayed senescence and consequently enhanced storage life of fresh-cut apples.

Edible coatings

In modern era, the edible coatings are receiving significance as methods that can preserve the quality of fresh-cut apples. It can serve as semi-permeable barriers come up with to enhance shelf-life by reducing moisture and solute migration, gas exchange, respiration and oxidative reaction rates as well as suppressing physiological disorders on fresh-cut apples. Recently, some investigations have proposed the use of edible coatings in combination with anti-browning agents to improve the colour preservation of fresh-cut apples. Through modification of oxygen, carbon dioxide and ethylene transmission, the edible coating has the ability to inhibit the moisture loss, form a barrier to oxygen and control the release of anti-browning compounds on the surface of cut tissues. Edible coatings may be used in combination with other preservation techniques such as low temperature and suitable packaging to achieve browning control in fresh-cut apples. The edible coatings in combination with anti-browning agents (4-HR, ascorbic acid and citric acid) effectively prolonged the shelf-life of the minimally processed apple slices by 1 week when stored at 5 ± 2 °C.

In general, chemicals used to prevent or control enzymatic browning are used in solutions, frequently as formulations containing one or more compounds, which are used for dipping the fruit pieces.

In general, increased enzymatic browning of fresh-cut apple wedges during storage was accompanied by an increase in a* and a decrease in L* values. The lowest L* and the highest a* values were obtained in control samples dipped in water. The solutions containing anti-browning agents significantly decreased the loss of lightness (L*) of apple wedges. Fresh-cut apple wedges dipping in the antioxidant aqueous solution helped maintain L* values during storage, although the most effective formulation was that containing 4-HR to maintain high L* angle values in apples over 7 storage days at 5 ± 2 °C. Overall, the combined application of anti-browning agents maintained

Apple slicer

in general, chemicals used to prevent or control enzymatic browning are used in solutions, frequently as formulations containing one or more compounds, which are used for dipping the fruit pieces.
lower $a^*$ and higher $L^*$ values than the alone antioxidant aqueous solution, which indicates its potential to control the enzymatic browning of fresh-cut apples.

**SUMMARY**

Enzymatic browning is an economically important physiological problem that impairs the sensory qualities and discourages consumer purchase of fresh-cut apples. Control of browning on fresh-cut apples has been the focus of extensive research and many technologies have been explored with successful results. Research on effective combinations of various chemical compounds above needs to be undertaken since no single treatment can effectively enhance the shelf life of fresh-cut apple wedges while controlling browning and preserving the quality and safety for consumers.

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Kalpatharu: A plant with virtues

The concept of waste valorisation has been precisely defined as the process of converting waste materials into useful products. Waste valorisation relies on the assumption that even after efficient intended use, the waste still contains untapped sources that can be converted into other useful forms. Apart from the development of technologies, waste valorisation has several advantages like, reduction of volume of produce, recovery of more space and mainly amelioration of environmental pollution. As banana fruit is considered, it is the cheapest, plentiful and most nutrient fruit which is having great economic significance in our country. In India it is so predominant crop and popular among people that it is liked by both poor and rich alike. It is an important source of fibre, fodder, food, beverages, fermented sugars, medicines, flavourings, silage, rope, cordage, garlands, shelter, clothing, making house roofs and wall linings. By considering all these multifaceted uses, it is referred to as Kalpatharu. The banana industry produces a large volume of waste which is neglected and left to decompose in an uncontrolled way. Hence the application of valorisation would save hindrances to the industrial development.

**Banana** is commercially fourth important global food commodity after paddy, wheat and milk in terms of gross value of production and great socio-economic significance. It is an herbaceous, monocarpic plant belongs to the family Musaceae which originated from the tropical region of South-East Asia. India is also considered as one of the centre of origin. Banana is one of the oldest crop of fruits which was earlier mentioned in the epics of Ramayana in 2020 BC and Kautilya’s Arthashastra in 300-400 BC. It is the cheapest, plentiful nutritive fruit having great economic significance in India and many research findings showed as one of the man’s first food. It is one of the most delicious fruit which contributes to livelihood through production, processing and marketing. It is deeply interwoven with the Indian cultural heritage that its leaves, pseudostem and fruits are considered very auspicious in all celebrations of the festivals.

Banana ranks first in terms of production and productivity among all fruit crops and covers 12% of the total area under fruits which contributes nearly one third of total production. It can be grown all over India is varied climatic regions. In India, about 7.1 lakh ha area is under banana crop with the total fruit production of 26.2 million MT contributing 14.7% of global the technological development in banana cultivation, its productivity is also showing rising trend. Apart from fruit, banana crop also generate huge quantity of biomass in the form of pseudostem, leaves, suckers, etc. For disposing purpose, farmers spending ₹ 8,000 to 10,000/ha used as dumping on field bunds and burning, disposing in natural drains which causing environmental problems. Hence the application of valorisation of waste would save hindrances to the industrial development.
Valorisation of plant waste

