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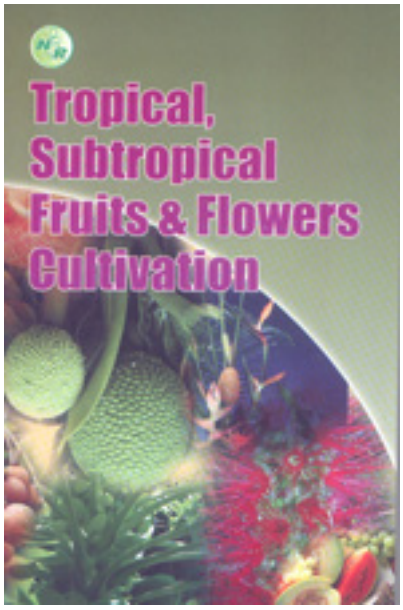
Tropical, Subtropical Fruits & Flowers Cultivation



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Tropical and subtropical plants grow in tropical jungles around the world. These plants often produce stunning blooms in a range of colors, and bring a unique and exotic feel to their growing environment. Although they hail from moist areas, many tropical and subtropical plants require warmth more than moisture. Some species of tropical plants are therefore quite easy to grow in warm, non tropical areas. One of the great characteristics of tropical plants is that they keep growing all season. There are thousands of tropical and subtropical fruits and flowers. The tropics have the capacity to produce large quantities of fruit and international trade is adding new kinds as rapid shipment possibilities increase. Some tropical fruits such as the banana, mango and pineapple are now as familiar as the apple and pear in temperate regions. Other examples of tropical fruits are grape, papaya, litchi, guava, coconut etc. In comparison with fruits of temperate regions, many tropical species have been much neglected in international markets. Citrus cultivation is carried out on a large scale. Citrus is grown worldwide although they are tropical plants so that most of the commercial groves are in subtropical regions. It is usually grown at sea level where sufficient moisture is readily available, or under irrigation. Any well drained soil, except an extremely sandy one, is suitable. The fruits ripen at different times of the year depending on the species and variety. There are various kind of tropical flowers; Aster (Callistephus chinensis), Jasmine (Jasminum sp.), Calendula (Calendula officinalis), Carnation (Dianthus caryophyllus), Lily (Lilium spp.), Narcissus (Narcissus spp.), Orchids and many more. Flowers require sincere, patient, soft, affectionate as well as expert handling. Most houseplants are tropical plants. That’s why they do so well indoors, at temperature levels humans find comfortable in their homes, around 60 F to 90 F. More technically, tropical plants are defined as all vegetation growing in a wide band around the equator between the Tropic of Cancer and the Tropic of Capricorn. Just north and south of that band are the subtropical areas, also rich in plants of interest to our group.

This book basically deals with seed propagation extraction and handling, effect of seed treatment and temperature on germination, vegetative propagation, effect of rootstocks on mineral composition, type of cutting, growth substances and season, postharvest management of fruits and vegetables, factors affecting postharvest life of flowers, postharvest management of flowers, postharvest management of spices, postharvest management of plantation crops, control of ripening process, pelletization, transportation, storage etc.

Plant propagation is an important aspect of agriculture in general and horticulture in particular. This book contains new methods for cultivation of tropical, subtropical fruits and flowers. The book is very useful for agriculture universities library, consultants, new entrepreneurs, plantation companies, farmers who wants to update their knowledge and adopt new cultivation techniques.

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Sample Chapter:

Mango

SEED PROPAGATION

Polyembryony

Although the Indian mango was commonly believed to be monoembryonic, a number of polyembryonic cultivars were discovered in South India. They produced up to 5 embroys and some of them gave a high percentage of germination. Sachan and Chopra studied seeds of 19 cultivars of Mangifera indica and one of M. odorata, out of which six cultivars were polyembryonic and the zygote was degenerating. The seeds of the rest of the cultivars had single embryo, usually zygotic in origin.

Tammes in an investigation on the seeds of polyembryonic cultivars observed that the generative embryo was situated immediately behind the porous vegetative embryos which were formed in a row on the wall of the mucellus at the dorsal side of the polyembryonic mango seeds, and the generative embryo might be eliminated before planting by a transverse cut through the seed. Seeds from South and North India were studied for germination, number of embryos/seed and the number of seedlings/seed. The number of embryos ranged from 2 to 10, seedlings from l to 7 and germination from 40.6 to 87.5%. Polyembryonic seed produced nucellar seedlings under field conditions and it was suggested that they could be used as rootstocks.

Storage

Storage of mango stones in charcoal powder proved more effective than in polythene bags, desiccators, refrigerators or open jars; 50-60 per cent viability was retained up to 90 days. Leaf mould was the best of several germination media which included sand, soil, sawdust and farm yard manure. Chin described the storage condition of mango seeds and the method used for short-term seed storage, usually at moisture levels above 20 per cent and ambient temperature above 15ÂºC in sawdust, charcoal or absorbent paper in plastic bags.

Germination

Mango seeds for rootstock purpose germinated better if the endocarp was opened and the kernel extracted. Mango seeds from underdeveloped but mature fruits showed earlier germination when the kernel was husked before sowing. Bakshi studied the germination of mango stones in relation to the depth and the time of sowing and reported higher percentage of uniform germination by sowing at a lower depth; no significant differences were, however, observed among the three dates of sowing, at an interval of 15 days. He also reproted that stones of monoembryonic cultivars germinated more freely than those of the polyembryonic ones and the fourth and the fifth shoots of the polyembryonic stone mostly failed to survive. Giri and Yaqub observed that seeds obtained from the seedling plant showed a better overall germination than those from grafted plants. Mango stones obtained from ripe fruits germinated better (91.4%). Germination was not affected by the removal of peel or pulp. Germination reached 100 per cent in decorticated mango seeds of five cultivars by the 18th day, but only 69-86 per cent by the 32nd day in undecorticated controls. Chauran et al. studied the effect of storage time, seed treatment and fungicides on seed germination and growth of mango seedlings. They observed that non-stored seeds with the removal of the entire endocarp gave the highest percentage of germination (97.5%) and produced the tallest plants (20.6 cm) after two months with the greatest number of leaves as compared to stored seeds.

Patil et al. obtained best germination of stones of cv. Alphonso after 90 days (40%) when stones were kept in polyethylene bags + charcoal at 25ÂºC. Germination of stones stored on the cement floor declined to 12 per cent at 60 days and stones stored in polyethylene bags at 8ÂºC failed to germinate. Corbineau et al. stated that mango seeds had no dormancy. Germination may occur between 5 and 40ÂºC but the optimum temperature was 25- 30ÂºC. For polyembryonic cultivars, the bigger the embryos the more rapid the

germination and the more vigorous the young plants.

VEGETATIVE PROPAGATION

Cutting

Part and age of Plant

Mukherjee et al. reported that cuttings taken from the lower part of mango plants yielded higher percentage of rooting and survival than those taken from the middle and the upper parts. They also reported that rooting and survival percentage of cuttings made from 4-year-old trees were almost double, compared to those taken from 10-year-old trees.

Effect of Forcing, Ringing and Etiolation

The application of 3 per cent indoleacetic acid to the ringed portion of marcots while wrapping and to a girdled section of the base of a cutting 24 hours before severance from the mother plant proved a very successful method of rooting when the plants were 2-3 years old. Juvenile etiolated shoots were ringed and treated with lanolin paste containing 5,000 ppm IBA; the cuttings prepared from such shoots showed 50 per cent rooting as compared to 30 per cent from non-juvenile, non-etiolated cuttings Sen et al. obtained 40-80 per cent rooting in mango cuttings taken from one, two and three-year-old ringed hardwood shoots under mist, and treatment with IBA improved the rooting. Non-ringed hardwood cuttings of mango failed to root under mist, but they successfully rooted when cuttings were taken from ringed shoots; IBA enhanced rooting percentage in ringed shoots. Bid and Mukherjee noted better root formation in the cuttings of mango from forced shoots, and that etiolation also improved rooting. A medium containing peat moss and sand (l :1) was better for rooting than any single item, or vermiculite and soil plus leaf mould.

