Planting material production technology in vegetatively propagated perennial spice crops - black pepper, nutmeg, cinnamon, cambodge and tamarind

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Introduction

Now a days, spices sector is gaining overwhelming response from Indian farmers for being one of the agriculture sectors wherein assured profit could be achieved in most of the crops. Attracted by high return, low management requirements and agro climatic suitability, the area under perennial spice crops especially nutmeg has registered an increasing trend during the last pentinnium in South India.

Perennial spices such as black pepper, nutmeg, cinnamon, cambodge and tamarind are integral part of our life and consumed one or the other way in daily life. Area and production of these spices during 2013-14 were 123,810 ha and 50,870 t; 18,900 ha and 12,780 t; 330 ha and 50 t; 58,590 ha and 188,130 t; 58,720 ha and 191,750 t, respectively, except cambodge for which official data on area and production are not available. Concentration of these spices is mainly in Western Ghats and adjoining areas and to some extent in Eastern Ghats and North Eastern hill regions. Non-availability of adequate quality planting material is always felt as one of the important production constraints in these spices. Vegetative propagation is much preferred compared to seed due to segregation of seedlings, long gestation period etc. In this paper the planting material production techniques of the above mentioned spices are discussed.

1. BLACK PEPPER

Black pepper (*Piper nigrum* L.) is a climbing vine, which requires support to trail. The climbing shoot is called 'main shoot' or 'leader shoot', botanically 'orthotrope', have long internodes; the side branches grown from main shoot are 'laterals', botanically 'plagiotrope', have shorter internodes which bears the spike. The buds present in the base of the main shoot will sprout and creep on the ground (if it is not trained to grow erect along the support) and are called 'runners' which are commercially used for the production of planting material (2 or 3 node cuttings) in India and elsewhere. The 'terminal shoot' or 'top shoot' with a few laterals also serve as planting material. The advantage of using this as planting material is that it will have laterals while planting itself compared to cuttings made from runners wherein laterals will be produced only after 12 to 18 months of planting. This method of production of planting material is common in Malaysia, Indonesia and Vietnam. A few terminal shoots may branch out and hang and such shoots are called 'hanging shoots' which are not used for planting material production. When 'laterals' or 'side branches' are used for production of planting material, the resultant plant will not be a vine, it will grow as a bush and is called 'bush pepper'.

Black pepper can be propagated through seeds as well. Seed propagation is not in vogue due to heterozygous nature of crop. Plants produced from seeds take more than five years for first bearing, whereas, vegetative cuttings produce first spike during second or third year of planting.

Conventional method

Runners from pre-selected healthy mother plants of regular high yielders are kept coiled on wooden pegs fixed at the base of vines to prevent the nodes to contact with soil. Runners are collected in Feb-March, cut into two or three node cuttings that are planted either in sand beds or polythene bags filled with potting mixture after trimming the leaves. Farmers also use orthotropic top shoots for planting as it establish quickly and flower early, however, it may be difficult to get the same in large number. The cuttings are kept in protected place under shade to maintain a humid and cool atmosphere. Regular irrigation with rose can or sprinklers are also essential. The cuttings will produce new sprouts within 3-4 weeks of planting and are ready for field planting in May-June with sufficient roots and 4-5 leaves. Senanayke and Kirthisinghe (1983) found that pepper cuttings under 50 per cent shade and irrigation every 3 days produced longest shoots, had the highest number of roots, largest leaf area and the greatest dry weight at 95 days after planting. The next best treatment was 35 per cent shade with daily irrigation. Hegde (1983) observed that three node cuttings of Panniyur 1 pepper vine rooted better than 1 or 2 noded cuttings. Seneviratne *et al.* (1985) reported that Panniyur 1 cuttings produced longest shoots with larger leaf, better rooting and high dry weight of roots and 3 - 4 leaves under 50 per cent and 75 per cent shade at 84 days after planting. Mathai *et al.* (1974) observed maximum sprouting of 75 per cent when cuttings were planted in June. However, increased sprouting and rooting were noticed when planting was done from March and June. Datta *et al.* (2003) reported that the second fortnight of March was the ideal time for propagation of black pepper through runner vine cutting in Teri zone of West Bengal.

Rooting media

Rooting media play an important role in establishment of cuttings. In general, soil, sand and FYM/Compost in 2:1:1 ratio is recommended. However, researchers found that either single or combinations of different component would serve as potting media. FYM, sand, soil (1:1:1) and soil + leaf mold (7:3) were reported to give better rooting (Yufdi and Hayani, 1991). Rooting percentage of 90-100 was reported in medium consisting of perlite + sand mixture (Mustafayeva, 1985). Sridhar *et al.* (1989) reported that the highest rooting percentage was obtained with sand. Potting mixture with vermicompost produced taller cuttings and had more number of leaves (Thankamani *et al.,* 1996). Kandiannan *et al.* (2000) reported that combined inoculation of biofertilizers with potting mixture enhanced the growth of cuttings. A medium consisting of coir pith compost, granite powder and FYM in 2:1:1 proportion with Azospirillum and Phosphobacteria has been recommended for the production of vigorous rooted cuttings in places where sand is scarce (Thankamani *et al.*, 2007a). Miniraj *et al* (2014) reported better rooting and root characters in the medium coir pith compost+soil (0.25:1). Thankamani and Sreekala (2008) reported the beneficial effects of bio-control agents *Trichoderma harzianum*, *Pseudomonas fluorescens* and VAM (Vesicular Arbuscular Micorrhiza) in nursery. Potting mixture should be disinfected before planting the cuttings. Solar energy can be effectively utilized for solarization of potting mixture. For solarization, beds of 1 meter width, 20-30 cm height and convenient length may be prepared after removing the pebbles present in the soil surface. Adequate quantity of organic manure may be incorporated in the soil after digging and irrigate the beds at the rate of 5 l/m^2. The beds may be covered with polythene sheet of 300 gauge thickness. Edge of the sheet should be sealed with soil to keep it in position so as to maintain the required temperature. Adequate soil moisture is necessary during solarization to increase the thermal sensitivity of the target organism, to improve heat

conduction in the soil and to enable biological activity. Solarization should be done during March to May under Indian conditions when the solar radiation is most intense and the soil should be covered for 45 to 60 days. Solarized potting mixture in combination with nutrient solution consisting of urea, super phosphate, potash and magnesium sulphate in 4:3:2:1 produces vigorous rooted cuttings (Thankamani *et al.*, 2007b).