The concept of waste valorisation has been precisely defined as the process of converting waste materials into useful products. Waste valorisation relies on the assumption that even after efficient intended use, the waste still contains untapped sources that can be converted into other useful forms. Apart from the development of technologies, waste valorisation has several advantages like, reduction of volume of produce, recovery of more space and mainly amelioration of environmental pollution. After the harvesting operation of banana, the pseudostem is cut near to the ground which ranging from 60-80 t/ha. Hence the application of valorisation would save hindrances to the industrial development. When we consider banana plant, there are mainly four components which we need to focus on for application of the theme ‘waste to wealth’.

b) Quality grade paper

Now a days, use of polythene has grown in a larger extent because of its widely application in storage of food. But polythene is a non-biodegradable material and does not decompose when it gets buried in soil and causes accumulation of toxic substances. Banana pseudostem contains potential source of cellulose and lignocellulose which can be used for making paper. Among extracted banana fiber (EBF) and waste banana fiber (WBF), WBF are quite acceptable for handmade paper. It has many advantages such as low density; stiffness and good mechanical properties with highly disposability and renewability. It also creates employment opportunity in rural area.

c) MCC

Microcrystalline cellulose (MCC) is purified, partially de-polymerized, non-fibrous cellulose. MCC can be extracted from fibre of banana pseudostem using alkali hydrolysis process followed by further treatment with peracetic acid which is used for many pharmaceutical drugs. Also it has huge application in bakery, beverages and other health products.

d) Handicraft

Various handicraft items are prepared using banana fibre which is extracted from pseudostem. These fibrous strings can be hand-woven into various decorative bags, baskets, mats, hats, ornamental baskets, picture frame, wall hangings, table mat, pillow, dolls, etc. Especially women’s can engage in this activity through self-help groups can increase their social and economic conditions.

I. Fibre based products

a) Fabrics

As earlier mentioned, banana plant not only provides the delicious fruit but also provides textile fibres, the banana fibre. Banana fibre can be extracted from the sheath of pseudostem either by hand or machine. The natural fibre has multifaceted uses in making various value added products. The banana fibres can be blended with cotton and jute fibres to make good eco-friendly fabrics. It is used as an alternative for garment which is commonly made from silk, so that when it comes to accessories banana fibre is frequently used for making scarves, hats and gloves as sustainable, organic products become increasingly popular. It is an eco-friendly substitute in textile industry in the place of hazardous synthetic fibres.
II. Sap based products

a) Liquid fertilizers and nutrient spray

The fresh sap of pseudostem can be enriched with essential plant promoting substances viz., gibberellic acid (GA) and cytokinin which can be used for plant liquid fertilizer for different crops like banana, papaya, sugarcane, etc. which may saving of about 20-40% recommended dose of fertilizers along with improving yield. Also along with sap vermiwash (1:1) can be sprayed on seedlings of vegetables crops which resulted in higher fruit setting. After long years research, NAU, Navsari developed the innovative product called as NAUROJI Novel Organic Liquid Fertilizer which contains all nutrients such as Nitrogen, Phosphorus, Potassium, Zink, Iron, Boron, Mn, Mg, Ca, S, Cu, etc. Not only these, but it also contains plant growth hormones like Gibberellic acid and Cytokines. Novel also contains bacteria which can improve soil health.

b) Mordant

The pseudostem contains tannins which are polyphenolic in nature having capacity of fixing dyes and produce crosslinks which provides excellent fastness properties. Banana sap which is extracted from the pseudostem can be used as mordant to dye silk fabric along with natural dyes like manjistha and annatto. It also has potential of dyeing cotton fabrics with stability to sunlight and slight fading.

III. Central core based products

a) Candy

The inner and most tender portion of pseudostem which is edible in nature i.e. central core can be utilized to various value added products that can be help to various self-help groups to improve their social and economic conditions. Navsari Agricultural University has developed and standardized the process of making of candy from central core which was tested by CFTRI, Mysuru. This candy has nutritionally advantageous as it contains iron and vitamins. It has opened doors for institutional suppliers like Government’s mid-day meal scheme and nutrition improvement programs of UNDP and WHO.

b) Pickles

Being tender in nature, central core is used as a vegetable and also made into various pickle as alone or mix with other vegetables which improves palatability and also controls constipation.
c) Banana Pseudostem Juice

CFTRI, Mysuru and NAU, Navsari has developed 100% natural juice extracted from the pseudostem or may be juice blended with other fruits like mango, pineapple, aloe vera, noni, etc, which having many health benefits like helping kidney, reduce hyper acidity, relieves constipation and cleans the urinary tract.

IV. Scutcher based products

a) Vermicompost and fish feed

Large quantity of about 30 to 35 t/ha is generated during the extraction of fibre. In order to utilize this many value added products have been standardized. Vermicompost can be prepared from Scutcher using cow dung and biodegradable bacterial consortium. NAU, Navsari has standardized the preparation with ratio of 70:30 of scotching waste and cow dung which is marketed in the trade name of NAUROJI. The pseudostem Scutcher was also utilized as a fish feed as cattle feed in fish culture. Hence scotcher based vermicompost used as a fish feed by partially substituting with the cattle feed.