Effect of Bottom Heat

Mango cuttings of cv. Dashehari were dipped in 5,000 ppm IBA and plantedin sphagnum moss sand mixture. A temperature of 30ÂºC Â± 2Âº at the rooting zone resulted in 97 per cent rooting in mango cuttings, compared to 15 per cent without bottom heat. Majumder and Prassad reported 85.8 per cent rooting in mango cuttings by bottom heat treatment at 35ÂºC, when combined with wounding and 5,000 ppm IBA application.

Effect of Growth Substances and Other Chemicals

Rao et al. reported success in the rooting of mango cuttings by using a mixture of IAA, IBA, PA and NAA at 0.25 or 0.5 per cent each in lanolin paste. Benincasi, however, reported that softwood cuttings of mango did not root in soil despite IBA treatment.

Reddy and Mazumder reported synergism of phenols and flavonoids with IBA in root regeneration in cuttings from young Dashehari seedling. Preplanting treatment with phenolic compounds, such as p-hydroxybenzoic acid, p-coumaric acid and ferulic acid, generally promoted auxin-induced rooting on mango cuttings. They also recorded that Ethrel too stimulated better rooting in the presence of IBA than IAA and further observed that application of IBA to the cuttings pretreated with Cycocel or Ethrel improved rooting, Cycocel pre-treatment was more effective than Ethrel.

Sadhu and Bose recorded success in the rooting of mango cuttings by pre-soaking treatment in Ethrel (50 ppm) and acetylene (100 ppm) followed by quick dip in IBA or IAA at 2,500 ppm. Pre-treatment with Ethrel increased the number of rooted cuttings from 16 per cent in the untreated control to 41 per cent when applied alone or 48 per cent when used with IAA or 76 per cent with IBA. Acetylene treatment was less effective (10-30% rooting).

Effect of Age of Cutting, Bottom Head and Growth Substance

Rajan and Ram stated that juvenile cuttings rooted well in mist or hot bed whereas non-juvenile ones (from 30-year-old Langra trees) did not. Wounding the cuttings had a beneficial effect only if up to 2 cuts were made. IBA at 10,000 ppm applied to juvenile cuttings gave good results; these cuttings rooted better in hot

beds than in mist. Reddy and Singh studied the effects of bottom heat temperatures (25 or 30ÂºC), propagation durations (28, 35 or 42 days) and wounding on rooting of hardwood cuttings of cv. Dashehari. They found significant increase in percentage of rooting and length of longest root by increasing the propagation duration from 28 to 35 days. Treatment with IBA at 5,000 ppm + wounding significantly increased rooting, number of roots and length of the longest root compared with IBA at 5,000 ppm with no wounding. In another experiment they studied the effects of month (Nov., Dec., Jan. or Feb.) and age of the source tree (3, 6 or 13 years) on rooting of hardwood cuttings of the cv. Dashehari using bottom heat (30Â° Â± 1ÂºC) with wounding + 5,000 ppm IBA or wounding with no IBA. The percentage of rooting, number of roots and length of the longest root showed no significant effect at different months. The juvenile hardwood cuttings taken from 3- and 6-year-old trees showed higher percentage of rooting, number of roots and length of longest root than cuttings taken from 13-year-old trees. Wounding with IBA treatment gave a significantly higher percentage of rooting than wounding with no IBA, irrespective of the month or the age of the source tree.

Life of Cutting

Kalifa et al. observed that soaking in running tap water for 24 hours increased the life of the cuttings compared to hot water treatment or subjecting the basal ends to a flame for 1-2 seconds. They noted that the combination of 100 ppm IBA+10 ppm vitamin B1+2% ammonium sulphate + 2 % sucrose resulted in the greatest longevity of the cuttings.

Biochemical Changes

Ringed cuttings of mango treated with IBA showed increased metabolic activity, with an increase in reducing and non-reducing sugars, starch and C/N ratio. Root-promoting substances extracted from the seedling cuttings of mango were mainly abscisic acid, p-coumaric and p-hydroxybenzoic acid. Treatments with 1 per cent IAA and IBA on mango cuttings increased non-reducing sugars, whereas their lelvel declined with NAA. Auxin treatment led to initial increase in total and soluble N, followed by a steady decline.

The rootings of hardwood mango cuttings was promoted by ringing and IBA treatment. Ringing caused accumulation of carbohydrate and greater synthesis of proteins. The endogenous levels of sugars, nitrogen, phenols, growth substances, root-promoting and inhibiting substances and enzymes were studied in 2 clones of mango by Sadhu and Bose to elucidate the reasons for clonal variation in rooting response. The levels of sugars and polysaccharides in stem and leaf tissue of cultivars Baramasia (easy-to-root) and Langra (difficult-to-root) were quite different. Soluble sugar level and C/N ratio gave positive correlation with rooting, total carbohydrate and polysaccharide level did not show such correlation. Amylase activity was higher in Baramasia than in Langra. The auxin activity was low in both clones and there was no difference between the two cultivars in IAA oxidase activity. The levels of total phenols including mono- and di-phenols was higher in Baramasia than in Langra.

The role of endogenous growth substances, ethylene, cofactors and metabolities for the variation in the natural rooting capacity in cuttings from seedling and mature clone of mango and the effect of Ethrel, acetylene and IBA on root formation in such cuttings were studied by Dhua et al. Cuttings from mature clones failed to produce roots while 40 to 90 per cent cuttings from seedlings rooted, depending on the treatment. IBA proved more effective than Ethrel and acetylene and a combination of IBA and Ethrel further stimulated root formation. Although the variation in the endogenous ethylene concentration in the seedlings and clonal cuttings was not very pronounced before treatment, a marked rise in ethylene was recorded in seedling cuttings. Soluble and protein nitrogen showed a much increase in the seedling cuttings compared to clonal cuttings. No growth promoting substances were found to be present in clonal cuttings while those from seedlings contained growth promoters between Rf 0.1 and 0.3 when treated with acetylene and IBA; a high concentration of growth promoters was recorded in the bound fraction of Ethrel treated cuttings. The

seedling cuttings also contained root promoting substances under the different treatments including control and a higher concentration was found in the IBA-treated cuttings. The cuttings from mature clones did not show any appreciable endogenous root promoting activity in any of the treatments. Presence of p-coumaric acid and ferulic acid was very conspicuous in the extract from seedling cutting.

LAYERING

Air-Layering

Etiolation

Bid and Mukherjee in an experiment on air layering of mango reported that the etiolated shoots produced more fibrous roots than the non-etiolated ones, and application of IBA + NAA further improved the rooting in Langra, Chausa and Bombay Green cultivars.

Media

In an experiment on media and wrapping materials for rooting in the air layers of mango, Prasad and Singh found that sphagnum moss and vermiculite wrapped with polythene and then with gunny sack markedly improved the root formation.

Effect of Growth Substances

Treatment with NAA and IBA at 10,000 ppm caused rooting in 100 per cent layers, and all the rooted layers survived after transplanting. Sen et al. reported 95, 80, 67 and 63 per cent success in cultivars Bombai, Himsagar, Langra and Fazli, respectively, when IBA at 5,000 ppm in lanolin was applied in the ring, but the survival was low. IBA at 5,000 ppm in lanolin applied immediately after ringing in the middle of June produced better rooting in air layers of mango.

Rao et al. observed that the mixture of IAA, IBA and NAA was effective in inducing high percentage of rooting when applied at 0.25 or 0.5 per cent each. Azzouz et al. found that IBA was superior to IAA, and the best root system was found after 90 days in marcots of mango treated with IAA + IBA at 0.25 per cent. They also obtained 40 per cent rooting in the untreated marcots after 90 days, and a maximum of 70 per cent with IBA treatment. Beneficial effect of IBA at 5,000 ppm on root formation when applied at the time of ringing in air layers was also reported by Chhonkar and Singh. Pre-treatment of stock plants with Cycocel or Ethrel induced rooting on the air layers of mango. Application of IBA to the air layers from pre-treated shoots improved rooting, Cycocel pre-treatment being more effective than Ethrel. Patel and Singh recorded 66.6 per cent rooting in air layers of one-year-old shoots on 25-year-old trees of cv. Langra by treatment with IBA at 20,000 ppm + NAA at 5,000 ppm in lanolin paste.