Growth regulator

In general, pepper cuttings are prepared from one year old shoots. The use of growth regulator would improve the rooting and establishment. Leite and Infrozato (1966) subjected softwood and hardwood cuttings to 15 h treatment by immersing their bases in distilled water or in 50 mg/l solution of either IAA or NAA and obtained the highest rooting of 62.5 per cent in NAA. Larcher (1970) observed that three node pepper cuttings dipped in 2 per cent IBA before planting improved rooting percentage; with respect to root number and root length compared to untreated cuttings. Choudhary and Phadnis (1971) obtained best result in rooting of leaf buds of pepper cuttings with Seradix B, IBA+ IAA at 25 or 50 ppm and IBA at 50 ppm. Pillai *et al.* (1982) indicated that the cuttings dipped in IBA solution (1000 ppm) for 45 seconds is the optimum treatment for early inducement and better development of roots in pepper cuttings. Aboa and Solidum (1991) reported that IAA at 150 ppm enhanced rooting in black pepper nodal cuttings. Sasikumar and Johnson (1992) found that single node cuttings planted in poly bags and kept in pits covered with poly sheets with frequent water sprays gave about 90 per cent rooting without any hormone treatment. Application of 25 per cent cattle urine gave the same effect as 2000 ppm IBA in terms of fresh and dry weights of roots and the number of roots per cutting (Superman *et al.*, 1990). Kandiannan *et al.* (1994) reviewed the uses of growth regulators in black pepper production and reported beneficial effects on establishment of cuttings. Sujatha (1997) obtained 90 per cent rooting in 2 node cuttings dipped in 1000 ppm IBA and kept in poly tent, with regular watering. Yufdy and Ernawati (1987) found that cuttings soaked in 25 per cent coconut water for 12 h increased shoot and root length, number of roots and shoot diameter of black pepper rooted cuttings. However, Sujatha *et al.* during 2004 noted that IBA had no positive influence on rooting of pepper. Miniraj *et al.* (2014) reported early sprouting along with better root and shoot characters when the cuttings were dipped in charcoal paste prior to planting.

Bamboo method of Rapid multiplication

In order to meet the large scale demand, a rapid multiplication method was developed and popularized and first demonstrated by Bavappa and Gurusinghe (1978), and later modified by Sivaraman, (1988). The cuttings from primary vines and runners had almost similar rooting ability. Single node cuttings taken from ground runners are multiplied under bamboo method would produce more cuttings for commercial planting. A suitable leveled area having good drainage is needed for rapid multiplication. Overhead shade may be provided by using 50 per cent shade net or with coconut leaves. The semi-permanent shed size may be 24 x 6 m (or suitable size). Four trenches of 30 cm wide, 45 cm deep and of convenient length may be taken. Trenches are filled with soil, sand and farmyard manure in 1:1:1 proportion. Bamboo poles of 8-10 cm diameter are selected and cut into 1.25-1.50 m long pieces and split into halves keeping the septa intact. Coal tar is smeared to prolong the life of bamboo splits. The split bamboos are arranged at an angle of 45° alternatively either side on straight wooden poles or strong supports fixed on small supports from ground and tied each other with coir rope at the free end. Rooted cuttings are planted in the trench, one for each bamboo split. As the cuttings start growing, bamboo should be filled with rooting mixture composed of farmyard manure, coir dust and sand in equal proportion. Each tender node is carefully tied to the bamboo using banana fibre, so that every node is in contact with the rooting medium. For rapid growth, daily irrigation through rose can is essential. Nutrient

solution consisting of urea (1 kg), super phosphate (0.75 kg), muriate of potash (0.5 kg) and magnesium sulphate (0.25 kg) in 250 litres of water may be used for drenching the vine once in a month with 250 ml/ plant. Alternatively, drenching the vines with cowdung solution once in a month also encourages plant growth in the nursery (Kandiannan *et al.*, 1998). When the vines reach the top of the bamboo, the tip should be nipped off and crushed the vine at the base at 3rd or 4th node from the ground, to activate the buds. After 7-10 days, the vines are cut at the crushed point and removed from the bamboo with the roots intact and with the adhering soil. The cut vines are separated into single nodded pieces. Plant each cutting in a polythene bag filled with potting mixture consisting of soil, sand and farmyard manure (1:1:1) or solarized soil enriched with biocontrol agents.

After planting in the bamboo, the first harvest of cuttings can be done after 3-3½ months and the subsequent harvest at every 2-2½ months. Each rooted vine can give about 10 cutting in one harvest and about 40 cuttings will be obtained in a year. Multiplication rate is 1:40. A shed of 24 x 6 m would accommodate 600 bamboo splits. On an average 20,000 cuttings can be produced annually by this method. The method is thus advantageous for producing a large number of rooted cuttings within a short period, throughout the year. The cuttings are also vigorous with good root system leading to more than 90 per cent establishment in the field.

Serpentine method

Another novel propagation technique in black pepper is the serpentine method (Thankamani *et al.*, 2004). The rooted cuttings kept in polythene bags are trailed horizontally and each node is pressed into the polythene bags with potting mixture arranged one after another with midribs of coconut leaves made into V" shape. Once twenty nodes get rooted in the bag, first 10 will be separated by cutting at the inter nodes. The cut ends will be pushed back into the potting mixture and kept in shade for further growth .The cuttings would be ready after three months for field planting. On an average, 60 cuttings will be obtained in a year by this method from each mother cutting. Serpentine method can be followed throughout the year, it is simple, cheap and quick and suited to small and marginal farmers. Recovery percentage is higher compared to rapid multiplication technique.

Pit method

Pit method for propagating black pepper utilizing single nodes of field grown vines was developed at IISR. A pit of 2x1x 0.5 m dimension is to be prepared under a cool shaded area. Single nodes having 8-10 cm length with their leaf intact taken from runner shoots of field grown vines are to be planted in polythene bags with a potting mixture having soil, sand and cow dung in 1:1:1 proportion. Care should be taken to keep the leaf axil above the potting mixture at the time of planting. Around 150 polythene bags can be accommodated in a pit of above size. Then the pit should be covered tightly with polythene sheet. Cuttings should be watered at least five times a day with rose can. Within three weeks, the cuttings will start producing roots. When rooting starts, watering may be reduced to three to four times a day. After one month, healthy shoots start emerging from the leaf axil. At this stage it is advisable to keep the pit open for about one hour per day so that the cutting will not suffer from any shock when they are taken out of pit. After two months of planting, the cutting can be taken from the pit and they can be kept in a shaded place and may be watered twice in a day. These cuttings will be ready for field planting after about another 2.5 months. By this method, 80-85 per cent success could be obtained. This method is simple, cheap and quick. Cuttings are ready to plant in the fields after about 4-4 ½ months compared to six months in bamboo method and well suited to small and marginal farmers. Since single node is used instead of three nodes in conventional method, more number of cuttings can be produced from unit length of runner. Pit method is not common.

Bed method

In this method, raised beds with height of 10 to 15 cm, 1.5 to 2.0 m width and convenient length can be made in suitable medium (coir compost and vermicompost at 3:1 ratio) under protected polyhouse (Anandaraj *et al.*, 2014). The bed has to be treated with bio-control agents like *Trichoderma* spp. The cuttings are planted one side (width side) of the bed and vines are allowed to creep on the bed so that each node strikes root and when it reaches the end of the bed, entire strip is harvested and each node with a leaf and root are separated individually and planted in protray or ploy bags for further establishment. The separation of each node could be done when the entire vine is trailing on the bed. After a week when the bud is activated, it can be taken out and planted in protrays.