Conclusion

Banana is considered such a crop which produces huge quantity of fresh biomass and so far not much attention has been given towards the waste utilization. Every year million tonnage of banana pseudostem are dumped as waste and many farmers facing many difficulties in disposing the pseudostem. In order to utilize this residue in an effective and profitable way, many agricultural universities and national institutions are undergoing many research and findings. NAIP (Component II) also plays an important role in sanctioning to improve value chain on utilization of pseudostem which can strengthen the condition of banana growers, entrepreneurs, policy makers and industry people. Using pseudostem many products can be developed which have the capacity to generate additional income and also provides eco-friendly raw materials to the industries like pharmaceuticals, textile, paper, confectionary, etc. It can also overcome unemployment problems in rural areas. Especially women can play a major role in this sector which can improve social and economic conditions of the family.

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Fruit nutrition garden: A new approach towards Food Security and Diversification

Establishment of Fruit Nutrition Garden in an area of 625 square meters (25 m length and 25 m wide) can meet daily requirement of balanced diet apart from getting good quality, fresh and naturally ripened fruits without pesticide residue throughout the year. Important points to be considered while establishing fruit nutrition garden is discussed in this article. In Fruit Nutrition Garden, 21 types of fruit plants can be planted which can prove as new approach for diversification of fruit plants.

FRUITS are integral part of our life and known as protective foods as they are rich source of vitamins, minerals and antioxidants. Major health benefits of fruits are lower risk of cancer, heart disease, blood clots, high blood pressure, high cholesterol, and eye health and diabetes. It is a fact that fruits are generally expensive in market and moreover treated by various chemicals which are harmful for our health. With increasing awareness among population especially, urban masses are interested consuming safe fruits which are ripened naturally and without pesticide residue. Even deficiency of important nutrients like iron, calcium, vitamins, etc. among masses necessitate to develop some sort of planned fruit nutrition garden to strengthen nutritional security in addition to availability of fresh, naturally ripened fruits without pesticide residue.

Keeping in view the above facts, Punjab Agricultural University has developed model of fruit nutrition garden in an area 625 square meters i.e. 25 m length and 25 m wide which can accommodate 21 types of fruit plants. Since fruits are perennial in nature and come into bearing after at least 2-3 years of planting, so utmost care must be taken while selecting right fruit variety, right time, source and planting distance.

Some important points to be kept in mind while establishing Fruit Nutrition Garden

Establishment plan: Fruits plants like mango, jamun, sapota, loquat, fig, etc. which are taller and vigorous in nature should be preferably planted in northern side of garden to prevent shading effect on smaller fruit plants. The middle portion can be occupied with short statured fruit plants like guava, citrus, etc. The deciduous fruit plants like pear, peach, plum and pomegranate can be planted on south-western side. On the extreme southern side, fruit plants like papaya and banana can be grown with protection measures as both are sensitive to frost conditions. Eastern side of garden can be used to grow different grape varieties on Y-trellies system. Karonda and phalsa on western side whereas sweet lime can be used for boundary on northern side.

Planting time: Evergreen fruit plants like mango, jamun, citruses sapota, loquat, etc. should be grown in Feb-March or August-Sept. Whereas deciduous fruit plants like peach, pear plum, grapes, pomegranate, karonda etc should be planted in Jan-Feb, before onset of sprouting.

Pit preparation for planting: One meter wide and one meter deep round pits are dug for most of the fruit plants. In case of shallow rooted plants like banana, papaya and phalsa smaller pits of 50 cm × 50 cm can be dug. Refill the pits with top fertile soil and well rotten farm yard manure in equal parts. Add 15 ml chloropyriphos 20 EC to each pit mixed with 2 kg soil for control of termites. The pits should be watered before actual planting so that soil may settle down properly and more soil can be added. The fruit plant should be planted in the centre of pit in such a way that bud union remains about 9 inches above the ground level. Soil around it should be pressed firmly followed by light irrigation.

Initial care of fruit plants: The young plants after planting should be stalked up to few months to encourage straight growth of plant. Any growth/sprout arising below bud union should be removed regularly to attain adequate growth of scion and prevent over growth of root stock.

Pruning: Plants should be pruned to get good quality fruits and yield. Generally evergreen fruit plants require only corrective pruning i.e. dead, diseased and criss cross branches should be removed. But deciduous fruit plants like peach, plum, pomegranate, karonda, phalsa, etc. require regular pruning every year and should be pruned in the month Dec to Jan when plants are not active. In case of pear, minimal pruning is required as it bears on spur which remain productive for many years. Ber is pruned in the months of April–May.

Irrigation: Generally irrigation at weekly intervals is sufficient during summers and during winters irrigation at
15 days interval is adequate for normal growth of plants. Deciduous fruit plants should not be irrigated during winters.

**Manuring and fertilization:** Generally, well rotten farm yard manure is added in December in all fruit plants except ber and guava in which it is added in May-June. In most of the fruit plants fertilizers are added in two split doses i.e. half before flowering and other half after fruit set. Care should be taken that fertilizers are to be added about 1 feet away from tree trunk and distributed uniformly along all sides of plant and mixed properly.

