

Agronomy of tree spices (clove, nutmeg, cinnamon and allspice) - a review

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ABSTRACT

Clove (*Syzygium aromaticum*), nutmeg (*Myristica fragrans*), cinnamon (*Cinnamomum verum*) and allspice (*Pimenta dioica*) are important tree spices and have economic value as ingredients in food, beverages and medicines. Agronomical aspects like nursery practices, selection of site, spacing, planting, manuring, mulching, weeding, irrigation and harvesting are important packages for higher and sustainable yield. The available information on these aspects are reviewed.

Key words : agronomy, allspice, cinnamon, clove, nutmeg, tree spices.

Introduction

India produces about 5500 t of tree spices (clove, nutmeg, cinnamon and allspice) per year as against a demand of 7000 t. The deficit is met by imports. There is an urgent need to augment production by expansion of area and adopting low input sustainable technologies. Research work on tree spices is confined mainly to standardisation of propagation techniques; information on cultural practices and fertilizer schedules to be followed are limited. The economic part used, origin, major producing countries and major areas of production of tree spices in India are indicated in Table 1.

Clove (*Syzygium aromaticum* (L.) Merr. & Perry)

Climate and soil

Clove requires a humid climate (Crofton

1936; Pillai 1972; Shanmugavelu & Rao 1977), and grows at 600 m (Simpson 1978) to 1000 m above MSL (Sheffield 1950; Pillai 1972; Shanmugavelu & Rao 1977) with a rainfall of 1500-2000 mm and a mean temperature of 20-30°C (Simpson 1978; Bavappa & Ruettimann 1981a). Deep red loam, sandy soil (Purseglove *et al.* 1981), black soil and deep gravelly sub soil (Simpson 1978) are suitable but water logged conditions are undesirable (Ridley 1912).

Propagation and planting

No distinct varieties are recognised in India or elsewhere (Sritharan & Bavappa 1981). The common method of propagation is through seeds, collected from healthy and regular bearing trees (Pillai 1972). A branch 50 cm long, selected from such trees should have more than 10 terminals, 14 clusters, 100 flowers and 1.5 cm long flowers (Bavappa &

Table 1 . General information on clove, nutmeg, cinnamon and allspice

Name	Economic part	Origin	Major producing countries	India		
				Area* (ha)	Production* (t)	Major States
Clove <i>Syzygium aromaticum</i> (L.) Merril & Perry (Myrtaceae)	Dried unopened flower buds	Moluccas Islands of Indonesia	Indonesia, Tanzania, Sri Lanka, Madagascar	1735	1477	Kerala, Tamil Nadu, Karnataka, Andaman & Nicobar Islands
Nutmeg <i>Myristica fragrans</i> Houtt. (Myrtaceae)	Seed and mace	Moluccas Islands of Indonesia	Indonesia, West Indies, Grenada	3828	3663	Kerala, Tamil Nadu
Cinnamon <i>Cinnamomum verum</i> Bercht & Presl. (Lauraceae)	Bark excluding exoderm	Sri Lanka, Malabar Coast of India	Indonesia, Tanzania, Sri Lanka, Seychelles, Madagascar	565	355	Kerala, Tamil Nadu
Allspice <i>Pimenta dioica</i> L. (Myrtaceae)	Dried fruit	West Indies, Central America	Jamaica, Guatemala, Mexico, Honduras, Costa Rica	NA	NA	Kerala, Tamil Nadu