Biochemical Changes

Sen and Bose noted the beneficial effect of IBA on rooting in mango air layers. They found a steady rise in moisture content which was directly related to increased rooting. In general, the nitrogen content of the bark of mango layers progressively increased during rooting. The increase in rooting in mango layers treated with IBA was associated with a greater depletion of sugars in the bark and wood of the rooting region.

Basu et al. studied the biochemical changes during regeneration of roots in air layers of mango at four stages. They observed that the total carbohydrates increased progressively and the layers contained a relatively greater amount of available carbohydrate at the root-emergence stage. The concentration of arginine + histidine fell sharply to a level below that in the unlayered control shoots. Alanine, r-aminobutyric acid and serine + glycine and glutamic acid increased sharply until the pre-callusing stage and fell steadily thereafter.

In another investigation Basu et al. recorded that total nitrogen in the bark and wood decreased during root formation. In both treatments soluble nitrogen rose during the pre-callusing and callusing stage, but fell before root emergence, when there was a net synthesis of proteins. Basu et al. also noted that the extracts from root-forming zones of mango air layers showed a greater inhibitory effect on the growth of wheat

coleoptiles than the extracts of non-layered shoots. A decrease in the level of rooting factors was noted as the root-forming process progressed.

Stooling

A modified form of stool layering was proved successful. Freshly germinated seedlings were headed back near the ground, and 3-5 lateral shoots developed below the cut. A ring of bark 1/2 to 1 inch in length was removed and IBA at 5,000 ppm in lanolin was applied. This resulted in profuse root development.

Mukherjee and Majumder observed that stooling of three-year-old seedling rootstock in situ resulted in 93.8 per cent survival, while layering showed 65.0 per cent survival. Bid et al. studied the different methods of propagation of Mangifera indica in the matter of success, survival, growth and their clonal multiplication by stooling. According to them, plants grown from the seedlings and veneer grafts were the most useful for rooted shoot production and establishment. Clonal propagation of mango rootstocks by stooling was also reported by Singh and Srivastava. Ringing of shoots and treatment with 5,000 ppm IBA resulted in more production of roots in Goa and Moovandan rootstocks compared to Dashehari and Chausa. All the shoots produced in Rumani, Chausa and ST-9 showed more rooting capacity followed by Goa, Bappakai, Kalapady, Moovandan, Nakkare and Dashehari.

Grafting

Method

Parsons reported successful propagation of mango by inarching or patch budding on wild rootstock. A hardy rootstock was also found to be able to impart its frost resistance power to the scion. Mangoes were also successfully cleftgrafted on 3-month-old seedling stocks.

Tanaka described a simple greenwood side graft in which the wood of the stock for preference and of the scion was always immature. The scion wood was unpetioled, the leaves being cut off some days before. The stock was young seedling material. Older stocks (10-15 cm diameter) and trees could be topworked by this method by grafting on the vigorous shoots that arose after the stock or trees had been headed back. The stock was cut back 5-10 cm from the ground, leaving 2 or 3 leaves in place.

Experiments with a new method of greenwood side grafting for mango as recommended by Tanaka showed very encouraging results with most cultivars, provided the scions were over 0.5 cm in diameter and terminal shoots were used. Grafting mango by the Nakamura method (greenwood side grafting) was fairly successful; Peter, a cultivar which had always failed to respond at Kodur, showed 41 per cent success at Burliar. The Nakamura method of side grafting mango was successful with scions obtained from a distance and cut three to five days before.

In packets of wet moss in which they had germinated, the rootstocks were grafted by approach to equally tender shoots of scion trees. The grafts were separated from the scion trees 10 weeks after grafting and the percentage of survival was more than 94.

Naik reported that inarching was the traditional method of vegetative propagation. He observed that side grafting was more effective, economical and convenient with some mango cultivars than inarching.

Trials indicated that tongue grafting, although difficult to perform, gave the highest percentage of success. The use of lanolin stimulated new growth of the scions. Eight-year-old Sabre trees growing on local sour mango stock were successfully topworked onto cv. Karuthacolomban without initial deheading by adapting the side grafting method.

Garg reported an easy method of mango grafting. In this method one-year-old mango seedlings were dug up with a ball of earth round the roots and wrapped with moss round the earth ball which was then enclosed in a polythene bag. Then the seedlings were hung on a mango tree for approach grafting. Rao and Rao obtained 70 per cent success in inarching when the soil ball of the seedling rootstocks was wrapped with alkathene film. Bharath recommended a modified system of approach grafting. The stocks used were six-

week-old seedlings, 6-9 inches tall, lifted and wrapped with moist moss, and finally enclosed in polythene to prevent drying out. They were tied to the scion and approach grafting was done in the usual way. Union was effected in four weeks, and the plants were then cut from the scion trees, potted and hardened-off for one month in partial shade.

Carmiehae recommended a method of topworking. The branches were cut back to the desired height leaving one as shock-absorber. The new sprouts were tip-grafted when their diameter was inch. The sprouts around the new grafts were removed, and when the new scions were about 2 ft long, the shock-absorber branch was removed.

Hosein developed T-grafting method in mango. In this method the stock plant should be about 4 months old, and at least to 1 inch in circumference at 3 inches above the ground level. The scions were selected from terminal shoots, 3 to 4 inches long and slightly thinner than the stocks. They were defoliated 8-10 days before removal, so that the petioles might fall off naturally. A sloping cut was made from a point inch below the terminal bud to at least 1 inches below on the other side. This was inserted into a T-shaped cut in the bark of the stock, which was 1 to 2 inches long and half the circumference wide and above which a chip of bark was removed to facilitate a close fit. The graft was tied with raffia and wrapped with polythene tape. The stock was cut back gradually over three months. This method costs only 23 per cent of the cost of conventional inarching and requires less than half the time.

Mulat developed a successful method of side tongue grafting in mango and obtained 82 per cent success in June. Teaotia and Srivastava developed a new method of inarching in mango which required only three weeks time for the graft to unite. They used four to six-week-old seedlings lifted from the ground and their roots wrapped with moist moss and placed in polythene bags for inarching.

According to Mukherjee and Majumder, veneer grafting was considered better than inarching, since scion shoots may be detached and grafted onto seedlings in the nursery. Jagirdar and Bhatt reported that in case of veneer grafting, the age of the rootstock (three or nine months) did not affect grafting success, but the percentage was increased by the use of mature scion wood. Rajan and Sinha in studies with mango cv. Dashehari, 5- to 6-month-old scion shoots were defoliated 1 week before veneer grafting. After grafting, 12x5 cm strips of aluminium foil were loosely secured around the graft union for protection against high temperature and solar radiation; the strips created a beneficial microclimate around the union. Grafting was carried out in Apr., May, June, Oct., Nov., Dec. and Jan. In each months aluminium protection showed higher grafting success compared with controls. The success was over 80% in June and Oct., and 70% in April, May and November. Without aluminium foil the highest success was recorded in June (70%) which declined to 50% in October and April and to 22% in November.

Gupta et al. reported that stone grafting between mid-August to mid-September on 10-day-old rootstock seedling gave 50-55% success in cv. Dashehari. Secion shoots 4- to 4.5-months-old were most suitable. The success with splice (57%) side (46%) and veneer (40%) grafting was better than with wedge (27%) and saddle (24%) grafting.

In mango cv. Uba, cleft grafting was most successful (97.1 %), followed by whip grafting (88.9%) and whip and tongue grafting (88.7%). Krochmal achieved success in grafting mango by planting the young rootstock plant in polythene bag with the roots in peat moss and tying the stock to the scion tree into which its stem (previously shaped to a wedge) was inserted. Singh et al. obtained 96.6, 100 and 100 per cent success in veneer grafting, vineer grafting with immediate top removal and softwood grafting, respectively in the month of June of cv. Langra on 1-year-old seedling rootstock. Dhakal and Hoda recorded 17.63 cm of scion length after six months from veneer grafting, when the scions were defoliated 10 days before grafting, compared with 12.63 cm when scions were stored for 10 days before grafting. In trials with cv. Pairi, Tayde et al. observed significant differences in graft success in softwood, veneer and stone grafting. Softwood grafting between July and September showed higher success (70-100%) and ultimate survival after 9 months and

also produced maximum scion growth, compared with the other methods.