**Protection from adverse climatic conditions:** Fruit plants should be protected from frost during winters by covering with paddy straw thatches or polythene sheets. Regular irrigation can also protect plants from frost. During summer months, main trunk of plants can be white washed to protect from sunburn. White wash solution can be prepared by adding 2.5 kg slaked lime, 50 g copper sulphate, 50 gm suresh gum in 10 litres of water. Gum can be dissolved in some hot water before dissolving in mixture. Pure water sprays can also prevent sunburn injury in fruit plants.
Insect, pest and disease management

- Use of insecticides /pesticides should be avoided in nutrition garden. Spray of Bordeaux mixture comprising of 2 parts each of copper sulphate and unslaked lime dissolved in 250 parts of water can protect fruit plants from disease infestation during rainy season.
- Neem sprays can be used to control insect pests.
- PAU Fruit fly traps can be used in fruits like mango, guava, peach, pear, plum, kinnow to protect fruits from fruit fly infestation.
- Good quality guava can be produced by covering the mature green hard fruits of rainy season with white nonwoven bags at the end of June to middle of July. It protects the fruits from fruit fly and also improves fruit size and quality.
- For mango malformation disease, malformed bunches should be removed and buried.
- To avoid damage of leaf curl virus in papaya, cover the plant with net to prevent attack of aphid. In case of infestation uproot the infected plant. Avoid excessive irrigation to papaya to prevent colour rot disease.
- Do not plant baramasi lemon near wall or building to avoid cracking.

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**Table 1. Some of Recommended varieties for Fruit Nutrition Garden**

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Fruit Plant</th>
<th>Recommended Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Amla</td>
<td>Neelam</td>
</tr>
<tr>
<td>2</td>
<td>Bael</td>
<td>Kagzi</td>
</tr>
<tr>
<td>3</td>
<td>Banana</td>
<td>Grand Naine</td>
</tr>
<tr>
<td>4</td>
<td>Ber</td>
<td>Sanaur-2</td>
</tr>
<tr>
<td>5</td>
<td>Fig</td>
<td>Brown Turkey</td>
</tr>
<tr>
<td>6</td>
<td>Grapes</td>
<td>Perlette, Flame seedless and Punjab MACS purple</td>
</tr>
<tr>
<td>7</td>
<td>Grapefruit</td>
<td>Star Ruby</td>
</tr>
<tr>
<td>8</td>
<td>Guava</td>
<td>Shweta, Punja Kiran, Punjab Apple Guava</td>
</tr>
<tr>
<td>9</td>
<td>Jamun, Phalsa and Karonda</td>
<td>Local</td>
</tr>
<tr>
<td>10</td>
<td>Lemon/Lime</td>
<td>Baramasi lemon/Kagzi lime</td>
</tr>
<tr>
<td>11</td>
<td>Loquat</td>
<td>Golden Yellow</td>
</tr>
<tr>
<td>12</td>
<td>Mango</td>
<td>Amarpali</td>
</tr>
<tr>
<td>13</td>
<td>Papaya</td>
<td>Red Lady 786</td>
</tr>
<tr>
<td>14</td>
<td>Peach</td>
<td>Shan-i-Punjab</td>
</tr>
<tr>
<td>15</td>
<td>Pear</td>
<td>Punjab Beauty</td>
</tr>
<tr>
<td>16</td>
<td>Plum</td>
<td>Satluj Purple /Kala Amritsari grafted</td>
</tr>
<tr>
<td>17</td>
<td>Pomegranate</td>
<td>Bhagwa</td>
</tr>
<tr>
<td>18</td>
<td>Sapota</td>
<td>Kallipatti</td>
</tr>
<tr>
<td>19</td>
<td>Sweet orange</td>
<td>Blood Red, Musambi</td>
</tr>
</tbody>
</table>
Traditional importance of Indian butter tree and genetic resources management

**Madhuca longifolia** (Koenig) Macbr. (syn. *M. indica* Hamilton ex Gmet.) locally known as Mahua is an important tropical tree species having vital socio-economic value for the tribal populations of India. Vast genetic diversity of this species exists in tropical and sub-tropical parts of India. During various surveys, a total of 154 accessions were collected from different phyto-geographical regions. Substantial variability was present in collections made from west-central region especially from the states of Rajasthan, Gujarat, Madhya Pradesh and Uttar Pradesh and from southern states of Andhra Pradesh and Tamil Nadu. It is a multipurpose tree providing food, fuel, timber, green manure, oil, liquor and raw materials for several commercial products. In spite of its high economic value there are no improved cultivars or varieties developed in Mahua, however, some selections based on physico-chemical characters, period of fruit maturity and high seed oil content have been identified. Due to direct harvesting of economically important parts of this tree from natural habitat and deforestation, genetic diversity of Mahua is facing threat of extinction and requires immediate conservation efforts. Limited success achieved in cryopreservation of embryonic axes of this highly recalcitrant tropical tree species necessitates further refinement of protocol and also implementation of complimentary conservation strategy by maintaining field genebank collections of promising genotypes. Urgent attention is also required for popularization and needful value addition to the commercial products of Mahua to attract present day market demand.
was allotted a National identity (accession number- iC) made using selective sampling strategy and each collection was localization of various populations and collection of Mahua from the natural populations. Collections were of economic importance and scope for marketability of its products.