NA - Not available

*1992-93

Reuttimann 1981a). Healthy olive green single seeded fruit is more ideal than two seeded fruits (Purseglove *et al.* 1981). Seed viability is short and hence are to be sown immediately after collection (Pillai 1972; Shanmugavelu & Rao 1977; Prasanna Kumari Amma 1981; Krishnamoorthy & Rema 1988; Nazeem, Sudhadevi & Nair 1992; Sabale, Nadkarani & Nawale 1992). The viability is higher at 16°C than at 25 - 30 °C (Hasnah, Wahid & Hobir 1984; Sutarno & Utami 1984). Germination and vigour of seedlings are increased by keeping the seeds between two moist gunnies (Nair *et al.* 1977) and sowing during June, with heavy (Prasanna Kumari Amma 1981), dehusked seeds (Pillai 1972) and by keeping the groove upward (Badami 1938). Growth regulators are also used to induce germination (Dhalimi 1983 a & b; Hasnah *et al.* 1984). Ten to fifteen days are required for 90 per cent germination (Purseglove *et al.* 1981). Rooting medium in general, consists of soil, sand and farm yard manure in equal proportion (Pillai 1972; Bavappa & Ruettimann 1981a; Prasanna Kumari Amma 1981; Krishnamoorthy 1988). Different sizes of polythene bags are used for raising seedlings (Simpson 1978; Wahid *et al.* 1978; Bavappa & Ruettimann 1981a; Krishnamoorthy 1988). Seeds are to be dibbled at a spacing of 2-3 cm (Krishnamoorthy 1988) and not below 3 cm depth (Anonymous 1949). Simpson (1978) has described nursery practices for clove. A fertilizer solution of 1 kg urea, 0.75 kg super phosphate and 0.5 kg muriate of potash dissolved in 100 l of water when applied at monthly intervals promoted early vigour (Bavappa & Ruettimann 1981a). Vegetative propagation by cutting (Fernie 1946), marcoting (Zulkifli 1986) and approach grafting (Rema &

Krishnamoorthy 1994) are possible but due to low meristematic activity, vegetative propagation is difficult (Purseglove *et al.* 1981). *In vitro* propagation has also been reported (Mathew, Francis & Hariharan 1987; Mathew & Hariharan 1990; Superman & Blake 1990; Anonymous 1994).

Age, colour of cotyledon and height of seedlings determine the time of transplanting. Nine to twelve months (Bavappa & Ruettimann 1981a; Prasanna Kumari Amma 1981) to 2 year old seedlings (Krishnamoorthy 1988) with olive green cotyledons and radicle not blackened (Wigg 1940) after attaining 30-50 cm (Verheij & Snijders 1989) to 60-80 cm height (Bavappa & Ruettimann 1981a) are suited for main field planting. Seedlings established in coconut husk pots (Prasanna Kumari Amma 1981) and polybags (Martin *et al.* 1992 a) have higher survival. Land preparation and planting were described by Simpson (1978) and different spacings and pit sizes recommended (Table 2).

Aftercare

Shade is essential to protect the crop from adverse weather conditions (Ridley 1912). Banana (Anonymous 1957; Bavappa & Ruettimann 1981a; Krishnamoorthy 1988), cassava (Verheij & Snijders 1989; Martin *et al.* 1992 b) *Glyricidia* sp., *Peltophorum ferrugineum* (Anonymous 1959), *Acacia* sp., *Albizia* sp., subabool (Krishnamoorthy 1988) and *Erythrina* sp. (Verheij & Snijders 1989), the common shade plants, are to be established, 6-12 months prior to clove planting (Pillai 1972; Bavappa & Reuttimann 1981a). Artificial shade with plaited coconut leaves (Pillai 1972; Bavappa & Ruettimann 1981a) is also

Table 2. Recommended spacing and pit sizes for clove

Spacing (m)	Pit size (cm ³)	Reference
2.7 × 5.4	90	Simpson 1978
6.0 × 6.0	80	Bavappa & Ruettimann 1981a
7.0 × 7.0	75	Krishnamoorthy 1988
7.7 × 7.5	90	Pillai 1972
9.0 × 9.0	-	Tidbury 1954
8.0 × 8.0	-	Verheij & Snijders 1989
6.0 × 8.0	-	Verheij & Snijders 1989
8.0 × 11.0	-	Verheij & Snijders 1989

useful. From third year onwards, shade is not needed (Simpson 1978) and wind breaks like casurina and Japanese bamboo may be planted at the border of plots. Mulching the soil near the tree base during summer conserves moisture (Pillai 1973; Martin *et al.* 1992 b). Soil erosion needs to be controlled when slopy land is used for cultivation by bench terracing to a diameter of 0.5 m (Bavappa & Ruettimann 1981a) and it may be widened as the plant grows. Weeding is to be done when weed intensity is high (Pereira & Hosegood 1962 ; Pillai 1973; Purseglove *et al.* 1981). Herbicides are also used to control weeds (Arif & Putrawan 1977; Martin 1990). Cover crops (Simpson 1978; Djafaruddin 1980; Martin 1990) and green manure crops like *Tephrosia candida* (Anonymous 1936), *Calapagonium* sp. (Pereira & Hosegood 1962; Krishnamoorthy 1988), *Mimosa* sp., *Stylosanthes* sp. (Bavappa & Ruettimann 1981a) and *Vigna hoesi* (Verheij & Snijders 1989) conserve moisture and suppress weed growth. Regular irrigation is essential especially during summer at younger stages (Pillai 1973; Simpson 1978). Irrigation with 10-20 l water thrice a week per plant is

recommended for 4 year old plants (Simpson 1978).

