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Vegetative Propagation and Rootstock for Nutmeg: A Review

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ABSTRACT

Nutmeg (*Myristica fragrans* Houtt.) is an important perennial spices of dioecious nature. Seed propagation leads to segregation into males and females in a ratio of 1:1. The unpredictability of nutmeg sex during the seedling stage drives vegetative propagation, which is the only viable method for commercial multiplication and conservation of elite genotypes. Many vegetative propagation methods like stem cuttings, approach grafting, epicotyl grafting, softwood grafting, patch budding, forket budding, *in situ* budding, air layering and top working, have been tried in nutmeg with varying degrees of success. Three species *viz*., *M. fragrans, M. beddomei* and *M. malabarica* are widely used as rootstocks for vegetative propagation. Research findings showed that the performance of nutmeg trees budded on self-rootstock (*Myristica fragrans*) is superior to that of plants budded on wild rootstocks in terms of growth and yield performance, irrespective of location and altitude. In this paper reviewed the nursery activities, propagation methods, establishment of budwood nursery and ideal rootstock for nutmeg. This reviews also guide researchers on the present condition in nutmeg propagation and scope for refinement in the techniques.

Key words: Dioecy, Nutmeg, Seed propagation, Vegetative propagation, Wild root stocks.

Nutmeg (*Myristica fragrans* Houtt.), a member of the Myristicaceae family, is an evergreen aromatic tree spice yielding two distinct spices, nut and mace, both spices having enormous potential in industrial applications. Nutmeg is indigenous to the Moluccas Islands of Indonesia (Vikram *et al.,* 2022). The present area under nutmeg cultivation in India is about 23,353 hectares, with an annual production of 18,429 tonnes (Spice Board, 2022). In India, it is cultivated throughout Kerala, some parts of Karnataka, Tamil Nadu, Goa and Maharashtra. In Kerala, nutmeg is grown in an area of 22,152 ha with annual production of 17,435 tonnes. Thrissur and Ernakulum districts account for 31.46 per cent and 30.35 per cent of Kerala's total nutmeg growing area, respectively. Over the past decade, nutmeg cultivation in Kerala has increased by 29 per cent in area and 53 per cent in production (Department of Economics and Statistics, Government of Kerala, 2022). Among the tree spices cultivated in Kerala, nutmeg is a high-value crop in domestic and international trade. To increase the production and productivity of nutmeg, the area should be expanded into traditional and non-traditional areas by planting superior planting materials of high-yielding varieties and adopting improved agro-techniques. The farmers have become highly dependent on commercial private nurseries to procure planting materials and no-named varieties and plants that are budded on wild rootstocks because of high bud success. Normally, nutmeg budding is a highly skill-bound practice, reported with a low success percentage. So, the availability of quality planting material is a significant constraint for expanding nutmeg cultivation. To address this problem, it is vital to plant orthotopic nutmeg buddlings budded on appropriate rootstocks.

Seed propagation and raising of rootstock

The earlier nutmeg plantations were established through seed propagation. The nutmeg seeds were collected from regular-bearing and high-yielding trees, producing more than 3000 fruits per year and fruits having at least 30 g weight, 10 g nut and 3 g mace weight per fruit. Miniraj *et al.* (2015) have opined that to designate as a plus tree; it should possess a minimum of 2 g of dry mace weight, 10 g of dry nut weight and produce around 2000-3000 fruits tree^{-1}year^{-1}. Further, Vikram *et al.* (2016) have developed a statistical tool using 13 key quantitative characters to identify an elite nutmeg tree. Number of fruits square meter^{-1} (19), dry mace weight (2 g), dry nut weight (10 g) and kernel weight (7 g) are the minimum values prescribed by them to classify a nutmeg tree as an elite type.

Well-matured seeds are collected from naturally split open and healthy fruits harvested during the month of June-July. Seeds are sown immediately as the viability of the seed gets reduced three days after extraction due to their recalcitrant nature. A higher percentage of germination was observed in nuts collected from female trees growing nearer to male trees (Perrl, 1938). Since nutmeg seeds are recalcitrant, they lose germinability at moisture content below 45 per cent on a dry weight basis (Sangakkara, 1985). They can be preserved in moist sand or moss for 3-7 days

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in poly bags or other containers having suitable rooting medium (Kannan, 1971; Mathew, 1992; Madhusudhanan and Babu, 1994; Gunasekaran *et al*., 2000). Small and immature seeds have low germination percentage (Shanmugavelu and Rao, 1977). Old seeds and those in which kernels rattle inside the shell will not germinate (Krishnamoorthy and Rema, 1989). Heavier seeds, sown immediately after harvest during June, recorded the highest germination percentage and maximum vigorous seedlings (Mathew, 1992; Gunasekaran *et al*., 2000). The seeds with the shell are sown in nursery beds at a spacing of 30 cm apart and 2.5-5 cm deep, over which pandals are erected to provide shade (Chezhiyan *et al*., 1996; Singh and Singh, 2008).