Shrivastava et al. assessed age of seedling (15, 30 or 45 days), method of grafting (whip, wedge or veneer), cultivar (Dashehari, Langra, Fazri and Taimuria), length of cut on rootstock and scion (2 or 3 cm) and plant growth regulator treatment (IAA and IBA each at 50 or 100 ppm) on the grafting success. They found that the whip method of grafting (followed by the wedge method) was very successful, giving the maximum percentage of sprouting of bud sticks. Thirty-day-old seedlings gave better results than 15- or 45-day-old seedlings. A 3 cm-cut on the rootstock and scion was better than a 2 cm-cut. Lifting the seedlings from the nursery beds before grafting gave better results than grafting in situ. The effect of plant growth regulators was negligible. Grafting success was found highest in Dashehari (86%) followed by Langra (72%), Fazri (52%) and Taimuria (12%).

In order to rehabilitate three-year-old mango trees, the canopies of which had been frozen to ground level, head and side grafting methods at the collar were investigated by Ben-Ya'acov. He noted that the rate of graft-take was satisfactory and the danger of losing the scion in the event of additional frost spells was small, since grafting was performed below the ground.

Reyes observed the highest percentage of take (97%) in mango grafts when covered with wet plastic bags and placed in shade, followed by 95 per cent when covered with dry bags and placed in the sun or covered with dry bags and placed in the shade. Softwood grafting was reported to be a successful method of propagation of mango in Gujarat.

Stone grafting in mango was standardized at the Horticultural Research Station, Krishnanagar by Bhan et al. and they claimed 75 to 80 per cent success by using germinating seed as a rootstock and semi-mature terminal shoot as a scion.

A new method of epicotyl grafting was reported by Maity. Well-filled mango stones, usually from inferior cultivars, were put to germination in sand on a floor underlaid with a hard layer or polythene sheet to prevent root penetration and thereby facilitating lifting of seedlings with minimum root injury. Base of the seedling, still with half-folded pinkish or reddish leaves, was tied water-tight in a polythene bag containing moist sphagnum moss medium for root growth. Its top was removed with a slanting cut to form a tongue. A scion shoot irrespective of age but nearly equal to the seedling in thickness was selected. At a place varying from 15 to 20 cm down its tip the scion was sliced from below upwards just enough to contain the tongue of the rootstock. Both the rootstock and the scion branch still attached to the mother plant were tied firmly in this position with a polythene strip to hold them together securely. Union took place usually in two weeks and the graft was ready for separation in another two to three weeks. Both union and survival of the grafts were nearly 100 per cent. This method took much less time than the age-old method of inarching to prepare a mango graft.

In an experiment on epicotyl grafting, Chakravarty and Sadhu reported that graft success was more or less uniform in June, July and August when epicotyl grafting was done on mango. Forced scions gave better results than non-forced ones. Etiolated as well as invigorated scions showed no appreciable improvement in graft success or graft growth when compared with non-etiolated or non-juvenile scions. Regardless of treatments and time of grafting, Langra performed best, followed by Bombai and Himsagar.

Patil et al. in studies on epicotyl grafting, grafted 2, 4- or 6-day-old seedlings with scion cv. Totapuri in the 3rd week of August. The scions were defoliated on the tree for 2, 5 or 7 days prior to grafting. The grafts were held in a greenhouse and assessed for success 150 days after grafting. They found best results with 4-day-old seedlings and 5 days of defoliation. Nagawekar et al. stated that in stone grafting, when terminal or subterminal parts of shoots were used as scions, survival (60.6-63%) and subsequent growth were very similar. Graft survival was also significantly better when grafting was carried out on container raised seedlings (63. 1-65.4%) than on lifted seedlings (52%). Chakrabarti and Sadhu obtained highest success rates of epicotyl grafting by using 5-day-old seedling rootstocks and 1 -month-old scion shoots and scions

10 cm long gave better results than those of 5 or 15 cm long. They also found better results by grafting at 5 cm than at 2 or 7 cm above the rootstock collar. Desai and Patil recorded 70 per cent success when Alphonso scions were stone grafted on 7-day-old seedlings on 1st of July under greenhouse, compared with 40 per cent in open. Gaur, however, observed highest success (75-80%) by softwood grafting.

Effect or Stock and Scion on Graft Union

Stocks as young as 4Â½ months could be inarched. The older rootstock did not necessarily produce larger grafted plants than the younger stocks.

Bhatt suggested that mango grafts with a number of shoots should be taken to 2-year-old seedlings grown in situ and suitable shoots should be grafted on the seedlings in the usual way. When the union is complete the mother graft should be detached and used to graft other seedlings in succession.

Certain mango cultivars gave a very high precentage of take when pre-cured scions were side grafted onto 13Â½ month-old seedling stocks; other cultivars were less successful. Double grafting appeared to increase the stem girth.

Singh obtained 80 per cent success by inarching within 8 weeks from the germination of the seedling rootstock. One-year-old stocks were more successful than the three-month-old seedlings. Singh and Srivastava obtained best results with six-month-old scions, grafted onto one- or two-year-old stock in July/August. They suggested that the bud sticks should be defoliated and kept in moss wrapped with polythene for 3-5 days before grafting. Of the several tying materials tested, white polythene strips were most suitable.

Inarching of Bennet Alphonso and the Baneshan cultivars of mango on the polyembryonic rootstocks, Chandrakaran and Bappakkai, was more successful than on the monoembryonic rootstock, Puliyan.

The effect of the girth of the seedling stock on the success of inarching was studied by Giri, and he noted higher percentage of success on seedlings having 1.3-1.6 cm girth, and the success was more in autumn than in spring. The percentage of success of side grafting in mango was raised from 70-80 to 100 per cent when the scions were defoliated 10 days before detaching them for grafting.

Wedge grafting on one- or two-year-old seedlings by using scions defoliated l -2 weeks earlier resulted in 98.5 per cent success in a nursery and 76 per cent in the field without irrigation.

The length of the scion ranging from 2.5 to 10 cm did not affect the initial success of veneer grafting, but the subsequent growth was better with longer scion. The scion from the non-flowering shoots proved better. They were able to store scion shoots at room temperature by wrapping them with moist moss in plastic bags for 6-9 days.

Kanwar and Bajwa recorded 92 per cent survival of mango side grafts when stocks were transplanted after cutting the tap root, compared with 77 per cent survival when seeds of the stock plants were sown directly. Besides, transplanted seedlings developed more fibrous root system but direct sown seedlings were taller. They also noted that scion shoots, 7.5 cm long, were the most satisfactory, and grafting in March-April or June-October produced the best results.

Three-year-old mango trees damaged to ground level by frost were top-grafted at the root crown. The highest take (70 per cent) was observed in Palmer top-grafted on Sabre and in Tommy Atkins on Ruppin.

Thomas recorded 95 per cent success with cv. Mabroka and 80 per cent with cv. Julie by saddle grafting onto the seedling of local polyembryonic rootstock. Inarching on 4-month-old seedling rootstock showed higher percentage of success by using scions of 4 cultivars, followed by side grafting.

Kahlon and Mishra studied the effect of leaf lamina on the success and scion vigour in veneer grafting of mango and they acheived the highest percentage of success and the most vigorous scion growth by excising the distal half of the lamina, compared to the proximal or side half or the whole lamina, or leaving it intact. Maity and Biswas observed that in epicotyl grafting the defoliated scion shoots always produced higher percentage of successful grafts than the undefoliated shoots; and the percentage of success with

defoliated shoots was found to be 96 per cent in Fazli, 94 per cent in Ranee Pasand and 90 per cent in Kohinoor. Patil et al. reported that before grafting the rootstock was defoliated or 2 or 4 leaves were left. The scion shoots were defoliated 5, 10 or 15 days before grafting in the 3rd week of September. The best results were obtained with rootstocks with 4 leaves grafted with scion shoots defoliatd 15 days before grafting.