Clove responds to applied fertilizer (Wahid & Usman 1984; Daswir & Zulkifli 1986). Nutrient removal by adult clove tree showed the following trend:K>N>Ca>Mg>S>Mn>P>Fe>Cu>B> Zn (Nazeem 1989). Fish and prawn refuses are used as manure (Anonymous 1936; Pillai 1973). Compost or farm yard manure can also be used (Shanmugavelu & Rao, 1977). Fertilizer mixutres @ 200 g (6:20:6 NPK) is recommended for 18 month old trees (Djafaruddin 1980). Urea, rock phosphate and muriate of potash in the proportion of 2:2:3 along with magnesium sulphate 1/3 part by weight is recommended per tree for initial 5 years, the quantity being 0.25, 0.50, 0.75, 1.00 and 1.25 kg for first, second, third, fourth and fifth years, respectively (Bavappa & Ruettimann 1981a). NPK mixutre of 15:15:15 is recommended @ 4-8 kg per tree and applied in four splits, during September, December, March and June at Indonesia (Usman & Wahid 1986). Rao (1991) recommended 500:320:400 g N,P₂O₅ and K₂O per adult tree per year. The Kerala

Agricultural University (Anonymous 1993) has recommended a fertilizer schedule of 20:18:50 g of NPK along with 15 kg of compost per year during the first year of planting which is to be gradually increased to 300:250:750 g NPK and 50 kg of compost per year from 15th year onwards. Scattering of manure around the tree base to a radius roughly equal to canopy spread (Pillai 1972) or to a depth of 10-15 cm and 15-20 cm away from the base of the tree (Shanmugavelu & Rao 1977) and band application of fertilizers at a distance of half the radius of canopy and quarter the radius away from the base of plants are suitable (Bavappa & Ruettimann 1991a). Nutrient deficiency symptoms in clove have also been described (Nazeem 1989).

Sudden death of clove (Nutman & Roberts 1953; 1954 & 1971) and Sumatra disease (Verheij & Snijders 1989) are important diseases. Apart from pathogens, unfavourable soil conditions and nutritional deficiencies (Finck 1973) lead to disease conditions which are managed by keeping the plant vigorous by providing shade, wind breaks, mulches and watering (Pruseglove *et al.* 1981), herbicidal ring weeding and nitrogenous fertilizer application (Martin 1990).

Harvest and yield

Pruning is practiced to facilitate easy harvest (Ridley 1912). Flower buds are harvested when they turn pink (Pillai 1973) and the best time of harvesting is when the flower bud is developed fully and turns reddish but not bloomed (Crofton 1936). Clove oil obtained from flower buds harvested at lower maturity stages has more of eugenol acetate and

less of eugenol (Gopalakrishnan, Nirmala Menon & Mathew 1982). Harvesting commences during January in plains and March-April in high ranges in India (Krishnamoorthy 1988); in Zanzibar, during June-July and in Amboyna and Penang, during November-December (Verheij & Snijders 1989). Harvesting is done using a step ladder and care must be taken not to break the branches. Forty kg of green cloves can be harvested by a person in a day and 3-8 pickings are possible in a year (Verheij & Snijders 1989). Chemical harvesting has also been tested at Indonesia (Araujo, Sacramanto & Silva 1989); it is economically feasible in areas more than 2.33 ha and productivities above 763 kg per ha. For harvesting seed, the optimum time has been identified as 78-91 days after fruit set (Nair, Hariharan & Koshi 1979; Sutarno & Utami 1984). Yield varies with age of tree and location. Three to four kilograms of dried buds can be harvested on an average from 15-20 year old clove trees (Simpson 1978; Krishnamoorthy 1988). The average yield in Indonesia is 4.1 kg per tree (Verheij & Snijders 1989). Alternate bearing habit is observed in Tanzania, Indonesia, Malagasy Republic (De Waard 1974) and India (Pillai 1973). The reasons for the alternate bearing habit are yet to be found.