Vertical column method

The continuous demand for quality planting material created a novel idea of producing orthotrope on vertical 2m column having one foot diameter made with half an inch plastic coated welded wire mesh filled with composted pasteurized coco peat and vermicompost @ 3:1 ratio fortified with bio-control agent *T. harzianum* in hi-tech poly house of fan and pad system with temperature of 25 to 28^{0}C and relative humidity 75 to 80 per cent. Eight to ten cuttings can be planted around each vertical column. The cuttings are allowed to trail on the column and it takes four to five months to reach the top and produce more than 20 nodes. Each vine invariably produce laterals (plagiotropic branches) within four to five months time at 12thto15th node, whereas, vines allowed to grow horizontally on the bed with same medium also produce similar number of nodes but will not produce plagiotropic branch. The advantage of vertical column method is that three types of cuttings *i.e.*, normal single node cuttings, top shoots with lateral branch and laterals (plagiotropes) for making bush pepper can be produced (Anandaraj *et al.*, 2014).

Trellis method of Rapid multiplication

Comparatively open areas are good for this method. Take trenches of 30 cm width and 50cm depth and fill with dried and powdered farm yard manure and top soil. Plant rooted cuttings at closer spacing. Irrigate regularly. After the cuttings are established, give NPK@10:5:5. Trail the vines on wire trellis erected at 45-50^0 slope. As they grow further, tie the vines to the trellis. Vines planted in June will grow to a length of 2m by February by which time they can be cut retaining 3-4 nodes. The vines will again sprout and continue to give cuttings. The vines thus obtained are cut into 2-3 noded pieces and kept for rooting (Sujatha and Nybe, 2012).

Bush pepper

Bush pepper is becoming popular now a days in homestead farming and urban horticulture. Scarcity of labour for harvesting is another factor which has prompted farmers to go for intercropping of coconut and other perennial plantation crops with bush pepper. Lateral branches are used for bush pepper production. One year old laterals with 4-5 nodes are planted in poly bags filled with potting mixture and kept in mist chamber for rooting. Leaf blades on the cuttings are half cut before planting. Rooting is slow in bush pepper, which may take 2-3 months after which the cuttings are shifted from mist chamber to shade net house. After one month they can be used for planting. Bush pepper can also be made by grafting lateral shoots on *P. colubrinum*. Bush pepper starts yielding from first year onwards. When grown in the field as inter crop in coconut, spacing of 2m x 2m is to be provided which will accommodate 2500 plants/ha. Studies at Kerala Agricultural University has shown that varieties P 2, P 5 and Pournami are good yielders as bush pepper in coconut plantation (Sujatha and Nybe, 2012).

Grafting

In areas where there is water logging and incidence of foot rot (*Phytophthora capsici*) as in Kerala and Assam, grafts on *P. colubrinum* rootstock has been recommended. *P. colubrinum* is a marshy species resistant to *Phytophthora capsici. When P. nigrum* is grafted on to *P. colubrinum,* the resultant graft is found to escape the *Phytophthora* infection through roots. The growth of plant will also be vigorous on *P. colubrinum. P. colubrinum* cuttings are raised in polybags and six month old cuttings can be used as rootstocks for grafting. Scion is taken from healthy bearing vines and grafted by cleft/wedge method with slight modification. Success of grafting is 90-95 per cent. After two months, grafts can be planted in the main field. *P. colubrinum* can also be planted directly in the field and grafting done *in situ* on two to three shoots to get faster development of the bearing column. If anyone of the grafted shoots are damaged, the other shoots will compensate or even grafting can be done on fresh shoots. The same grafting technique can be used for making bush pepper for field planting as well as for poly house cultivation. Farmers are growing grafted pepper particularly in areca plantations in Karnataka. There are 10-15 year old grafted black pepper plantations in Kerala giving good yield.

In Brazil, there are reports that the resistant grafts died after 4th year (Alconero*et al.*, 1972) and in Sarawak, Malaysia, 'Kutching' grafted to resistant 'Balancotta' did not survive beyond the fruiting stage (Purseglove *et al.*, 1981).

Plant protection measures in the nursery

Maintenance of health and hygiene is of at most importance in black pepper nursery. Select only healthy and disease free mother vines for collection of runners and laterals. Make sure that the mother vines are not virus infected. Virus indexing before starting nursery can eliminate viruses to a great extent. Provision of good ventilation, adequate sunlight and drainage in the nursery is of prime importance as the activities are concentrated in the rainy season.

Solarisation of soil in the summer months followed by enriching the potting mixture with *Trichoderma harzianum* and *Pochonia chlamydospora* can take care of the soil born fungi and nematodes. The nursery should be sprayed with 2 per cent *Pseudomonas fluorescence* at weekly intervals as a prophylactic measure. One or two foliar applications of 1 per cent Bordeaux mixture can be given if required. Copper oxy chloride at 0.02 per cent may be used alternatively. Infestation of scales and mealy bugs are sometimes noticed in the nursery. Foliar application of Quinalphos 0 .05% will control these insects. If magnesium deficiency is noticed as interveinal chlorosis, spray 0.1% MgSO4.

Micro propagation

Micro propagation protocol has been standardized in black pepper . Techniques for direct and indirect organogenesis have been standardized (Shylaja and Nair,2000)).Shoot tip and eye bud explants were found to be the best explants for *in vitro* culture.MS medium with 10 ppm BA resulted in speedier establishment of cultures. Better rooting was observed in Knudson medium containing 5ppm NAA. A mixture of 1:1 V/V vermiculite and sand was found good for establishment of plantlets after sterilizing with 0.1% emisan. The TC derived black pepper plants successfully established in the field with more than 80% survival. High amount of somaclonal variation was reported from callus cultures.(Shylaja.,1996).

2. NUTMEG

Nutmeg (*Myristica fragrans* Houtt.) yields two spices *viz.*, nut and mace. Among the tree spices, it is a major and highly remunerative spice crop. In India, nutmeg is mostly cultivated in Kerala and parts of Karnataka, Tamil Nadu, Maharashtra, Andaman and Nicobar.

Nutmeg is an evergreen tree with dense foliage. It is usually dioecious, though occasionally male and female flowers are found on the same tree. Nutmeg being a strictly cross pollinated crop, plants differ in growth, vigour and yield. The height, spread, number of secondary branches, crown volume and crown surface area revealed the variability in nutmeg fruit yield positively (Haldankar *et al.*, 2004). Miniraj *et al.* (2014) have reported considerable variation among the genotypes with respect to growth and production in the nutmeg growing tracts of Kerala. Further, they also observed that, the range of fruit weight from 69.75 g to107.92 g, seed weight from 11.0 g to 15.0 g and mace weight from 2.13 g to 4.68 g under Kerala conditions. Since nutmeg and mace are of economical importance, elite trees possessing both these economic traits would help in increasing the productivity to a great extent.