Reddy and Melanta selected the polyembryonic cv. Nekkare as the rootstock and the seedlings were raised in polythene bags (36 x 24 cm) for container grafting. For in situ grafting the seeds were sown in the field at 60 x 30 cm. Grafting with scions of the cv. Alphonso was carried out on rootstocks 3-9 months old. In the container trial, success ranged from 58% with 3-month-old rootstocks to 40% with 4- 5- and 6-month-old rootstocks. In the in situ trial the highest success (90%) was obtained with 7-month-old rootstocks and the lowest (25%) with 3-month-old. Dhakal and Hoda conducted two trials to study the effect of defoliation period and storage of scion shoots on success of veneer grafting. In one trial, scion shoots of cv. Langra were taken immediately after defoliation or 5, 7, 10 and 15 days later. In another trial, scion shoots taken 5 days after defoliation were stored for 3, 5, 7 or 10 days. The age of the rootstocks and scions were 12 and 6 months, respectively, and shoot diameter at the graft union was 1-1.5 cm. In the first trial, grafting 10 days after defoliation gave the best results (90% initial success and 75% survival after 6 months). In the second trial, storing for 3 days gave the best results (90% initial success and 80% survival after 6 months).

Experiment conducted at Bangalore by Reddy and Melanta using 6-month-old mango cv. Nekkara plants raised in container or in situ as the rootstocks. Shoots of the scion cultivars Alphonso, Dashehari, Langra, Mallika, Pairi and Totapuri were preconditioned for 10 days before softwood grafting. They recorded the highest grafting success (90%) with Dashehari and Totapuri scions with both container and in situ grown rootstocks. The phenol content in all the scion cultivars were found to decrease with increasing duration of preconditioning. The highest phenol content at all preconditioning stages occurred in cv. Alphonso which had the lowest grafting success while the lowest phenol content occurred in Dashehari which suggest that graft union success is related to the phenol content in the scion. They also stated that 7-month-old rootstock gave the highest success rate when the scions were preconditioned for 10 days prior to softwood grafting. Panickar and Desai studied the effect of age of scion mother tree (5 to 45-year-old), different flushes of rootstock (2nd or 3rd flush) and in situ grafting on success and growth of softwood grafts of Alphonso mango. They found that the scion sprouting and survival after 3 months were best (72 and 70%, respectively) when the scions were taken from 25-year-old mother trees. The results also indicated that softwood grafting can be carried out on any growth flush from the rootstock provided that it is coppery red in colour.

In mango cv. Banganpally, success with veneer grafting was recorded highest (71.42%) with nursery grown rootstock then with these raised in containers (60.29%). Preconditioning of scions for 10 days gave higher success (78.96%) with 100-day-old scions compard with 62-67% with 120-day-old scions. Shankar et al. studied the greenwood wedge grafting in mango cvs. Alphonso, Pairi, Neelum, Totapuri and Mallika on one-year-old seedling rootstock. Grafting was carried out between February and March and they observed the highest sprouting (88.66%) and graft take (44.66%) when the grafting was done in the second fortnight of March. Among the cultivars, highest sprouting (75.55%) and graft take (57,10%) were found in Mallika.

Effect of Season

In spring, nine-month-old stock yielded the best result when budded on 10 May, but in autumn the results were, generally, less promising. Asadullah and Khan reported that inarching in spring gave better success than in autumn season in case of cultivar Langra. In mango, the percentage of survival of the grafts was higher when the rootstocks were kept in pots than when wrapped with polythene and grafted in spring, as compared to monsoon. Ahmad carried out veneer grafting on 9- and 12-month-old seedlings of Langra, Dashehari and Samar Bahishet on four different dates in the spring and autumn. Samar Bahishet was the

most successful stock, spring grafting being better on 12-month-old seedling.
Mukherjee and Majumdar reported that mango could be successfully veneer-grafted between March and July and the maximum scion growth was obtaind in grafts made during March to April. In an experiment on veneer grafting in mango cultivars in different seasons, Jagirdar et al. noted over 90 per cent success in Sindhri and Dashehari in dry hot spring and over 90 per cent in Sindhri, Langra and Baganpali in the cooler months and over 80 per cent in Dashehari in moist spring.
Gunjate and Limaye reported that the percentage of success of veneer grafting in mango varied between 68 and 91 when done at intervals from 5 March to l June, 15 May being the Optimum date for grafting.
Singh and Srivastava reported 84 per cent success with inarching and softwood grafting in the month of July, when the scions of Dashehari were grafted on the seedling rootstock cv. Bappakai.
It was observed that grafting between the 3rd week of May and the 3rd week of August resulted in 90 to 100 per cent take, while it was 85 to 90 per cent between February and May.
Five to 15 cm long scion shoots of the mango cv. Dashehari defoliated 15 days before or immediately before grafting were veneer grafted on mango seedlings on the 15th day of each month between January and August. Grafting success was on an average 20, 80 and 40% with 5, 10 and 15 cm long scions, respectively. Better results were obtained with pre-defoliated scions than with freshly defoliatd ones. The best months for grafting were June, July and August during which 100% take could be expected. Singh and Srivastava opined that softwood grafting gave better performance in comparison to veneer grafting in success as well as extension growth of shoot in early stage and better success was recorded in the month of August.
Upadhyay and Prasad recorded maximum success (85%) of veneer grafting in the month of June followed by July, August and September, each with 80% and 70 per cent in October, compared with 18-25 per cent between November and February.
Effect of Growth Substances
Treatment of mango seeds with GA3 increased the stem height and the circumference of the seedlings which attained a graftable size within 2-2Â½ months of sowing. The chemical when applied to graft union at the time of approach grafting as well as the pre-treatment of the rootstock and the scion resulted in an earlier callus formation and graft union. Callus formation in stock and scion was accelerated by IBA treatment. Between inarching and veneer grafting the union was stronger and earlier in the latter method.
In studies on stone grafting in mango with cv. Neelum, Ratan et al. treated the scions of 5, 6 or 8 cm in length with IAA or GA3, each at 100 or 250 ppm and grafted on rootstocks of different heights (2-4, 4-6, 6-8 or 8-10 cm). The grafts were then covered with transparent or black polythene bags or were left uncovered (control). They found the highest sprouting and survival with 8 cm-long scions treated with IAA at 100 ppm, grafted on 6 to 8 cm high rootstocks and covered with transparent bags.
Anatomy of Graft Union
In transverse sections of successful side and veneer graft unions parenchymatous cells proliferated from both the stock and the scion. It was further observed that the thin-walled cells of xylem ray in most recently formed xylem, cambial layers and most recently formed phloem rays were involved in the production of callus tissue.
Root grafting was also reported by Naik. This was successfully carried out by repotting previously potted seedling in such a manner that 2 to 3 inches of taproot below the collar remained above the soil. The pot bore a U-shaped notch, against which the root was placed to facilitate the approach of the scion. There was a high mortality on repotting with exposed root but a good take among the survivors.

Budding

Methods

In Jamaica, besides patch budding, mango was successfully budded by the ordinary T-bud method. De Jong suggested a method of budding mango which would be ready for sale in two years instead of three years by the conventional method. Teaotia compared the two methods of budding in mango by using scions of Langra and Dashehari and he observed that patch method was much superior to modified Forkert method of budding. In another trial on the propagation of mango, patch budding and T-budding were found to be superior to modified Forkert method of propagation in Langra and Dashehari. March was the best month for budding and white alkathene was better than black alkathene for wrapping. Prasad and Singh found that patch budding was superior to shield budding, and budding in May was better than April or June with both the methods; cutting back the stock above the scion after 10 days was better than immediate cutting.

Budding in Situ

Budding seedling mango in the place where they are to grow had undergone successful trials at the Horticultural Stations at Lyallpur and Gurdaspur, Punjab. They also observed that older trees might be successfully topworked by budding shoots arising from the headed back limbs.