Nutmeg (*Myristica fragrans* Houtt.)

Climate and soil

A humid tropical climate is the best for nutmeg and it grows up to an elevation of 1000 m above MSL (Shanmugavelu & Rao 1977). A well distributed rainfall of 150-250 cm and an annual mean temperature of 20-30°C are ideal for

Table 3. Recommended spacing and pit sizes for nutmeg

Spacing (m)	Pit size (cm ³)	Reference
8.0 × 9.0	60	Shanmugavelu & Rao 1977
9.0 × 9.0	75	Ridley 1912; Flach 1966; Krishnamoorthy 1987
6.0 × 6.0	80	Bavappa & Ruettimann 1981b
6.0 × 7.5	90	Purseglove <i>et al.</i> 1981

nutmeg (Bavappa & Ruettimann 1981b). Nutmeg grows in clay loam soils in Indonesia, lateritic clays in Malaysia and volcanic loams in Moluccas. Well drained soils rich in humus are best (Shanmugavelu & Rao 1977). Water logged or soils having inadequate moisture may be avoided (Purseglove *et al.* 1981).

Propagation and planting

No distinct varieties are reported (Flach & Cruickshank 1969; Joseph 1980). The general method of propagation is through seeds collected from regular bearing and high yielding trees, yielding more than 10,000 fruits per tree per year, and having 30 g wet weight per fruit, 1 g wet weight of mace per fruit and 10 g wet weight of nuts per fruit (Bavappa & Ruettimann 1981b). Seed viability is low and hence they should be sown soon after harvest (Krishnamoorthy 1988; Mathew 1992). Storing seeds in polythene bags, moss (Shanmugavelu & Rao 1977), moist sand (Mathew 1992) or plastic bags (Madhusudanan & Babu 1994) are ideal. Small and immature seeds have low germination (Shanmugavelu & Rao 1977). Seeds should be collected during periods of peak production (Flach 1966). Seeds may be sown in nursery beds, baskets, polythene bags or other con-

tainers having suitable rooting medium (Kannan 1971a; Purseglove *et al.* 1981; Krishnamoorthy 1987). Sprouting starts in about 4 weeks (Ridley 1912; Kannan 1971a; Purseglove *et al.* 1981) and maximum germination occurs between 50-80 days (Kannan 1971a). A higher germination is observed in nuts collected from female trees growing nearer to male trees (Perrl 1938). Sprouted seeds are transplanted immediately to polythene bags since delay causes damage to root system (Krishnamoorthy 1987). Nutmeg is a dioecious plant and it is very difficult to find out the sex at seedling stage. Several workers described methods for sex determination (Flach 1966; Phadnis & Chowdhari 1971; Nayar, Rai & Vatsala 1977; Zachariah *et al.* 1986; Packiyasothy, Jansz & Dharmadasa 1991; Krishnamoorthy *et al.* 1992); however none of them are reliable.

Vegetative propagation techniques like stem cuttings, air layering, approach grafting, epicotyl grafting, budding and top working were tried in nutmeg (Cheeseman & Spencer 1936; Macmillan 1954; Sunderaraju & Vardarajan 1956; Kannan 1973; Shanmugavelu & Rao 1977; Rasalam 1978; Mathew & Joseph 1982; Mathew 1985; Rethinam & Edison 1991) and 35-80 per cent success obtained. Propagation by tissue culture

is not reported.

Seedlings are transplanted to the mainfield from 6 months (Ridley 1912; Rosengarten 1969) or 18-24 months (Kannan 1971b; Shanmugavelu & Rao 1977; Nair 1978; Bavappa & Ruettimann 1981b; Krishnamoorthy 1987). The land is to be prepared well before planting (Purseglove *et al.* 1981). If nutmeg is planted in slopy areas, the base of seedlings should be bench terraced to a diameter of 0.5 m initially and widened as the plant grows to conserve soil from erosion (Bavappa & Ruettimann 1981b). In India, seedlings are planted during south west monsoon. Various spacings and pit sizes are recommended (Table 3). Ten per cent of males may be retained for pollination and the remaining male trees may be removed (Purseglove *et al.* 1981).