Propagation

Nutmeg can be propagated by seeds as well as vegetative means. The percentage of success in the vegetative methods of propagation is between 38 to 80 per cent.

Propagation by seeds

The first step is to select high yielding female trees. A female tree in the age of 15-20 years yielding above 3000 fruits per year with a single dry kernel weight of above 10 g and single dry mace weight of 2 g can be considered as an elite tree. The seeds are collected from such regular bearing and high yielding trees during the peak period of fruit bearing (Flach, 1966).Tree split fruits are collected and seed separated from the fruit and mace. Seeds are to be sown immediately after extraction as the germination falls when sown three days after extraction. They can be preserved in moist sand or moss for 3-7 days in poly bags or other containers having suitable rooting medium (Madhusudhanan and Babu,1994; Gunasekaran *et al.*, 2000).

Small and immature seeds have low germination (Shanugavelu and Rao, 1977). Seeds may be sown in nursery beds, baskets, ploythene bags or other containers having suitable rooting medium (Krishnamoorthy, 1987). Seed germination will begin after about four weeks and maximum germination could be seen between 50 to 80 days (Kannan, 1971a). A higher percentage of germination was observed in nuts collected from female trees growing nearer to male trees (Perrl, 1938).

Seeds treated with 200 ppm gibberellic acid recorded 75 per cent germination (KAU, 2001) while, seed treatment with thiourea recorded 88.28 per cent germination (Haldankar *et al.*, 2007). In a study on germination of nutmeg seeds at Dapoli, Maharashtra, higher germination percentage was recorded in seeds sown in rice bran (82.3%) followed by sand (82%) and sand+rice bran (81.7%). Same medium also recorded minimum time for the first emergence. In rice bran, sand+rice bran and sand, emergence started at 21.17 days, 28.10 days and 28.50 days respectively (Khandekar *et al.*, 2006). Abirami *et al.* (2010) studied seed germination and seedling growth in nutmeg using the different media. The potting mixture, soil: sand: coir dust: vermicompost in a ratio of 1:1:1:1 gave better results and also, that supports seed germination and seedling growth in nutmeg. Sprouted seeds are transplanted immediately to polythene bags since delay may cause damage to root system (Krishnamoorthy, 1987); they are potted and allowed to remain in the pots for about 12 to 18 months prior to planting in the main field.

Variation exists among the nutmeg genotypes for germination (Haldankar *et al.*, 2005).The variations recorded for germination percentage, period required for germination and seedling growth parameters were significant. The selection traits of nutmeg genotypes at seedling stage on the basis of vigour of number, length and breadth of leaves, collar thickness and petiole length would help to identify genotypes for propagation .

Seed nursery

Miniraj *et al.* (2012) have given the seed nursery techniques to be followed in nutmeg. Select a shady area for nursery. Raised nursery beds of about one meter width and convenient length are taken. Apply well decomposed and powdered cattle manure and sand and mix well with the soil. Sow the seeds shallow about 2cm deep with the flat portion facing down. Cover thinly with sand and mulch with leaves. Irrigate daily, seeds sprout in 45 days and germination may extend up to 60-80 days. At the needle stage (before unfurling of leaves) the sprouts are transferred to poly bags filled with potting mixture. The grown up seedling at appropriate stage can be used for planting in the main field or for vegetative propagation. The seedlings will segregate into male and female at varying proportions. Research to determine the sex at the seedling stage has not yielded conclusive results so far.

Vegetative propagation

Vegetative propagation has got the advantage of overcoming the dioecy problem in nutmeg and thus to considerably reduce the pre bearing period. Due to the cross pollinated nature of the crop; it also helps in the multiplication of superior types. For these reasons, clonal propagation has become popular now a days.

Cuttings

Very little work has been done on rooting of cutting in nutmeg. In earlier study, Nichols and Pryde (1958); Nichols and Cruickshak (1964) have reported rooting of semi-hardwood cuttings to be successful in Trinidad and Grenada. However, these rooted cuttings failed to establish after the field planting.

Reports from Wageningen on rooting of cuttings in a poly house with mist humidifier were also not positive (Flach, 1966). The high amount of tannins and phenolic compounds present in the stem may probably hinder root formation. No reports are available on this aspect from India; there is great scope for further studies on production of adventitious roots in nutmeg by manipulation of these factors.

Air layering

In New Guinea, about 60 per cent rooting was reported in a period of six months but the rooted layers failed to sustain in the filed (Deinum, 1949). A very low rate of success of 8.5 per cent was reported by Nichols and Cruickshank (1964) in Grenada.

Budding

Budding is the most popular method of vegetative propagation in nutmeg. Rootstocks other than *M. fragrans* have been used for budding in nutmeg. *M. beddomei*, *M. malabarica* and *M. succedanea* were used as rootstocks for *M. fragrans* and a success of 26 per cent was obtained on *M. succedanea* (Postma, 1935). *M. fragrance, M. beddomei* and *M. malabarica* are used as rootstocks in Kerala with varying degrees of success. Budded plants on *M. beddomei* exhibit enlargement below the bud union at later stages. Even though the wild rootstocks possess capacity to withstand water stress and heavy winds, their performance is not uniformly good at different locations and hence Kerala Agricultural University recommends *M. fragrans* as the ideal rootstock for nutmeg (Miniraj *et al.*, 2014). In a study at IISR, Kozhikode, *M. malabarica* exhibited relative tolerance to water stress and *M. fragrans* and *Gnema canerica* appeared as drought susceptible(Krishnamurthy *et al.*, 2006).

Nursery budding

Both patch budding and forket budding are commercially adopted in nursery budding of nutmeg. Budding is done at the green as well as brown stage of the bud stick. Beena (1994) has reported maximum success of 66.66 per cent with forket budding on *M. fragrans* and *M. beddomei* rootstocks during the month of December. In another study, both brown and green patch budding gave high success percentage on various rootstocks. Maximum success was for green budding on *M. beddomei* (70%) followed by brown budding on *M. beddomei* (60%) (Lissamma *et al.*, 2012).

The technique of budding standardized at Kerala Agricultural University is as follows: Healthy seedlings of 8 months to two years can be used for budding. Take straight shoot bud sticks from elite mother trees; separate the bud carefully without any bruises. Remove carefully a slightly larger patch of skin from the rootstock and do the budding. Both the rootstock and scion should be in the active growing stage and the budding is to be done immediately after the separation of the bud wood. Bud wood taken from the apical region of the tree will be more vigorous (Miniraj *et al.*, 2012).In the case of green budding, the leaf supporting the bud can be retained on the bud patch for easiness in the budding process. The bud union is fastened with polythene ribbon and the plants are kept under shade under good care and management. Success of bud union can be ascertained after 45 days after which the rootstock is bended down above the bud union for facilitating early bud sprouting. After sprouting, the rootstock is cut above the bud union. The sprouts after reaching single tier stage are ready for field planting. Best season for budding in Kerala is July to September. In summer the success is below 25%.