Survey and exploration trips were undertaken to diversity-rich areas of Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh and Uttar Pradesh for the systematic localization of various populations and collection of Mahua germplasm from the natural populations. Collections were made using selective sampling strategy and each collection was allotted a National Identity (accession number-IC) and detailed passport information was recorded in the prescribed format developed by NBPGR. A total of 29 accessions were collected in the form of fruits from Rajasthan and Madhya Pradesh. Passport data and all the related information was recorded in the NBPGR data base for the collected germplasm. Detailed information about indigenous traditional knowledge regarding the use of various plant parts, socio-economic value and livelihood contribution of this important multipurpose tree species was collected from the elderly persons of tribal communities and other local inhabitants of the forest and marginal areas. Information about present status of genetic variability, population structure, market value and support system was gathered during the survey of field, local markets and weekly markets (Hats).

Young leaves are pinkish red and woolly underneath. Flowers white to cream colour with tubular, fleshy and juicy corolla, clustered at the end of branches. Fruits ovoid berry, green at maturity and turn pinkish yellow when ripe. Fruits are pulpy with large ovoid seeds, number of seeds per fruit varies from 1 to 4. Fruits occur single or in a bunch up to 20-30 in one bunch. Seed is large, 3-4 cm long, elliptical, flattened on one side, seed light brown to black in colour. Most of the leaves fall between February to April and at the same time musky-
Survey, collection, variability and uses of Madhuca longifolia (Mahua) fruits and flowers: (A) Natural wild population of Mahua in Gujarat; (B) Flowers being collected in early morning by tribal women; (C) Preparation of Mahua liquor using traditional methods from Mahua flowers by tribals of Madhya Pradesh; (D) Fruit variability collected from Madhya Pradesh; (E) Prolific bearing in heavy bunches of 25-35 fruits in genotype collected from Rajasthan; (F) Seed extraction from fruits by tribals for oil extraction.

Scented flowering commences. Fruits mature generally in the months of May-June. Tree blooms at night and in early morning hours flowers fall on the ground and are collected by local tribal populations for commercial use. In southern parts of India Madhuca longifolia var. latifolia occurs which is similar in the tree morphology to M. longifolia, with a exception in the shape of leaves which is linear lanceolate in M. longifolia var. latifolia and also flowering period varying between November-December.

Ecology, diversity and distribution

M. longifolia is predominantly distributed in northern and central states of India while M. longifolia var. latifolia is more common in southern states of India. Mahua grows
well on a wide range of soils especially on alluvial soil in Indo-gangetic plain. Mahua being hardy tree, thrives well on rocky, gravelly red soils and also on saline and sodic soils. Tree prefers tropical to sub-tropical climate and withstands drought admirably. It grows up to an altitude of 1,200 m, mean annual temperature 2-46°C and mean annual rainfall ranging from 550-1,500 mm. Some of the Madhuca species grow in Western Ghats and also found in Himalayan regions up to an altitude of 4,500 m.

Uses and indigenous technical knowledge

Every part of Mahua tree is used for economical and medicinal purposes by the local and tribal people. Their livelihood is based on the various tree parts and range of products developed from these which are collected directly from the forests and sold in local markets. Flowers of Mahua are of high economic value and collected fresh in the morning by tribal women. Mostly the dried flowers are used for distillation of Mahua liquor locally known as “Mahudi” which is a very common alcoholic drink in the tribal areas. For making liquor, flowers are fermented in the large sized earthen pots for months and fermented extract is distilled in locally developed distillation units known as “Bhattis”. Liquor is collected in small earthen pots for selling it to local people. Mahua flowers yield approximately 340 litres of alcohol per tonne of flowers.

Marketing potential of its flowers, fruits, seeds, wood and other products have not been realized fully by industry. Till now tribal and local inhabitants are collecting the produce and either utilizing for traditional preparations or selling these to middlemen. For seed oil extraction local middlemen purchase the dehulled kernels from villagers and supply to wholesale markets for use in small expellers.

Propagation

Mahua can be propagated by seeds and by vegetative means. While propagating through seeds, germination of seeds may immediately be attempted after depulping the mature fruits. Seeds are highly recalcitrant and also showed precautious germination when seeds remained in the fruit. Vegetative propagation methods have been developed using softwood grafting, wedge grafting, veneer grafting and air layering with varying success.

Characterization

Mahua germplasm collected from various states have been characterized for different physico-chemical characters and field performance on the basis of early, mid and late season types. Variations in TSS, acidity, vitamin C and vitamin A in fruits and flowers have been reported. Genetic divergence were studied in 15 Mahua genotypes and MH-23, MH-26, MH-27, MH-32, MH-33, MH-34 and MH-35 and collections were reported to be promising in all the traits analyzed. Based on characterization of 20 accessions collected from Gujarat, MH-10, MH-14, MH-35 and MH-63 have been found promising for all the traits.