Aftercare

Care may be taken to protect plants from sunscorch (Aiyadurai 1966; Flach 1966; Kannan 1971b) by providing shade (Shanmugavelu & Rao 1977). *Canarium commune* in Moluccas, *Pithecolobium saman* in Trinidad (Ridley 1912), *Albizia* sp., *Sesbania* sp. (Flach 1966), *Glyricidia* sp., dadap (Bavappa & Ruettimann 1981b), banana, *Acacia* sp. and subabool (Krishnamoorthy 1987) are used for shade. Lopping of branches may be done at later stages to regulate shade (Purseglove *et al.* (1981). In addition, wind breaks may also be planted.

Regular weeding and mulching keep the field clean and conserves moisture (Shanmugavelu & Rao 1977; Bavappa & Ruettimann 1981b). Cover crops like *Mimosa* sp. and *Stylosanthes* sp. may also be cultivated for suppressing weed growth (Bavappa & Ruettimann 1981b). Application of herbicide mixture

(Gramaxone and Fernoxone) checked weeds up to 6 months (Anandaraj, Sivaraman & Krishnamoorthy 1989). Seedlings may be irrigated periodically during summer (Shanmugavelu & Rao 1977). For 4 year old plants, 20 l of water per plant thrice a week are given; the quantity of water is to be increased at later stages of growth (Krishnamoorthy 1987). Bavappa & Ruettimann (1981b) recommended a fertilizer dose similar to that of clove. Shanmugavelu & Rao (1977) have recommended a fertilizer schedule of 1 kg each of ammonium sulphate, superphosphate and muriate of potash along with 50 kg of compost per year to mature plants. Seedlings and young plants are to be supplied with one tenth and half the dose, respectively; the fertilizers are to be applied during May-June and September-October. The Kerala Agricultural University (Anonymous 1993) has recommended a fertilizer schedule of 20:18:50 g of NPK along with 15 kg of compost per year during the first year of planting which is to be gradually increased to 500:250:1000 g NPK and 50 kg of compost per year from 15th year onwards. Young marcoted plants may be supplied with 0.5 kg of 12:8:24 NPK mixture after first year and gradually increased to 2.5 kg per tree for 10 year old trees (Cruikshank 1973; Sriram 1977). Rao (1991) recommended 400:320:400 g of N, P₂O₅, K₂O respectively, for an adult tree per year in Andaman and Nicobar Islands. Pruning is not required, but the branches affected with *Loranthus* sp. or Indian mistletoes may be removed as soon as they are observed (Ridley 1912).

Harvesting and yield

Variations in levels of nutrients and carbohydrate contents in flowering and

non flowering shoots were observed (Philip 1989). Flowering depends on climate and soil conditions (Shanmugavelu & Rao 1977). Differences in flowering habits of male and female trees were also observed (Nazeem 1979). Peak period of flowering in male and female trees coincide during July and October. Fruits are reported to ripen 6-9 months (Ridley 1912; Purseglove *et al.* 1981), or 7-8 months (Nazeem 1979) after flowering. A sigmoid growth pattern in fruit development is observed, the maximum being in 6th and 16th week after fruit set (Nazeem 1979). Fruit bearing begins after eighth or ninth year in Indonesia (Joseph 1980). Trees raised from seedlings begin to bear 5-8 years after planting and vegetatively propagated trees fruit earlier (Purseglove *et al.* 1981). In India, fruits that split on the tree exposing crimson coloured aril are harvested (Nair *et al.* 1977). Peak harvesting periods vary in different countries (Cruickshank 1973; Anonymous 1977; Nair *et al.* 1977; Nazeem 1979). Yield varies among trees and plantations. The average yield of a good tree in full bearing is reported to be 1500-2000 fruits (Purseglove *et al.* 1981) or 3000 fruits (Krishnamoorthy 1987) between 15th and 30th year of growth. Average weight of a single fruit is 60 g of which the seed weighs 6-7 g, mace 3-4 g and the rest pericarp (Krishnamoorthy 1987). Ratio of mace to nutmeg is 1:8 (Rethinam & Edison 1991). Immature fruit drop occurs to an extent of 60.0 per cent (Slooff 1951) to 74.4 per cent (Nazeem 1979) due to degeneration of embryos resulting from inadequate pollination, water scarcity, root competition due to closer planting or interplanting with shade trees, nutritional imbalance, fungus attack and

physiological reasons. Maximum fruit drop coincides with peak fruit development and application of fertilizers and fungicides reduced its incidence (Tombe, Tarigans & Wahid 1991).