Field budding

In situ budding standardized by Kerala Agricultural University, is now being followed by nutmeg farmers, to solve the problem of dioecy and the long juvenile phase. Forket method of budding is done on brown trunk above the first whorl of branches (Beena, 1994) on 2-5 year old seedlings in the field. Best season for *in situ* budding is July with about 30 to 50 per cent success. Budding on brown trunk could be done with maximum success in three year old plants followed by four year old ones. As the age advances, per cent of sprouting reduced. Sprouting percentage was maximum in 3 to 5 years aged plants. Field budded plants grow fast primarily because of their well developed root system. It has also been observed that retaining a branch of the rootstock (which happens to be male plants) for production of male flowers is good for improving the fruit set.

Grafting

Various grafting techniques like approach grafting, soft wood grafting and epicotyl grafting are successful in nutmeg.

Epicotyl grafting

Epicotyl grating is the most widely adopted propagation technique in nutmeg (Mathew and Joseph, 1982). Epicotyl grating is being done on *M. fragrans* (Krishnamoorthy and Mathew, 1985) and also on wild species, *M. beddomei* and *M. malabarica* (Mathew and Joseph, 1982). However, *M. fragrans* was found to be the most ideal rootstock. Though grafting could be carried out during all the seasons, on *M. fragrans*, the best result of 80 per cent success was recorded during the month of August in 20 to 30 days old seedlings (Krishnamoorthy and Mathew, 1985). Prior defoliation is not a prerequisite for this technique in nutmeg. It is essential to provide a cover of polybag on scion stick especially in non rainy season, whereas it is not essential when high humidity prevails (July). The location of scion stick did not influence the success of epicotyl grafting. September was found to be the most favourable season for epicotyl grafting in nutmeg (Haldankar *et al.*, 1999a).

In Maharashtra, Karnataka and in some parts of Kerala, epicotyl grafts are produced using plagiotropic or side shoots. These grafts are slow growing during the initial years and will be bushy in appearance. Special training would be required to get canopy development in these grafts. The only advantage of these grafts is the short stature which facilitates easy harvest and other cultural operations. However, on a commercial scale side grafts are not desirable.

Softwood grafting

Softwood grafting is practiced in nutmeg in Maharashtra. It was revealed that the month of May will be best for softwood grafting with maximum success (80 %) followed by June (54 %) and July (50 %). The medium matured to fully matured scion sticks of 4 to 6 months old were preferred for softwood grafting. Retention of one terminal leaf on the scion sticks recorded 75 per cent success. Prior defoliation of scion sticks, except the terminal leaf, for apical bud swelling was advantageous and recorded 70 per cent success. The retention of the leaves on rootstocks did not influence the success of softwood grafting (Haldankar *et al.*, 1997).

The success in softwood grafting differs according to the scion variety. The variation among genotypes for sprouting, survival and growth parameters was statistically significant. The graft survival has strong negative correlation with leaf width. Maximum graft sprouting was associated with faster production of new leaves with less breadth and longer petiole (Haldankar *et al.*, 2003). Very little studies have been conducted to understand the influence of rootstock on the performance of grafts. Khandekar *et al.* (2006) studied softwood grafting in nutmeg to find out best time (month) for sprouting, survival and growth of grafts. Maximum sprouting was recorded in July and August months followed by June.

Approach grafting

The approach grafts on nutmeg can be prepared through out the year. High percentage of graft take was recorded on both, cultivated nutmeg (*M. fragrans*) rootstock (40 to 90 %) and wild nutmeg (*M. malabarica*) rootstock (30 to 100%). The mortality after separation of the grafts was high as 30 per cent on cultivated nutmeg stock and 50 per cent on wild nutmeg stock (Haldankar *et al.*, 1999b). In Kerala too, approach grafting is practiced by a few progressive farmers to multiply their elite trees.

Production of orthotropic scions

Nutmeg tree exhibits branch dimorphism. The tree produces two different types of shoots. The straight growing orthotropic shoots or the vegetative shoots and the side growing plagiotropic shoots or the fruiting branches. The tree has a tendency to produce large number of plagiotropic shoots and very few number of orthotropic shoots. Attempts to induce orthotrops in nutmeg by physical as well as chemical treatments have not yielded positive results. Unavailability of sufficient orthotropic shoots is a major limiting factor in budding/grafting of nutmeg. Raising a close planted scion bank will ensure steady supply of straight shoot bud sticks year round (Miniraj *et al*, 2012). Rema *et al.* (2008) applied different measures to induce orthotropic shoots from plagiotropic grafts, it was observed that the frequency of occurrence of orthotropic shoot was low and is very cumbersome. In certain cases, production of orthotropic shoots was observed from plagiotropic grafts of 7-10 year old. As this phenomenon is rare, this cannot be a confirmatory method for converting the graft architecture.

Top working

Identification of sex in the seedling stage in nutmeg is not possible with the available information. The sex of the trees can be identified only after 6-7 years when they start flowering. Generally,

male and female trees are produced in 1:1 ratio. Since one male tree is sufficient for every 10 female trees for pollination, the rest of the male trees available in the plantation can be made productive by converting them to female trees by top working. Top working can be done by budding (Beena and Kurian, 1996) or by grafting (NRCS, 1990). The top worked trees yield from the third year onwards. One or two branches of the female trees can also be top worked with male scions so as to avoid planting of male trees. Unproductive female trees can also be made productive by top working. Trials on topping of male trees indicated that cutting the trees above the first tier during August was found to be the best with regard to sprout production and reducing the time for sprouting. Successful graft union was obtained by wedge grafting during March with scion shoots having mature leaf and full green stem and stock having two months growth (Rema *et al.,* 2000; Rema *et al.,* 2009).

Micropropagation

Micropropagation of nutmeg would be an ideal method for rapid propagation of male or female trees. *In vitro* experiments are in progress at IISR, Calicut, Kerala Agricultural University, Vellanikkara and Indian Cardamom Research Institute (ICRI), Myladumpara to develop protocols for multiplication of nutmeg. Nutmeg is highly recalcitrant to tissue culture especially owing to the heavy leaching of phenolics and literature on its *in vitro* propagation is scanty. Direct somatic embryogenesis was achieved in leaf explants of juvenile plants and also from intact and fragmented zygotic embryos in MS media with kinetin, 2,4-D, NAA and activated charcoal 0.3-0.5% (Iyer *et al.,* 2000; Iyer, 2007; Iyer *et al.,* 2009). AM medium at half strength of major nutrients and full strength of micronutrients with a hormonal combination of BAP,NAA and 2,4,D at 1mg/l and 0.5 mg/l respectively was found to the best for initial culture establishment of seedling explants. Phloroglucinal (40mg/l) in combination with IBA (2mg/l) gave superior results in the induction of roots in established shoot tip cultures (KAU, 2001). Micro grafting using *in vitro* produced shoots as scion and two month old *invitro* or *invivo* seedling as root stock was found successful in nutmeg (KAU, 2001).