Nutmeg seed germination can be observed from the 40th day and lasts up to 90 days after sowing. The germinated sprouts of or needle stage-before unfurling of leaves have to be transferred to polythene bags of size 10 × 12 inches containing a mixture of soil, sand and well-decomposed cow dung in a ratio of 3:3:1. Seeds treated with 200 ppm gibberellic acid increased the germination percentage (75 per cent) and showed earlier germination. The height of the seedlings increased by this. About one-year-old seedlings can be used as rootstock.

Vegetative propagation

The significant bottleneck in nutmeg cultivation is the dioecious behaviour; the seedling progeny will not be true-to-type and it will segregate into male and female in the ratio 1:1. Because of the uncertainty in sex determination of nutmeg in seedlings stage, multiplication through vegetative propagation is the only alternative method for commercial utilization and maintaining proper male-female ratio in the plantation. Many techniques like stem cuttings, approach grafting, epicotyl grafting, softwood grafting, forket budding, patch budding, air layering and top working have been tried in nutmeg with varying degrees of success (Nichols and Pryde 1958; Nichols and Cruickshank 1964; Sundararaju and Varadarajan, 1956; Kannan, 1973; Shanmughavelu and Rao, 1977; Rasalam, 1978; Mathew and Joseph, 1982; Mathew, 1985; Rethinam and Edison, 1991; Nissar *et al.,* 2019).

Stem cutting

Nutmeg is very difficult to multiply through cutting; however, rooting of semi-hardwood cuttings was found successful in Trinidad and Grenada, as reported by Nichols and Pryde (1958) and Nichols and Cruickshank (1964). The high amount of tannins and phenolic compounds present in the stem will probably hinder the success of rooting. The establishment of rooted cuttings in the field was very poor. Standardisation of methods for rooting of cuttings in nutmeg is very important for the production of clonally identical rootstocks for grafting and budding (Rema *et al*., 1997). At present, the grafting and budding are carried out on rootstock raised from seeds.

Grafting

Nutmeg can be successfully propagated through grafting methods like approach grafting, epicotyl grafting and softwood grafting. However, the most successful method among these is epicotyl grafting (Krishnamoorthy and Mathew, 1985; Krishnamoorthy and Rema, 1987; Haldankar *et al*., 1999). Haldankar *et al*. (1999) reported that the approach grafts could result in 40-100 per cent success on different rootstocks.

Epicotyl grafting

Twenty days old healthy rootstocks can be used in epicotyl grafting. 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). Krishnamoorthy and Mathew (1985) obtained a maximum of 80 per cent success in epicotyl grafting during the month of August in 20-30 days old *M. fragrans* as the rootstock. To provide an ideal microclimate for bud take a narrow polythene cover can be placed over the scion stick.

Soft wood grafting

Soft wood grafting provides scope for the production of nutmeg grafts for prolonged periods. Haldankar *et al.* (1999) reported that medium mature (4 months) and fully mature (6 months) scion sticks were preferred for softwood grafting. Covering the scion stick with an empty polythene cap is essential, especially in the post-rainy season. The month of May was the best time for softwood grafting, with the highest success of 80 per cent. The retention of leaves on the rootstock did not influence the success of softwood grafting. The characteristics of the scion sticks and grafting method were similar to those of epicotyl grafting. Wherever the scions failed in epicotyl grafting, the rootstock may be allowed to grow and later on can be grafted by the softwood grafting method.

Approach grafting

In India, successful approach grafting has been done on root stocks of *M. fragrans*, *M. malabarica* and *M. beddomei* (Sundararaju and Varadharajan, 1956; KAU, 2001). The grafts came to flowering in 4-6 years after planting, whereas the seedling took 6-8 years. Rasalam (1978) claimed 100 per cent graft success on wild species of nutmeg when erect branches of female nutmeg trees were used as the scion and flowering of the successful plants commenced in the second year after grafting. Haldankar *et al*. (1999) reported that the approach grafts could be prepared throughout the year and the maximum percentage of graft success was recorded on *M. malabarica* with 30 to 100 per cent and in the case of *M. fragrans* it was 40-90 per cent. After separation of the grafts, mortality was as high as 30 per cent on cultivated nutmeg root stock and 50 per cent on wild nutmeg root stock. Inarching, though successful, is expensive and laborious since benches have

to be erected and rootstocks brought to the mother plant to carry out grafting.