Conservation

Trees of Mahua were found to be growing as natural wild in the forest, marginal lands, farmers’ fields and as an avenue tree throughout the Indian plains. Due to the very high socio-economic importance of this tree species for tribal populations living in the forest areas and around the protected forests, its importance as livelihood support species is immense. These trees are also treated as sacred in some parts of the country, therefore, protected by tribal people and state forest departments. However, due to the large scale developmental projects, urbanization and demand of land for agriculture some of the promising populations of this highly diverse tree species have been wiped off completely and some are under great threat. In situ conservation of Mahua in forests and marginal lands needs to be ensured to protect the existing genetic diversity. Awareness regarding conservation of plants and equal participation of tribal farmers in such activities is imminent as for the collection of produce (flowers, bark and fruits) whole tree is damaged by cutting the main branches. Promising populations in the states of Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, and other states need to be protected as in situ conservation sites. Recently, some of the promising accessions are being established in the field genebanks at CHES, Central Institute of Arid Horticulture, Godhra (Gujarat) and at Central Institute of Sub-tropical Horticulture, Lucknow, Uttar Pradesh. Such efforts need greater attention and priority of institutions to protect the promising genotypes of this important tree species.

Mahua is essentially a forest crop till now with no organized cultivation by farmers. Genetic resources of this tree species have not received much attention due to limited awareness towards its economic potential and being a tree of forest or marginal lands. As no organized commercial cultivation of Mahua is undertaken at present, there is not much demand for planting material and trees are naturally grown by seeds. Recently, vegetative means of softwood grafting with 70-80% success, grafting with 70% success and veneer grafting with 90% success has been reported.

Conservation of vast genetic diversity of Mahua needs use of both in situ and ex situ strategies. Mahua seeds have been reported as short lived, desiccation sensitive and highly recalcitrant in storage behaviour. Seeds were desiccation sensitive as at critical moisture content they showed decline in viability to 40%. Seeds desiccated to 37.7% moisture content lost germinability by 11% and those desiccated to between 14 to 16% moisture content lost germinability by 90% of the original. Ex situ conservation using cryopreservation of embryonic axes is an important alternative for this tropical tree species bearing highly recalcitrant and large seeds. It has been amply emphasized that cryopreservation is the only means currently available for long-term ex situ conservation of genetic diversity of recalcitrant seeded species.
CIISH-Bael-1 is a selection from open pollinated seedlings especially identified for its very thin shell. This is a mid-season maturing selection in which fruit attain maturity during April-May. Trees are tall with vigorous growth and dense canopy having erect growth habit. The tree is precocious and prolific bearer. Fruit shape is oval to oblong, measuring the fruit size as 15.00 cm in length and 39.2-41.0 cm in circumference with an average fruit weight 1.00 kg/fruit. Fruit colour turns to attractive lemon yellow on ripening. Fruits have very thin shell with a thickness of 0.12-0.15 cm which can be easily removed to obtain a dark yellow pulp of pleasant flavour with least mucilage and seed content. Seed number varies between 45 to 60 seeds per fruit with seed to pulp ratio 1:206 which demonstrate an excellent pulp recovery preferred for juice industry. CIISH- Bael-1 has very good taste and flavour which is again a positive trait for processing industry. Fruits pulp recovery is quite high with about 65.57% pulp content having TSS of (38.0°B), total carotenoids (1.18 mg/100 g pulp), total sugar (20.54%), tannin content (3.5%), marmelosin (596.57 μg g⁻¹), psoralen (102.02 μg g⁻¹), aurapten (53.23 μg g⁻¹) and polyphenols (3.66%), ascorbic acid (79.00 μg g⁻¹), riboflavin (158 μg g⁻¹), thiamine (233 μg g⁻¹) and niacin (1340.00 μg g⁻¹) of this variety depicts a very high nutritive and therapeutic value. The yield of fully grown up trees (10-12 years) of CIISH- Bael-1 varies from 50-80 kg/tree.

The fruits are also suitable for processing into number of nutritive and medicinal products such as squash, nectar, leather, pulp, powder and jam.

Crop husbandry

Bael has wide adaptability for soil and climatic conditions in subtropical region. It can be grown up to an elevation of 1,200 m and tolerates low (7°C) as well as high (48°C) temperatures. All type of soils are recommended for its cultivation, however, sandy loam soil with proper drainage is considered ideal. Soil with pH 6.0-8.5, sodicity up to 30 ESP and salinity up to 9 dsm⁻¹ EC is also suited for its cultivation. It is considered as one of the scavenger plant for problematic soils, due to it xerophytic characters.