Effect of Stock and Scion

Paul and Guneratnum recorded high percentage of success by budding. The stocks used were sudlings, 6 months to l -year-old, and budding was done at a height of about 10 inches from the ground, at a point where the bark was brownish or greyish in colour, the most suitable time being during a growth flush. Ulvi noted that seedling stock should be fit for budding in one year if properly looked after. The budwood should not be selected from a branch in flush, the buds in the leaf axils should be prominent, about the size of a pin's head, and dormant. The bark should peel easily. In Jamaica, Haden mango was more easily budded than St. Julian and as easily budded as the Bombay cultivar. Mango budwood could be budded well after 10 days' storage in damp moss. With stored budwood better results were obtained when the wood at the back of the bud was removed.

Ahmad and Chadha used three types of buds and recorded that those which developed latest on 9-month-old shoots were the most successful, and those of medium size were the best and such buds were found on the cultivar Langra.They also reported that bud-union proved to be more uniform and complete than inarched unions. Jagirdar and Ali studied the effect of the age of stock plants on the bud take in mango and they reported higher percentage of success on 9-month-old seedling, compared to that on 3 and 15-month-old seedling.

Rootstocks from cultivars Gurih and Lalidjwo were found to show higher percentage of success in budding.

Season

Scions of the cv. Langra and Dashehari were budded by the Forkert method on one-year-old seedlings from July to September at an interval of 15 days. In both the cultivars 100 per cent success was obtained when budding was done in July. Jagirdar and Ali obtained greater percentage of sprouting in Sindhri and Langra when budded in the late summer. In a patch budding experiment on Langra, Jauhari and Singh obtained the best success in July by activating buds 2 weeks before budding and cutting back stocks one week after, and using white polythene. Mote et al. obtained the highest percentage of bud take in mango with patch budding and budding in June proved to be the best.

Growth Substance

Mango seedlings treated with GA3 were suitable for budding at 7 months, while the untreated seedlings did not attain suitable size until they were 12-month-old.

Storage of Budwood

Singh and Khan suggested a method to store the wood in budding conditions for 48 hours-the cuts on the budstick were made at least 1Â½ inch away from the sound buds. Both ends of the budstick were dipped in melted paraffin wax for a second, not deeper than Â¼ inch. The sticks were then placed in thermos bottle,

previously rinsed with ice cold water, and a little ice cold water (not ice) was added to cover the bottom Â½ inch portion.

Anatomy of Bud-Union

An antomical study of the bud-union in mango was made by Soule at different stages, and she observed that at the pre-callus stage (i.e., 4 days after budding) only a wound periderm was present, at the callus stage (8 days after budding) proliferation from the tissues mainly near the cambium resulted in firm attachment of the components; at cambial stage (12 days after budding) cambial layers from the stock and the scion formed a bridge and vascular tissues were differentiated within 36-48 days.

Effect of Different Methods of Propagation

Naik reported that the cultivar Bangalora proved more vigorous and more prolific than Neelum and there were no differences between the propagation methods except that inarched plants of Bangalora were higher-yielding than double-worked plants. Double working generally had a stunting effect and promoted earlier flowering. He also reported that there was no significant difference in the performance due to the age of the rootstock but one-year-old seedlings were considered to be the best. Singh and Sirohi studied the relative efficiency of different methods of propagation influencing the growth of mango, and found that macrotting was significantly inferior to the other methods; budding gave the best final results, but with this method stock thickness was found to be inferior to inarching. Bhambota et al. recorded 88 per cent success by veneer grafting in mango during two seasons; it was slightly superior to side grafting and considerably more successful than cleft grafting. Majumdar and Rathore studied the bench grafting in mango and achieved 50.0, 46.6 and 33.3 per cent success by splice, veneer and wedge grafting respectively and they suggested that these could be adopted profitably when climatic conditions are unfavourable for outdoor grafting. Bukhari and Razvi found side grafting to be the best method of propagation, shield budding was the slowest and the least successful method, while veneer grafting and side inarching were intermediate. Aravindkishnan and Nair recorded that intensity of flowering of the grafted plants was closely related to that of the mother tree.

Rootstock

The two most promising stocks were the sour mango or semi-wild varieties of Mangifera indica and the Ceylon wild mango or varieties of Mangifera zeylanica. The sour mango was ready for budding in 9 to 12 months, while the slower-growing wild mango required nearly 18 months.

An experiment was undertaken in November, 1937, at the Experiment Station, Pelwehera, Ceylon, to test the relative merits of 4 mangoes, Wal amba (sour mango), Koh amba (fibre mango), Et amba (wild mango) and Betti amba (Bombay mango) as rootstocks for 4 scion cultivars, the Jaffna mango, the most popular cultivar in Ceylon, Ambalavi, a dry zone cultivar for calcareous soils, Willard, introduced from Mauritius and Sabre from South Africa.

Effect of Rootstock on Growth and Yield

Neelum mango was grafted on Bangalora rootstock of various ages, viz., 10Â½, 13Â½, and 16Â½ months. It was found 37 months later that stem-girth of grafts was more when 16Â½ month-old rootstocks were used than on younger rootstocks. Height differences were not significant. During the first 27 months of orchard life trees on polyembryonic stocks made more rapid growth than those on monoembryonic stocks. Trials in relation to the effect of various methods of vegetative propagation on tree performance of mango gave no significant results. Field observation trail on rootstocks from polyembryonic and monoembryonic seedlings indicated that the polyembryonic stocks consistently induced greater scion vigour Double working trials on mango were successful. Field observations continued to show that mangoes on polyembryonic rootstocks were much more vigorous than trees of the same cultivar of equal or even slightly higher age on monoembryonic rootstocks.

The largest trees were produced by using Sabre stocks in spite of their dwarf character in Israel. The

uniformity of growth in the orchard was more when rootstocks from polyembryonic cultivars were used, and the cultivar Sabre consistently gave the best result. It has been also noted little difference in the yield or size of the trees in 22 mango scion cultivars on rootstocks Sabre, 14.6 and 14.7, but cropping on 3.2 and 14.12 was markedly less. Jauhari et al. compared the growth and bearing habit by grafting Dashehari onto the seedling stock of Dashehari and some polyembryonic rootstocks. They observed that the graft on the Dashehari seedling gave the most vigorous growth and the highest yield. Swamy et al. recommended Pahutan and Goa rootstocks for Neelum, and Pahutan and Olour rootstocks for Beneshan scions, over other polyembryonic rootstocks.

In an experiment on rootstock Singh and Singh reported that Dashehari trees on Vellaikolamban were the smallest, both in height and area covered, and when the same cultivar was grafted on Dashehari seedlings it grew vigorously and gave the highest yield followed by Ambalavi and Mylepalium. In a rootstock trial, 3 scion cultivars-Haden, Maya and Mabroka were grafted on 8 rootstocks (Sabre, Peach, Ruppin, Maya, Zill, 3.2, 12. l, 13.1). After 6 years of planting the rootstock 13.1 proved to be the best among the rootstock tested for all the 3 scion plants. The rootstock 12.1 was excellent for cv. Haden and Maya, but was mediocre for Mabroka. Maya on Ruppin was relatively good, Sabre was poor and Peach was the worst rootstock.

Singh et al. stated that Taimuria, Olour, Rumani, Nakkare and Kurukkan were dwarfing rootstocks while Dashehari, Chausa, ST-9, Moovandan and Sakarchina showed vigorous growth. In Puerto Rico, Cedeno-Maldonadoe et al. conducted a 10-year study with 3 scion cultivars and 4 rootstocks and reported that Eldon rootstocks significantly reduced scion diameter in all cultivars but its effects on the average number of fruits per tree were inconsistent. Eldon also produced significant reductions in tree height when cvs. Palmer and Irwin were used as scions. Significant reductions in tree height of cv. Edward were obtained with Julie rootstocks. The cv. Palmer produced the tallest trees and Irwin the smallest; the same pattern was observed for canopy volume. Eldon was found most effective in reducing canopy volume for Palmer and Irwin but the greatest reduction in canopy volume for Edward was obtained on Julie. The cultivar Irwin had the greatest yield efficiency regardless of rootstock while Palmer was the least efficient. The cultivar Irwin was also superior in terms of total fruit weight per tree. There was, however, on consistent influence of rootstock on total fruit weight per tree.