Cinnamon (*Cinnamomum verum* Bercht & Presl.)

Climate and soil

Cinnamon is a hardy plant which tolerates a wide range of climatic conditions (Bavappa & Ruettimann 1981 c). The crop thrives well from 300 to 350 m above MSL (Bavappa & Ruettimann 1981c) and up to 1000 m above MSL (Nair 1978). It flourishes in places with an annual rainfall of 150-250 cm with an average temperature of 27°C (Shanmughavelu & Rao 1977; Nair 1978). A hot and moist climate is highly suited for cultivation of cinnamon (Radhakrishnan 1992) and prolonged spells of dry weather are not conducive for its growth. It flourishes in a wide range of soils, even in marginal soils with poor nutrient status. Sandy loam soil rich in organic matter is the best (Ridley 1912). The quality of bark is influenced by soil and ecological factors. The best economic produce is obtained when grown in siliceous sandy soils whereas the yield is higher in other types of soils under Sri Lankan conditions (Bavappa & Ruettimann 1981c). Water logged and marshy areas may be avoided as they give an undesirable product (Purseglove *et al.* 1981).

Propagation and planting

No variety has been evolved in India but in Sri Lanka, a few types such as Panni Miris Kurundu, Thitta Kurundu, Khata Kurundu, Veli Kurundu, Sevel Kurundu,

Naga Kurundu and Penirasa Kurundu are reported; however under field conditions these cannot be identified (Bavappa & Ruettimann 1981c).

The most widely adopted method of propagation is through seeds. Seeds are extracted from ripe fruits from selected mother trees with desirable characters like smooth bark, erect stem, easy peeling of bark, vigorous growth, free from pests and diseases and having good qualities like sweetness, pungency and flavour (Bavappa & Ruettimann 1981c). The seeds are sown as soon as possible, otherwise viability is reduced (Purseglove *et al.* 1981). Seeds are sown in nursery beds or in tile pots filled with a mixture of sand, cattle manure and soil in the ratio 2:2:1 (Nair 1978 b). In beds, seeds are sown in holes of 2.5 cm depth and 10 cm diameter in rows 20 cm apart. About 20 seeds are sown or it may be reduced to 8 per hole. In beds, seeds may be reduced to 8 per hill (Samarawira 1964). Beds of 1 m width and convenient length are suggested by Bavappa & Ruettimann (1981 c). Seeds may be sown in rows of 12 cm apart and covered with thin layer of soil. Seeds are sown in nursery beds during July-August in India (Radhakrishnan 1992). Beds may be watered and shade provided during early stages. Instead of sowing in nursery beds, they may be sown in polythene bags of 10 cm × 20 cm size filled with soil and compost.

Kannan & Balakrishnan (1967) obtained a highest germination of 94 per cent by sowing seeds on the third day after harvesting. At the end of second week, germination was reduced to 52 per cent and after 40 days, there was complete loss of viability. Under normal conditions, seeds germinate within 20

days (Bavappa & Ruettimann 1981c ; Krishnamoorthy & Rema 1988). Ridley (1912) observed germination within 10 to 12 days. From beds, seedlings are transplanted to polythene bags when they attain a height of 15 cm. Polythene bags of 30 cm × 15 cm size filled with soil, sand and farmyard manure (3:3:1) are used (Krishnamoorthy & Rema 1988).