Nutmeg trees exhibit dimorphic branching pattern with orthotropic and plagiotropic shoots. Nissar *et al.* (2019) reported that scion or bud extracted from the orthotropic shoots only shows vigorous, erect growth and canopy spread similar to seed borne trees, even though the number of orthotropic shoots is limited. At the same time, the plagiotropic buds develop into squatty and stunted plants. Therefore, the fruiting area is comparatively less, resulting in low yield. The number of orthotropic branches produced in a tree limited and which offer major restraint in vegetative propagation especially grafting. Attempts have been made to modify the growth pattern by various workers but with little success.

Budding

Budding is the most common method followed by commercial plant nurseries, though the success rate is as low as 20-30 per cent. It economises the usage of scion material. One year old seedlings raised in poly bags are used for budding and a single scion provides a greater number of orthotropic propagules or bud patches in budding than using the whole orthotropic scion stick for grafting. Among the vegetative propagation standardised in nutmeg, *in situ* budding (field budding) and nursery budding are the widely adopted methods (Miniraj *et al*., 2012).

Forkert budding

Forkert method of budding was tried by Mathew (1979) in *M. fragrans* and *M. beddomei* rootstocks and success was observed very low (4%) in both cases. Forkert budding on the top worked tree sprouts only gave initial success, failing to grow even with physical and chemical treatments (Beena, 1994).

In situ budding (Field budding)

In situ budding is a method of budding commonly followed by farmers of Kerala to solve the two major problems that restrict large-scale cultivation of nutmeg, namely dioecy and the long juvenile phase. To reduce the cost of budded plants, *in situ* budding of field planted seedlings are practised within a plantation. Orthotropic scion shoots from elite mother trees are budded on to seedlings of two years after planting in the main field. The rootstock and scion should be at the bark slipping stage. Budding is done just above the first whorl of lower leaves. Studies by Beena (1994) proved that *in situ* budding on the hard trunk was most successful. The 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-olds. As the age of rootstock advances, the success per cent of sprouting is reduced. The sprouting percentage was maximum in plants which are aged 3 to 5 years. 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) provides enough pollen to improve the fruit set.

Rani (1994) obtained the highest success with patch budding on *M. fragrans* and the forkert method on *M. beddomei*, August was found to be the best time for *in situ* budding and July for budding in polybag plants. Partial shade was ideal for better bud take than the mist chamber conditions. Stumping the rootstock above the bud union and retaining the whorl of lower leaves gave better sprouting and late survival.

Nursery budding

Healthy seedlings of eight months to two years can be used for nursery budding. Both patch budding and Forkert budding are commercially adopted in the nursery budding of nutmeg. Budding is done at the green as well as brown stage of the bud/scion stick. Beena (1994) reported a maximum success of 66.66 per cent with forkert budding on *M. fragrans* and *M. beddomei* rootstocks during December. In another study, Lissamma *et al*. (2012) reported the highest success percentage with green budding on *M. beddomei* (70%), followed by green budding on *M. fragrans* (65%) and brown budding on *M. beddomei* (60%). Budded plants are kept under shade. After the budburst, they are ready to transplant after the formation of one or two whorls of leaves (one or two tier stage).

Air layering

The propagation through budding and grafting requires good skill and expertise for success; air layering is an alternative to these methods, taking the cue that trees naturally produce ariel roots. Air layering is successful in both plagiotropic and orthotropic shoots with 100 per cent survival. Initially, the roots were thick and proliferated producing profuse, thinner second and tertiary branches of roots within a month. The rooted twigs were detached, planted in polythene bags and hardened for 20-30 days. The success rate of air layering can be increased by de-topping mother trees or thinning the canopy. This method is cost-effective and easy to adopt (Nissar *et al*., 2019). However, air-layered plants are developing an adventitious root system for anchorage to shoots or canopy that has to be apprehended.