Salt Tolerance

Rootstock from polyembryonic line 13.1 was found to be resistant to salinity.

Gazit and Kadman suggested the use of the polyembryonic cultivar 13.1 for calcareous soil. The performance of cv. Maya on rootstock 13.1 was excellent on soils containing 20 per cent lime.

Anatomical Screening

Anatomical screening of different mango sedding for use as dwarfing rootstock was made by Mukherjee and Das. Among the cultivars, Olour, Vellaikolamban Mylepalium, Ambelavi, Dashehari, Belkhas, Parikhas and Ati-Bombai, Vellaikolamban showed the least and Dashehari showed the most vigorous growth potentiality.

MICROPOPAGATION

Litz et al. reported induction and growth of nuceller callus and somatic embryogenesis from the callus. Nuceller explants from the immature seeds of two-month-old fruits of cultivars Ono and Chino were used. Litz also reported that somatic embryogenesis occurred from callus on modified MS medium, and following subculture to a medium lacking growth regulators. The highest percentages for both callus formation from explant cultures and embryoid formation from callus cultures were recorded for Irwin (60% and 40%, respectively) followed by Ruby (52% and 23.l %) and Tommy Atkins (36% and 11.l %).

Histological analysis revealed the nucellar origin as well as the variable location of adventive embryos

within the micropylar portion of the ovules. Adventive nucellar embryos, characterized by densely staining cytoplasm and prominent nuclei were formed prior to the cellularization of the endosperm. Embryogenic callus was initiated from the micropylar and chalazal portions of excised nucelli. In suspension culture, proliferation occurred via secondary budding from the epidermis of preformed somatic embryos. These somatic embroy exhibited numerous developmental abnormalities, normal embryo development occurred on solid medium. Embryos had bipolar meristems with closed vascular system, thus demonstrating the embryogenic nature of plant regeneration from nucellar callus in mango. Embryogenic efficiency of callus was improved by transfer to solid medium containing glutamine, 2, 4-D and kinetin. Germination of somatic embryos occurred on medium where sucrose concentration were sequentially lowered and the synthetic growth regulators were replaced by 20% liquid coconut endosperm and 0.025% casein hydrolysate. Plants were regenerated and established in soil.

Litz and Vijayakumar removed the nucellus from fruitlets of polyembryonic mango cultivars at l.5 months after flowering and cultured on half somatic embryogenesis and the embryos matured and germinated on the same media.

When the nucellus was cultured on medium containing l-2 mg/1, 2, 4-D much dark brown callus was produced and when the callus was subcultured on medium that was free of 2, 4-D somatic embryogenesis of mono-embryonic cultivars was similar, although it was imperative to prevent contamination by the zygote. They opined that Florida's most important cultivar, Tomy Atkins responded well to this procedure unlike many other mono-embryonic cultivars. Mathews and Litz studied the kanamycin sensitivity of mango somatic embryos. They stated that the level of kanamycin necessary for growth inhibition was dependent on the size and stage of the somatic embryos at the time of treatment and the kind of exposure. Gorwth of proembryos in liquid Suspension was arrested at 12.5 mM/ml while the maturation of later stages of somatic embryos on solid medium was inhibited at 200 mM/ml.

Orchids

Orchids are valued for their long spikes which display a variety of colours and long-lasting flowers. They occupy a prime position among cut flowers. The family, Orchidaceae, consists of 600-800 genera and 30,000-35,000 species, distributed throughout the world.

In India, about 1,300 species are scattered all over north-east Himalayas (600 species), north-west Himalayas (300 species), Maharashtra (130 species), Andaman and Nicobar Islands (70 species) and Western Ghats (200 species). Eversince the creation of the first man-made hybrid in 1956, several have been added, totalling to over a lakh.

Genus Cymbidium is now among the top 10 cut flowers of the world market, whereas Dendrobium, the most widely cultivated tropical orchid, is also marching ahead to find a better place in the export market. The Cymbidium is mainly grown in the north-eastern Himalayan region, Sikkim, Arunachal Pradesh and Assam. Tropical orchids are mainly confined to Kerala and some parts of Tamil Nadu. North-eastern Himalayan region and the west-coast of Kerala are the main centres of production of orchids.

The commercial orchids are both terrestrial and epiphytic, with an abundance in epiphytic. Monopodial (having single-stemmed growth) and sympodial (having the appearance of multi-stemmed growth) are equally preferred for commercial cultivation. Sympodial types (Cymbidium and Dendrobium) rank high in the export market. Among the sympodial ones, a major share or the area in Kerala is occupied by Dendrobium hybrids. They can be successfully tried in the foothills of north-eastern states. Other sympodial genera suitable for Kerala are Cymbidium (at high altitudes), Oncidium and Cattleya. Vanda, Arachnis and Phalaenopsis are the monopodial genera that flourish under our conditions. Intergeneric monopodial hybrids-Aranda, Assocenda and Mokara-also perform well.

CLIMATE AND SOIL

Humidity is most important, in determining the growth and production of orchids. Regulation of shade is equally important which warrants attention. Good air movement is also essential for healthy orchids. Since the commercial orchids grown in India are mostly epiphytic, soil condition is not a problem, as long as it does not adversely affect the water quality.

VARIETIES

Cymbidium, the temperate orchid, is now grown in the north-eastern regions of India. The flower spikes are arching or drooping and display a wide variety of colours. Some of the hybrids of importance are Angelica Advent, Dingwall 'Lenes' and Peter Pan 'Greenleaves'.

Since Dendrobium consists of a large number of species (over 1,000), several hybrids have been produced and released for commercial cultivation. Those popular in Kerala are Sonia 17, Sonia 17 Mutant, Sonia 28 Mutant, Hieng Beauty, Renapa, Dorine White, Ekapol Panda, Sakura Pink, Pramot Sabine, Emma White, Kasem White, Mme Vipar, Kasem Gold, PM 11, Waipahu Beauty, Sarifa Fatimah, Walter omae and Jiad Gold.

Salient features and common varieties of other popular genera are as follows:

Arachnis (scorpion orchid) monopodial, requires good sunlight and temperature for growth and flowering. Renanthera is a related genus. Its variety, Maggie Oei, is most popular. On the basis of the colour there are 2 types, 'Red Ribbon' and 'Yellow Ribbon'.

Vanda: Its habit is that of Arachnis. Based on shape of leaf, terete (cylindrical leaved, pencil Vanda) semi-terete and strap leaved vanda. Aerides and Rhyncostylis are related genera. Varieties: John Clubb, Josephine Van Brero, Norbert Alphonso, Wirat Uchida and Ruby Prince are important.

Phalaenopsis (moth orchid): Monopodial, requires partially shaded conditions. Doritis is a related genus. Varieties: Rose parade, Keith Shaffer, Temple Cloud, Hennessy and Diana Pinky are important.

Oncidium (dancing girl): Sympodial, with or without pseudobulb, loves partially shaded conditions. Varieties: Goldiana and Gower Ramsay are important.

Cattleya: Sympodial, loves partially shaded conditions. Brassavola, Laelia, Sophronitis, Encyclia etc. are related genera. Varieties: Suzanne Hye and Edithe Bow Bells are important.

PROPAGATION

Orchids are grown by seeds, tissue culture and vegetative methods. Though vegetative propagation is a slow process, it is easier to carry out. Monopodial orchids like Vanda and Arachnis can be propagated by top cuttings. In Phalaenopsis, flower stalks give rise to plants. Sympodial orchids-Dendrobium, Cattleya and Cymbidium-can be propagated by division. The shoots growing on the plants, which are called 'keikis', can also be used. Keikis are very common in Dendrobium. Back-bulbs (spent canes) can also be used as propagules.