Table 1. Comparative nutraceutical contents of CIISH-B-1 with other commercial cultivars

<table>
<thead>
<tr>
<th>Nutraceuticals</th>
<th>CIISH-B-1</th>
<th>NB-5</th>
<th>NB-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit weight (kg)</td>
<td>1.11</td>
<td>0.75</td>
<td>1.62</td>
</tr>
<tr>
<td>Marmelosin (µg g⁻¹)</td>
<td>596.57</td>
<td>256.71</td>
<td>84.79</td>
</tr>
<tr>
<td>Psoralen (µg g⁻¹)</td>
<td>102.02</td>
<td>34.20</td>
<td>62.83</td>
</tr>
<tr>
<td>Aurapten (µg g⁻¹)</td>
<td>53.23</td>
<td>55.43</td>
<td>19.32</td>
</tr>
<tr>
<td>Polyphenols (%)</td>
<td>3.66</td>
<td>2.91</td>
<td>2.89</td>
</tr>
<tr>
<td>Ascorbic acid (µg g⁻¹)</td>
<td>79</td>
<td>78</td>
<td>81</td>
</tr>
<tr>
<td>Riboflavin (µg g⁻¹)</td>
<td>158</td>
<td>76</td>
<td>99</td>
</tr>
<tr>
<td>Thiamine (µg g⁻¹)</td>
<td>233</td>
<td>26</td>
<td>59</td>
</tr>
<tr>
<td>Niacin (µg g⁻¹)</td>
<td>1340</td>
<td>1041</td>
<td>471</td>
</tr>
</tbody>
</table>

Plants are commonly raised by seeds, which are sown in 15-20 cm raised beds of 1 × 5 m size at 1-2 cm depth just after their extraction in the month of June. Seeds germinate within three weeks. The seedling are then shifted and transplanted in the field after seven weeks of sowing. These seedlings are ready for budding/grafting after one year. Generally, plants are prepared commercially by budding and grafting, but sometimes plants are also raised from root suckers. Among different methods of propagation, patch budding gives 80-90% success, when performed in the month of June-July.

In situ orchard establishment

In the wasteland and areas having water scarcity, in situ orchard establishment can be advocated. As per layout plan, two bael seeds are sown in a pit refilled as stated earlier or seedlings grown in polythene bag should be planted during June-July. Desired cultivar is budded on these seedlings during June-July in the following year.

Typical pit of one cubic meter size are dug at a distance of 8 × 8 m two months prior to planting (April-May). About, 30-40 kg of well-rotted FYM and one kg of neem cake or 0.5 kg bone meal are mixed in top 50% soil of each pit. The pit is filled first with unmixed soil and then with mixed soil. In sodic soil, 5-8 kg gypsum along with 20

Bael (Aegle marmelos Correa.), which belongs to family Rutaceae occupies a special importance in Indian tradition and culture. Owing to its wider adoptability and unique medicinal vis-a-vis nutritional value and religious importance, it is greatly valued in Hindu religion where its fruits and leaves are used as important offering for lord Shiva. This article discusses CIISH-Bael-1, a new thin shelled variety of Bael.
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kg sand is also incorporated. Before filling, the rain water should be allowed to collect in the pit and then be flushed twice or thrice to remove harmful salts from the pit for better establishment of plants. Thereafter, filled pit should be irrigated immediately and planting should be done after 20-25 days of filling of the pit which helps to complete the soil reaction with pre-treated gypsum. After soil becomes workable the grafted/budded plants are planted in the centre of the pit with the help of planting board during July-August.

Young plants need irrigation; frequency should be at 10-15 days interval in summer and one month interval during winter. In bearing orchards, generally irrigation is not required. During dry summer, bael plants shed all its leaves enabling the plant to escape ill-effects of hot dry winds. However, irrigation may be applied at an interval of 20-30 days during May-June just after the emergence of new leaves. Apart from irrigation, basin of trees should be cleaned by weeding and hoeing to provide suitable environment for tree growth.

Mulching with organic waste has been found very effective for establishment of bael orchards in sodic and ravenous wasteland. Among the different materials, of mulch, paddy straw or sugarcane trash show better response.

Young plants are trained with the help of stakes, so that plants grow erect. In order to provide good framework, it is essential not to allow lateral branches upto 75 cm from the ground level on trunk. Afterwards, 4-6 branches emerging in different directions should only be allowed. The tree should be trained in modified leader system during initial 4-5 years. Generally, bael does not require pruning, however, dead and criss-cross branches, diseased, weak and broken twigs should be removed time to time.

For good yield and quality production, fertilizer dose of 5 Kg FYM, 50 g N, 25 g P and 50 g K per plant is applied to one year old plant. This dose is increased every year to the multiple of 10 years. Hence, a ten year or above aged plant should be given FYM 50 Kg, 1.0 Kg N, 250 g P and 500 g K. In sodic soil, plants generally show symptoms of zinc deficiency, which can be corrected by basal application of zinc sulphate (250 g) per tree along with fertilizer. In the orchards where fruit cracking is the problem, 250 g borax per tree should be applied along with fertilizers.

During the early years of young plantations, the inter-space can be utilized for growing suitable intercrops. Leguminous crops like, pea, cowpea, moong, urd, guar and vegetables like brinjal, tomato, spinach, coriander, chilli and garlic or oil seed crop like mustard can be cultivated. While taking inter-crop, care should be taken that crops requiring frequent irrigation and heavy dose of fertilizer should not be grown. In salt affected or marginal soils, green manure crops like Dhati neha should be grown in the bael orchards for few years to improve the physico-chemical properties of the soil.