3. CINNAMON

Cinnamon (*Cinnamomum verum* Bercht. & Presl.) is the oldest known spice by man. It is also known as 'Ceylon cinnamon' or 'true cinnamon'. The true cinnamon is a native of Sri Lanka and was introduced in to India by the British in the 18th century. Sri Lanka produces the largest quantity and the best quality of quills of true cinnamon. *C. verum* is a moderately sized, bushy, evergreen tree growing up to 18 m tall, low branching, trunk stout up to 60 cm diameter; bark thin pale brown, up to10 cm thick and strongly aromatic.

Cinnamon is a cross pollinated crop (Joseph, 1981) and wide variability has been observed in yield (Ponnuswami *et al.,* 1982; Krishnamoorthy *et al.*, 1992), quality of produce (Krishnamoorthy *et al.,* 1988), oil content (Krishnamoorthy *et al.,* 1991; Paul and Sahoo, 1993) and other morphological characters in the seedling progenies (Krishnamoorthy *et al.*, 1992). Being a cross pollinated crop, vegetative propagation is necessary for producing homozygous high yielding population and for propagation of elite lines. Cinnamon could be propagated easily through cuttings and layering. No other conventional method of vegetative propagation has been reported in cinnamon.

Propagation

Cinnamon can be propagated from seeds and cuttings of young three leaved shoots. However, propagation by seeds is easier and is the most common practice even though it is not advisable due to the heterozygous nature of the tree.

Ripe seeds are collected from mother plants with desired characteristics such as:

1. Erect stem with smooth bark
2. Vigorous growth
3. Ease of peeling the stem bark
4. Resistance towards pests and diseases
5. Chemical composition of the oil (viz., high oil content of the bark and leaves and desired chemical characteristics of oil)

Propagation by seeds

Common method of cinnamon propagation is through seeds (Joseph, 1981). Seeds are extracted from ripe fruits from the selected mother trees with desirable characters. Seeds are sown immediately after collection, otherwise viability gets reduced. Seeds are sown in nursery beds or in pots filled with a mixture of sand, cattle manure and soil in the ratio 2:2:1. Kannan and Balakrishnan (1967) obtained the maximum germination percentage (94) by sowing seeds on the third day after harvesting. After 40 days, there was complete loss of viability. Under normal conditions, seeds germinate within 20 days (Krishnamoorthy and Rema, 1988). Seeds may be sown in rows of 12 cm apart in nursery beds and covered with thin layer of soil. Radhakrishnan (1992) observed that July to August will be the best time for sowing. Beds may be watered and shade should be provided during early stages. From beds, seedlings are transplanted to polythene bags when they reached the height of 15 cm. Polythene bags of 30 cm x 15 cm size filled with soil, farm yard manure and sand (3:3:1) are used (Krishnamoorthy and Rema, 1988).

Vegetative propagation

In cinnamon, cutting and air layering are commonly practiced methods of vegetative propagation.

Cutting

As the crop produces abundant adventitious roots, single nodded cuttings with 1 or 2 leaves could produce roots within 40 days under humid conditions (CPCRI, 1985). Rooting can be enhanced by the use of growth regulators. Rema and Krishnamoorthy (1993) reported that IBA and IAA @ 2000 ppm were effective for rooting of terminal shoots with 73 and 65 per cent success, respectively. Softwood cuttings treated with NAA 500 ppm resulted in 22.5 per cent rooting whereas hardwood cuttings treated with IBA 2500 ppm resulted in 45 per cent rooting (Vadivel *et al.,* 1981). The rooting could be further increased by hormonal treatment of the etiolated cuttings. Etiolated cuttings treated with IAA 200 ppm resulted in 82 per cent success (NRCS, 1990). Wide variability exists in the rooting response of various cinnamon lines (Rema and Krishnamoorthy, 1993). Variation in rooting during different seasons and among different lines could be associated with the endogenous level of auxins, reducing and non reducing sugars, nitrogen, carbohydrate, C:N ratio, phenols, etc (Purushotham *et al.,* 1986; IISR, 1996). Nageswari*et al.* (2000) found 50 per cent rooting when hard and semi-hard wood cuttings were treated with IAA 100 ppm, while Ananthan and Chezhiyan (2002) reported 82.6% rooting of hard wood cuttings with NAA at 2500 ppm.

Air layering

Semi-hardwood cutting was found to be ideal for air layering in cinnamon (Ranaware *et al.,* 1994; Rema and Krishnamoorthy, 1993). Air layering of cinnamon using gallic acid (100 ppm),

a phenolic compound, resulted in 80 per cent rooting (Banergee *et al.*, 1982). Rooting can also be obtained in non girdled shoots treated with NAA 2500 ppm or in combination with IBA 100 ppm (Bhat *et al.*, 1989). Application of IBA 3000 ppm resulted in 70 per cent rooting in semi hard-wood cuttings (NRCS, 1990). Girdling enhances physiological activity which is manifested by increased starch and IAA in the girdled region (Poll *et al.*, 1991).Various rooting material can be used for layering depending upon their availability and capacity to retain moisture. Evaluation of different rooting media for layering indicated that sphagnum moss was ideal (89 % success) followed by soil (Ranaware *et al.*, 1994). Seasonal variation was also observed in rooting of air layers. A rooting of 68 per cent was observed in July followed by 65 per cent in June in Maharashtra with no rooting during January and February (Ranaware *et al.*, 1995). Air layers treated with IBA 250 ppm registered 90 per cent rooting in the month of August (KAU, 2001). Rooting medium sphagnum moss was found better than sand and saw dust in equal proportions. According to Ananthan and Chezhiyan (2002a), IBA 4000 ppm registered maximum percentage of rooting and survival of cinnamon layers.

4. CAMBODGE (MALABAR TAMARIND)

The dried fruit rind of cambodge or Malabar tamarind (*Garcinia gummigutta*) is hard and dark brown in colour. It is rich in acids and possesses marked antiseptic properties. The principle acid in the fruits of Malabar tamarind is identified as (-) hydroxyl citric acid 51 to 55 per cent. Cambodge is a small to medium sized tree with round, hemispherical, conical or pyramidal crown with horizontal or drooping branches which are orthotropic and plagiotropic. The tree is dioecious exhibiting male and bisexual types. Cambodge is commonly propagated through seeds; seeds of cambodge are dormant and take a long time for germination.