In tissue culture, seeds, axillary buds, apical buds, leaf segments and inflorescence axes-can be used. Seed propagation is carried out only in a tissue culture medium because the seeds are extremely small and are devoid of endosperm. Each seed pod contains millions of seeds and the time taken for maturity depends on the genus. The most widely used medium is Knudson C. Meristem culture, which enables the production of a much higher number of uniform plantlets in a short period is now used for large-scale production of orchids. The commonly used media are MS, Vacin and Went and Knudson C.

CULTIVATION

Planting

Earthern pots, baskets, tree fern blocks, wooden trays and whole husk of coconut are common containers used for planting orchids. Sufficient drainage is very essential for orchids. Therefore, holes of appropriate size are made in containers, both at the bottom and on the sides. The size of the container should be proportionate to the size of the plant and its growth habit. Orchids can be planted on the ground too, in

shallow trenches filled with media.

The medium used for growing orchids should allow good aeration and drainage. It should not absorb too much water and should not degenerate easily. Broken bricks, gravel, tile bits, charcoal, coconut husk bits and tree fern are components of media used for growing epiphytic orchids. The components are washed thoroughly before filling in pots. For terrestrial orchids, a judicious mixture of humus, leaf-mould, dried manure, chopped fern fibre and sphagnum moss suffice.

For epiphytic orchids, the pots are filled with the media and the plants are placed over it, exposing the roots. In sympodials, the plant is placed near the edge of the pot, the growing point facing towards the centre. A monopodial orchid is placed in the centre of the container. If necessary, a stake may be used to keep the plant in position. When growing on tree fern rafts, the plant is tied with a soft copper wire. The whole plant with pot may be dipped in water after planting and thereafter watered judiciously. The plants can also be grown on raised platforms over appropriate media directly or in pots.

Orchids can be grown in hanging pot or baskets too where, lighter media like charcoal, coconut husk and tree fern fibre are used.

In Dendrobium, the planting density should be 100,000-150,000 plants/ha. Sympodial orchids, in general, prefer a very close planting and crowded growth.

Manuring and Fertilization

Orchids require both major nutrients and minor nutrients. The relative proportion of N controls the vegetative or the productive phase of the crop. A higher level of N for stimulating vegetative growth and a lower level for flowering. Ready-made fertilizer formulations are available in the market to satisfy these requirements. A low concentration (0.1-0.2%) of these nutrients should be applied frequently as whole plant spray. Spraying 2-5 times a week is generally ideal. In flowering plants, care should be taken to see that the plants are kept free from fertilizer application at least 3 days prior to harvest of flowers. Otherwise the keeping quality of flowers may be affected. Care should also be taken to see that sufficiently grown up plants are not fed with high level of N. This may result in production of shoots or mixed spike instead of a quality spike. Micronutrients help improve the quality. These are applied once a month.

The chemical fertilizers are to be properly balanced with organic manures-cowdung, cow's urine, groundnut cake and neem-oil cake. They are to be diluted before application. Since urine contains high level of salts, a dilution of 1:25 is necessary. For others 1:10 dilution and subsequent storing for 4-5 days before application is ideal. One spray a week with organic manure is enough.

Aftercare

In both the locations (North-eastern states and Kerala), salubrious natural conditions exist for the growth and development of orchids. However, better post-planting attention is required to get healthy plants and quality flowers. Check the support given to plants, remove decayed and dried up parts, check water stagnation, provide good ventilation, remove weed growth on the media and exposing the roots are the main operations to be done.

The monopodial types-Vanda, Arachnis and Aranda-prefer open conditions with plenty of sunlight. The Dendrobiums, Cymbidiums, Cattleyas and Oncidiums should be grown under partial shade. The thumb rule is to provide maximum light which they can withstand, without adversely affecting their health. Care should also be given to see that the shading materials should not hinder the air movement. The ultra violet (UV) stabilized agro-shade nets are ideal for regulating shade, which are available at varying shade intensities. Green or black colour is usually preferred.

Irrigation

Besides improving the humidity of the environment, application of water should also help in washing out the deposits of fertilizer residues which may otherwise be harmful to the plants. In summer, 2 irrigations are ideal. A heavy irrigation in the morning, followed by a dry period and a light irrigation in the late afternoon is

preferred. The dry spell checks disease incidence and spread. A high pressure-low volume method of irrigation, such as mist irrigation, or fogging system (micro-sprinkler) is ideal. The quality of water is also important. Water should have a near neutral pH and should be free from dissolved salts.

In both the locations mentioned, heavy rains prevail for a long spell. This not only reduces light incidence but also may cause diseases due to direct impact of rains. Providing shade-nets at 2 levels during summer to give the required shade and replacing the lower shade net during rainy seasons with UV film, is highly beneficial under such conditions. The UV film allows more light to penetrate and also protects the plants from direct rains.

HARVESTING AND POSTHARVEST MANAGEMENT

In most of the genera, orchids take more than a year to come to flowering, after planting out from the flasks. Medium-sized plants take about 6 months to start flowering. Initial spike is very small and these are preferably pinched off to improve the quality of spikes.

The spikes of orchids are harvested when a few buds on the top remain unopen. Under tropical conditions, harvesting during early morning or evening is preferred. Leaving a small length of the stalk, the spikes are cut using a sharp knife. Application of fungicides to the open wounds of the plant prevents possible infection.

Yield of spikes varies from genus to genus and variety to variety. On an average, 6-8 spikes are available from commercial varieties of Dendrobium. In Sonia 17, more number of spikes are produced in Kerala. For a period of 2-3 months with the onset of south-west monsoon, there is a decline in flowering in most of the varieties.

The harvested spikes, also known as stems, are immediately put in a bucket of water. The cut end is fully immersed. These are then taken to the packing house for grading and packing. The cut ends of the spikes are wrapped with wet cotton and tied with a rubber band. Alternatively, the cut ends are inserted into a plastic tube containing water.

Number of buds to be retained on the spike and grading vary in different places. It is usually 25-50% of the total flowers in a spike. In spikes producing larger number of flowers, as in Dendrobiums, those having less than 5 flowers are not usually preferred.

Boxes used for packing different types and grades of orchids vary in their size. Use strong cartons of adequate size for better handling of flowers. About 50 flower spikes are packed in a single box. It is desirable to keep the boxes in refrigerated trucks during transport. They are also to be stored in refrigerated rooms. A storage temperature below 7Â°C causes chilling injury to the flowers.

After reaching the destination, the flower spikes are carefully removed from cartons and placed in water. It is desirable to cut and remove a small portion of the base of the spike once in every 2 or 3 days to help better absorption of water. Usually no chemicals are used in the holding solution. However, use of 8-Hydroxy Quinoline Citrate (100-200ppm) with sucrose (3-5%) and boric acid (0.1%) improves the vase-life.

Pricing of spikes depends on the type of orchid and the grade of the spike. In Kerala, the cost of one Dendrobium spike ranges from Rs. 10 to Rs. 25, depending on the grade. For Oncidium and Vanda, the usual pricing is between Rs. 10 and 20.

At present most of the flowers produced in the country are fed to internal markets. There are agencies like societies and traders who arrange for collection of spikes at a reasonable price. These societies and traders in turn take the flowers to bigger traders who are located in certain major cities. The flowers are then passed on to wholesale agents in metroplitian cities who then dispose the flowers to retailers or consumers directly. Certain agencies also take up value addition by making floral arrangements and bouquets.

PHYSIOLOGICAL DISORDERS

Though orchids are perennial in their growth habit, sympodial orchids usually show a setback in growth after a period of 4-5 years. In Dendrobium the leaves shed and the canes appear bare. Flowering is also very shy. This physiological setback is recovered if repotted. Application of a high concentration (5,000-10,000ppm) of an auxin also helps.

At times, some of the buds do not open, which may also result from high fluctuation in humidity that is experienced in summer months. Wetting the floor (not the plants) during noon time checks this. Occasional wilting of certain flowers on the spikes could be due to loss of pollen, sometimes caused by insects. Shedding of pollinia could also happen during transport.

Certain defects are inherent and genetic. Yellow streaks on the leaves are found due to mutations. Stunted plants, malformed leaves and ill developed spikes also appear due to genetic changes, occurring sometimes due to unscientific tissue culture techniques and conditions. It is necessary to remove and destroy such plants.

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