Plant health management, yield and economics

Fruit of CISH-B-1 is ready for harvest in the month of April-May when shell changes its colour from deep green to yellowish green (colour break stage). The fruit should be picked individually along with a small portion of stalk (approx. 2 cm). It not only makes handling easy but also provides a signal for ripening of the fruits as the stalk gets easily separated when fruits ripen.

Bearing in budded/grafted plants start within 4-5 years of planting, whereas in seedling, it starts only after 7-8 years. The number of fruits per tree increases with the age of the tree. A 10-15 year old full grown up tree of CISH-B-1 can yield up to 80-100 fruits per tree.

CISH-B-1 is not much affected by disease and pest. However, canker and gummosis disease affect the crop to some extent. Gummosis is cured by pasting of copper fungicide or spraying of cupper fungicide. However, Canker is cured by spraying the tree with streptomycin (200 ppm).

Leaf weevil and leaf eating caterpillar are two important insect which affect the tree growth and these can be controlled effectively by spraying of Rogar (0.5%) twice or thrice at fortnightly intervals.

Generally bael fruits cracks during December-January. These can be managed by maintaining proper moisture in root zone. Mulching of tree basin by paddy straw/dry leaves and also protecting orchard by plantation of wind break reduces the fruit cracking. Sometimes, due to borax deficiency fruits crack. This can be corrected by 50-100 g per tree borax along with fertilizer application in tree basin.

For further interaction, please write to:
Devendra Pandey (Principal Scientist), CISH, Rehmankhera, Lucknow, Uttar Pradesh 226 101. Corresponding author e-mail: dpandey2005@yahoo.com
Karonda or pickle berry is indigenous hardy plant and its fruit is used for making pickle and candy. It is rich source of iron and vitamin C and flourishes well in regions with high temperature and suited well under arid and semi-arid areas. It serves as one of the best bio-fencing materials and raising of hedges due to presence of auxiliary spines.

**Climate and soil requirement**
Karonda can be grown on wide range of soils. It can be grown successfully on poor sandy and rocky soils. It is classified as medium salt tolerance crop. It is well adapted to varying agro-climatic condition from altitude of 300 to 1,800 m in the Himalayan region, but it is susceptible to prolonged frost. Heavy rainfall and waterlogged conditions are unsuitable for growing this fruit crop.

**Botanical name**
Carissa carandas L.

**Other important species**
C. grandiflora, C. bispinosa, C. Spindrum, C. ovata, C. edulis, C. inermis, C. spinarum, C. arduina

**Family and chromosome**
Apocynaceae and 2n=22

**Status of genetic diversity**
Diverse karonda forms are available in the states of Bihar, West Bengal, Chhattisgarh, Odisha, Maharashtra, Gujarat and in North western India.

**Growth habit**
Shrub having spreading growth habit

**Leaf**
Simple leaves, evergreen, oval or elliptic, dark green glossy, new emerging leaves are light reddish in colour

**Flower biology**
Corymbose cyme

**Pollination**
Cross pollination

**Pollinating agents**
Insects

**Commercial varieties**
Thar Kamal, Konkan Bold, Pant Manohar, Pant Sudarshan, Pant Suvarna

**Economic parts**
Fruit, root and shoot

**Propagation techniques**
Seed and semi-hard wood cuttings treated with IBA at 5000 ppm in 50% alcohol, exhibited 40-50% success under semi-arid conditions

**Propagation period**
Seed sowing: June-July
Cutting: July-August

**Nursery period**
6-12 months

**Spacing**
Normal spacing: 2.5 m × 2.5 m

**Fruit**
Botanically berry

**High density/hedge**
1.5 m × 1.5 m

**First harvest**
3rd year after planting

**Economic yield/ tree**
5-10 kg in mature plant

**Harvesting method**
Individually

**Harvesting period**
July to September in 2-3 picking

**Pests**
Digama hearseyana and Simcronyx rorida

**Diseases**
Anthracnose, leaf blotch and bacterial canker

**Shelf life**
Mature fruit: 5-7 days, ripe fruit: 2 days at room temperature

**Nutritional value**
1.75 g protein, 3 g fat, 1 g fibre, 1.1 mineral, 4 g carbohydrate, 21 mg calcium, 39 mg iron, 28 mg P, 2.0-2.40% acidity, and 15-25 Vitamin C mg/100 gm of edible portion in ripe fruits.

**Post harvest products**
Chutney, jam, candy, pickle, jelly, squash and syrup

**Medicinal significance**
Astringent, antiscor, earache, antidiarrhoea, roots serve as stomachic, vermifuge and useful in itches, leprosy, epilepsy, malaria and leaves for intermittent fever.

For further details, please contact or write to:
Dr PL Saroj, Director
ICAR-Central Institute for Arid Horticulture, Bikaner
Drs Sanjay Singh and A K Singh, Central Horticultural Experiment Station (ICAR-CIAH) Vejalpur, Panchmahals (Godhra), Gujarat.
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