Seed propagation

The seeds of cambodge or Malabar tamarind are recalcitrant and loose viability fast. They do not germinate once dried. This necessitates the collection of fresh seeds for immediate sowing. The fruits of Malabar tamarind ripe in June- July during the monsoon season, when seeds can be collected from the fruits. Collected seeds are washed and spread on a floor under a roof for 20 days and sown afterwards in bags (2 seeds/bag) or in beds. This is done in the months of August-September. The best way to keep seeds viable is to keep them in moist sand under shade and may be kept intact upto one year. Natural regeneration is quite common along the river banks because the seeds get protected by moist soil conditions. The seed remain dormant for about 8 to 9 months and take 10 months for germination. Seeds sown with seed coat intact and removal of seed coat is the best method compared to chemicals to get enhanced germination in 2-3 months time (Sara *et al.*, 2000). The author further reported good germination with GA_3 and 10 to 20 per cent poly-embryony but advised sowing in beds and transplanting at 2 leaf stage to avoid tap root injury.Seed dormancy is a major problem in cambodge. Joseph *et al.* (2007) reported that soaking cambodge seeds in hydrogen peroxide (30%) for 30 minutes was effective in breaking the dormancy.

The following seed treatments are recommended by Kerala Agricultural University for ensuring good seed germination.

1. Remove seed coat without injury to cotyledon and sow 3 cm deep. Germination starts in 20 to 25 days.
2. Remove seed coat, soak in GA_3 (250 ppm) for 6 min, as well as soak in macozeb (4 g/ litre) for 2 min and sow in bags, water daily, germination starts in 16 to 20 days.
3. Transfer seeds to a 20×25 cm size poly bag with 30-50 ml water. Tie the bag tight with air using rubber band. Keep for germination for 10 to 12 days. Sow germinated seeds in bags or beds. One bag will hold about 500 to 750 seeds.

Grafting

Softwood grafting is found best for propagation of Malabar tamarind (Haldankar *et al.*, 1993; Sara *et al.*, 2000) though the use of root suckers has been suggested (Shinde *et al.*, 2001). Bush habit will be useful for high density planting and back yard planting in kitchen garden. To achieve this, orthotropic shoots arising from the main stem (Sara *et al.*, 2000) or root suckers arising from the base of yielding tree may be used (Shinde *et al.*, 2001).

In Malabar tamarind, June to October is the best time for graft success coinciding with the humid period though grafting is possible throughout the year (Sara *et al.*, 2000). Three to four months old scion of 15 cm length of light green colour was found to be the best (Sara *et al.*, 2000) and neither pre curing nor covering scions with poly covers had any effect in graft success even in summer months under poly shed conditions (Mathew *et al.*, 2004). It is recommended to use primary branches with whorled leaf arrangement, 6 to 10 cm long and leaves partly removed as scion. The age of seedling suitable for grafting in Malabar tamarind is 12 month old (Sara *et al.*, 2000).

Top working of Malabar tamarind is suggested to convert non-bearing trees in which the trees are pruned in February- March and the newly emerging shoots are cleft grafted with scions from desired trees during rainy period (Sara *et al.*, 2000).

4. TAMARIND

Tamarind (*Tamarindus indica* L.) belonging to the family Fabaceae; is a native of tropical Africa. It is distributed throughout the tropical countries of the world with the highest population in India. Tamarind is a hardy tree; grows well under warm climatic conditions of tropical and subtropical countries.

Tamarind trees are generally raised on roadsides, in backyards or on the bunds of the field and in wastelands. In India, tamarind has been in commercial demand since long time. At present, the tamarind plantations available in the country are mostly seed propagated. Being a cross pollinated crop, it does not produce true to type plants, resulting in variation in size and quality of fruits. This necessitates the clonal propagation of elite trees. Various vegetative methods of propagation have been reported in tamarind and high yielding varieties are being distributed through these methods.

Propagation methods

Tamarind is generally propagated through seeds. It does not produce true to type, due to heterozygosity since the flowers are cross pollinated. Prolonged juvenile phase is one of the problems associated with tamarind propagation (Karle *et al.*, 1997). Therefore, vegetative propagation of superior genotypes is necessary for shortening juvenile phase, production of uniformly growing trees and to assure the quality of produce. Non conventional methods of propagation *viz.*, tissue culture techniques are also gaining momentum recently.

Seed propagation

Seeds should be collected from high yielding tree in March- April month. The petioles that hold the fruit to the tree are very strong and the pods should, therefore, be removed by clipping in order to avoid damage to the fruit (NAS, 1979). The pods should be dried in the sun and the seeds removed from the pulp manually. Seeds are washed and dried in the shade, stored in well-ventilated gunny bags or paper bags in a cool place.

The seeds are exalbuminous and consist of an outer hard brown testa. The seeds are normally sown directly in sand and germination commences within 5 to 10 days. The young plant grows best in porous soil in shade; very sensitive to frost. Generally, no pre treatment is found necessary for germinating the seed. Some *et al.* (1990) scarified seeds using 7 per cent H_2So_4, washed and dried, and then stored in sealed containers for 52 weeks at 4°C. The germination percentage after 20, 28 and 52 weeks was satisfactory, but showed little improvement over untreated seed (Some *et al.*, 1990). Seeds soaked in cow urine and cow dung solution increased germination (Sankararayanan *et al.*, 1994). At times the ends of the seeds are sliced off to enhance the germination.

Germination is found to be maximum in heavy seeds than light seeds due to rich nutrient contents in the former. Seedlings attain plantable size of 30 cm and above within three to four months. Seedlings are raised in the nursery and are transferred to deep bamboo or other deep containers. Two years old transplants are better than one year old.

The behaviour of tamarind seed is orthodox (Ridley, 1981; Hong *et al.*, 1996). Fresh seeds retain viability for at least six months when kept at ambient temperature in dry conditions. Under field conditions, viability is more than a year when the seeds are well dried, mixed with sand and kept in air tight containers. Seeds could be stored for several years in air tight packs at 10^0 C with 7 to 15 per cent moisture content (Hong *et al.*, 1996).

The germination of fresh or well preserved seed may vary from 65 to 75 per cent. In Malawi, seeds thoroughly cleaned and soaked in water overnight resulted in more than 80 per cent germination (Prins and Magehembe, 1994).

The best medium for seed germination is sand or soil mixed with cow dung. Chattopadhyay and Mohanta (1988) reported that seed germination could be encouraged by using cow dung and sand in the propagation medium. However, a nursery potting mixture containing three parts of top soil, one part of sand and one part of compost can be successfully used for germinating tamarind seed. Seeds may be sown in deep polythene nursery bags in order to accommodate the tap root without casing and distortion and abnormality.

Seedlings grow rapidly in the early stages and produce a long tap root which may attain 30 cm or more within two months of germination (Troup, 1921).

Vegetative propagation

Tamarind can be propagated vegetatively by many methods. Proven methods include stem cuttings, air layering, patch budding or grafting on to seedling rootstocks Vegetative propagation is preferable to seed propagation as seed propagation does not produce true to type progenies.