Top working

The sex of nutmeg trees can be identified only seven to eight years after planting when they begin to flower. Generally, male and female trees are produced in a 1:1 ratio (Thangaselvabai *et al.,* 2011). Since a single male tree is sufficient for every 20 female trees for pollination, the rest of the unproductive male trees can be converted to productive by making them into female trees by top working. Trials on the topping of male trees indicated that cutting the trees above the first tier during August was the best with regard to sprout production and reducing the time for

growing. The emerging sprouts are budded with orthotropic scion from elite female trees or varieties and two successful buds are retained and allowed to grow. They will start bearing from the second year onwards.

Establishment of budwood nursery

The budwood nursery (scion bank) should be established with the recommended nutmeg varieties. The buddlings should be carefully labelled and planted at closer spacing of 3 × 4 m in order get the consistent supply of the scion. The plant should be mulched and manured with recommended dose of NPK (500:250:1000 g per plant per year) fertilizers during monsoon season to get adequate number of scions (KAU POP, 2016). Separate shade should be given to each plant in nutmeg budwood nursery. The flower should be removed in order to get a greater number of scions. The canopy of plants in the scion bank should be maintained at a reachable height of 1.5 m from ground level by heading back and pruning. Beheading should be practised at regular interval of 3-4 years. Rani (1994) reported that on the mature branches of nutmeg trees, maximum number of orthotropic shoots can be induced by pruning close to the tree trunk leaving 30 cm stump. Staking the immature brown shoots of one to two years of age and young green shoots of less than six months of nutmeg grafts acquired a reduced angle with the vertical even one month after removal of stake. Among the physical and chemical treatments tried to induce orthotropic shoots in nutmeg grafts of plagiotropic nature, the treatments stumping and application of 5 ppm kinetin was found superior with respect to the number of shoots produced per plant. Pruning of trees may be carried out annually during September to October in the scion bank. When pruning, ensure that the cut ends of shoots face downward to prevent rainwater entry which may lead to decay or attack of pests and diseases. The cut ends should be treated with Bordeaux paste (10%) and the plants are sprayed with Bordeaux mixture (1%). Tender shoots should be protected by timely sprays of insecticides and fungicides. Prior to cutting of budwood, a colour band should be painted on every plant 15 cm above the graft union or bud union. Remove all stock shoots, which appear below the colour band and allow only the scion shoots to grow. Green buds are taken from bud shoots of six to eight weeks after pruning whereas brown buds are taken from one year growth. Over budding on existing clones with new clones should never be practised.

Ideal rootstock for propagation

M. fragrans, M. beddomei and *M. malabarica* are used as rootstocks in Kerala with varying degrees of success. *M. malabarica* exhibits relative tolerance to water stress and *M. fragrans* and *Gnemacanerica* appeared as drought-susceptible (Krishnamurthy *et al.,* 2008). Though the majority of *Myristica* species are of non-swampy habitat, *Myristica fatua* Houtt. var. *magnifica* is exclusive to the swamps, with occasional occurrence of *M. malabarica* as well as *M. beddomei* subsp. *sphaerocarpa, M. beddomei* subsp. *beddomei* and *M. beddomei* subsp. *ustulate* (Saji *et al*., 2019; Banik *et al.,* 2017). *Gymnacranthera canarica* is the other most important entity in the swamps. At later stages, budded plants on *M. beddomei* exhibit enlargement below the bud union. Even though wild rootstocks possess the capacity to with stand water stress and heavy winds, their performance is not uniformly good at different locations. Priyanka *et al.* (2023) reported that the performance of nutmeg trees budded on self (*Myristica fragrans*) is found superior to that of the plants budded on wild rootstock (*Myristica beddomei*) in terms of growth and yield performance irrespective of location and altitude. Significantly higher yield characteristics were obtained in the trees budded on self-rootstock, such as high fresh nut and mace yield per tree (6.93 kg and 5.19 kg); dry nut, mace and kernel yield per tree (1.92 kg, 1.04 kg and 3.84 kg). Commercial nurseries in South India use *Myristica beddomei* as rootstock on a large scale as the bud take is more on wild rootstock when compared to *Myristica fragrans.* The study findings revealed that *M. fragrance* is the ideal rootstock for nutmeg.

CONCLUSION

Screening of the nutmeg cultivars for various biotic and abiotic stresses is very essential for use as rootstocks. Further, selection of root stocks based on the ecosystem will contribute more sustainable and productive nutmeg plantations. The guidelines issued for accreditation of nutmeg nurseries in India insists on development of mother blocks of superior varieties for the production of good quality buddlings. The establishment of nurseries with mother blocks is very essential for the consistent and reliable production of genetically identical and healthy buddlings in nutmeg.

Conflict of interest

All author affirms that they do not possess any conflicts of interest.

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