Propagation by cuttings

The easiest and cheapest method of propagating tamarind is by stem cuttings. Although vegetative propagation through rooting of stem cuttings was reported to be unsuccessful by Mascarenshas *et al.* (1987), a number of other reports have claimed an efficient response. Swaminath *et al.* (1990) developed an effective technique for propagation through mature stem cutting over middle or basal cuttings for rooting of tamarind. In mature stem cutting, IBA at 1000 ppm was found to enhance rooting in 10 to 15 days. Navaneetha *et al.* (1990) reported that semi hardwood cuttings produced 19.6 per cent rooting followed by softwood cuttings (11.25 %) with 1000 ppm IBA treatment and more than 48 per cent of them survived..

A technique using softwood terminal cuttings has been developed by Srivasuki *et al.*, (1990). Shoots bearing new flushes of fully turgid leaves are collected and immediately dipped for 10

seconds in 1000 ppm of indole butyric acid (IBA) and in 50 per cent isopropyl alcohol. They were planted in vermiculite/ perlite (1:1) and placed in a mist propagator with 70 to 80 per cent humidity. Use of IBA was found to increase the rooting besides reducing the time taken for root initiation.

Soft or semi soft stem cutting (15 to 20 cm) excised from 1 to 2 years old branches is rooted (Swaminath *et al.*, 1990). The cuttings are wrapped in moist cloth after removal from the tree and dipped in IBA (1000 ppm) and planted in a sand bed in a mist chamber. Buds and roots initiated after 20 days, leaves are formed after about 45 days. Softwood cuttings are better than semi hardwood and hardwood cuttings.

Air layering

Air layering or gootee method of propagation is successful in tamarind. Navaneetha *et al.* (1991) and Nachegowda (1997) reported the positive influence of hormone (IBA, NAA and IAA) treatment on rooting of layers. Navaneetha *et al.* (1991) used wet saw dust or coir fibre to cover the cut portion and then a polythene film was wrapped around the etiolation medium and tied on both ends by a string. As regards etiolation medium, saw dust proved superior to coir fibre. Root length and number was more in the beginning of the rainy season (mid-June to mid-July); lowest at the end of the rainy season (mid-September to mid-October). Hanamashetti and Sulikeri (1997) studied the genotypic response to air layering in tamarind. There was significant difference among the genotypes in respect of root parameters. The survival per cent of layers varied from 11.11 per cent to 100 per cent. Significantly high survival of layers was observed in NTI-60, 61, 31 and 15.

Studies by Duarte *et al.* (2002); revealed that air layering was the most suitable method for tamarind propagation. The effect of indolyl butyric acid and gibberellic acid on the root growth of tamarind seedlings was also proved in his trials. Patil (2004) studied the response of different genotypes to air layering in tamarind and found that the range of rooting varied from 16.66 to 60 per cent in different varieties.

Grafting

Different methods of grafting have been tried in tamarind with varying degrees of success.

Approach grafting

Approach grafting is a reliable method and up to 95 per cent success can be achieved (Swaminath and Ravindran, 1989). Nadagoudar and Basavanneppa (1997) found approach grafting as an ideal propagation method due to various advantages such as easiness, cost effectiveness and higher establishment rate. Seasonal influence on success of approach grafting has been reported by Biradar (2001). Higher per cent of graft success was recorded during second fortnight of June (88.88%) followed by second fortnight of May (77.77%) and first fortnight of November.

Veneer grafting

Veneer grafts are made 8 cm high on the rootstock and immediately after the stock is cut above the graft union. This method is reported to give about 50 per cent success (Amin, 1978; Purushotham and Rao, 1990).

Softwood grafting

Softwood grafting was shown to be the best grafting method in terms of successful union and survival rates (Navaneetha *et al.*, 1990). The age of rootstock is important for success. Scions pre conditioned for 30 days prior to grafting on to 6 and 9 months old rootstocks resulted in 69 to 72

per cent success at 60 days. Grafting success has been attributed to the fact that rootstock of this age contain a higher proportion of reducing sugars to total sugars than at other ages (Karale *et al.*, 1997; Satisha *et al.*, 1997). Karale *et al.* (1997) concluded that softwood grafting in March- April on to 8 months old seedlings of 22 to 32 cm height and 0.3 to 0.4 cm diameter was highly successful. Similar results were also observed by Sathisha *et al.* (1997).

Age and maturity of rootstock on success of softwood grafting has been reported by Biradar (2001). Higher per cent of sprouting (93.33%) was recorded when grafting was done on six months old rootstock followed by 5 months old rootstock (43.33%). Patil (2004) studied the age of rootstock for softwood grafting. Higher per cent of success and survival was noticed in soft-wood grafting done at the age of 7, 8 and 9 months old rootstocks.

Giri and Lenka (2007) standardized the suitable time for softwood grafting in tamarind. The highest percentage of success was found in August (73.66%) followed by June (69.00%). Palande *et al.* (2005) studied softwood grafting at monthly intervals under Rahuri, Maharashtra conditions. Results revealed that maximum success and growth were obtained when grafting was conducted in May-June and October using 8- to 10-cm long scions.

In Thailand, a dwarf rootstock has been identified for tamarind based on morphological characteristics, such as internode length and leaf area. These characters were correlated with the number of stomata on the leaves. An attempt to reduce canopy size by intergeneric grafting on other leguminous species has not been successful.

Cleft grafting

In green wood cleft grafting studies, Nachegowda (1997) found that grafting during May recorded maximum graft success (80%) followed by April (76.7%) and June (70%) and least success was in February month of grafting (26.7%). This technique can be very well adopted for the large scale multiplication of tamarind clones. Shinde *et al.* (1997) claimed to have produced thousands of using wedge grafting which were made available to the farmers.

Patch budding

Pathak *et al.* (1991) reported success in patch budding (96%) and modified ring budding (94%). Singh and Singh (2007) studied patch budding and soft-wood grafting round the year to standardize method and time of propagation in tamarind. Among the two methods of propagation, patch budding in the month of July-August and soft wood grafting in the month of April-May may be adopted for multiplication of elite tamarind genotypes.

CONCLUSION

Perennial spice crops such as black pepper, nutmeg, cinnamon, camboge and tamarind can be propagated by seeds as well as by vegetative methods. The best method suited to each crop and region may be chosen depending on the multiplication rate, cost effectiveness, skilled labour availability, uniformity in the field establishment, pre-bearing period, etc.,. Maintaining pest and disease free mother gardens for collecting cuttings or scion is important. Potting mixture is important for any nursery, the composition may vary with availability of components such as compost, FYM, coirdust, soil, sand etc.,. Good media should free from pest and pathogen, support young plants in nursery with adequate nutrients, moisture and anchor for good growth. Quality planting material is very essential for successful establishment of plantations and accredited nursery would ensure the quality. All those who involved both government and private in the value chain should put earnest effort to produce and supply high quality material by using efficient production techniques.

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