Cinnamon is also propagated by cuttings and layerings (Anonymous 1970). Growth regulators are also used (Sriram 1977; Banerjee, Chatterjee & Sen 1982; Bhat, Hegde & Sulikeri 1989; Hegde, Sulikeri & Hulamani 1990). Propagation by tissue culture (Ravisankar Rai & Jagadish 1987; Anonymous 1994) is also successful. Six to eight month (Bavappa & Ruettimann 1981c) or 10 to 12 month old seedlings (Nair 1978 b; Krishnamoorthy & Rema 1988) are suitable for transplanting. Under rainfed conditions, planting during June-July is ideal (Shanmugavelu & Rao 1977) in India. But for irrigated crop, planting during October-November is recommended (Nair 1978 b). In Sri Lanka, seedlings are planted in holes of 0.3 m at a spacing of 1.2 m × 1.2 m and 15-20 plants are planted in a single hole (Bavappa & Ruettimann 1981c). As this type of planting causes competition among plants, a spacing of 1.2 m × 0.6 m between plants and planting of three plants per hole is suggested (Bavappa & Ruettimann 1981c). A spacing of 3-5 m between plants is suggested by Radhakrishnan (1992).

Aftercare

Shade and irrigation are essential immediately after planting (Shanmugavelu & Rao 1977). Weeding and mulching

reduce weed growth (Nair 1978b; Bavappa & Ruettimann 1981c; Nazeem *et al.* 1992). Three or four weedings are required for first two years; thereafter, two weedings in a year are sufficient (Ridley 1912; Purseglove *et al.* 1981). Weeding during June - July and October - November and digging during August - September are practiced in Randathara Estate, Kerala, India (Nair 1978 b).

Manuring is considered as a luxury by growers and generally not practiced (Ridley 1912; Nair 1978b). Since leaves and shoots are economic parts and nitrogen promotes vegetative growth, nitrogenous fertilizers are advocated for quick and rapid growth (Nair 1978b). A fertilizer mixture of urea, rock phosphate and muriate of potash in a proportion of 2:1:1 is suggested (Bavappa & Ruettimann 1981c). The rate of application suggested is 200, 400 and 600 kg per ha for first, second and third year, respectively. For an adult plant, NPK in the ratio of 100:18:100 g per year is recommended (Rao 1991). The Kerala Agricultural University (Anonymous 1993) has recommended a fertilizer schedule of 20:20:25 g of NPK along with 20 kg of compost per year during the first year of planting which is to be gradually increased to 200:180:200 g NPK and 50 kg of compost per year from 15th year onwards. Fertilizers may be applied in two splits during May-June and September-October.

Harvesting and yield

Coppicing is practiced from second (Bavappa & Ruettimann 1981c) or third year onwards (Rao 1991). Stems are cut during rains to facilitate peeling

(Purseglove *et al.* 1981). The best time for peeling is when new flushes and leaves are hardened after a rainy season (Bavappa & Ruettimann 1981c; Radhakrishnan 1992). Stems may be cut at a height of 6 cm (Bavappa & Ruettimann 1981c) and is repeated for every side shoot so that the plant assumes the shape of a low bush and a bunch of canes suitable for peeling are available subsequently. When harvested, the cut surface may be faced inside the clump to promote tillering. In Sri Lanka, the main harvesting season is during May-June and October-November, whereas in Kerala, the first season is in May and the second in November (Anonymous 1993). The regular peeling operations are commenced from fourth or fifth year depending on extent of peeler shoots available (Rao 1991). The best quality is obtained from the thin bark of shoots in the centre from the middle portion of shoots (Purseglove *et al.* 1981). Fully developed cinnamon shoots of 1.5-3.0 cm diameter harvested during rainy season (July-August) gives good quality bark and high yield (Pruthi, Varkey & Bhat 1978). From first cutting, after 3-4 years, 56-67 kg of quills per ha are obtained. In a mature plantation, the yield is around 180-200 kg of quills per ha (Rao 1991).

Allspice (*Pimenta dioica* L.)

Climate and soil

Pimento grows from sea level to an altitude of 1000 m above MSL; however it grows well below 300 m (Purseglove *et al.* 1981). An annual rainfall of 100-200 cm or more with a mean monthly temperature up to 27°C are the best. The performance of allspice in plains is

poor and fruiting is not observed (Krishnamoorthy & Rema 1991). The plant grows in a wide range of soils with good drainage. It is not suited to red lime soils with inadequate moisture (Purseglove *et al.* 1981).

Propagation and planting

No variety is reported in India but in Jamaica 2 male and 12 female varieties are reported (Anonymous 1976). The common method of propagation is by seeds. Ripe fruits are collected from high yielding regular bearing trees. Seeds are extracted after soaking the fruits overnight in water and rubbing them in a sieve and washing with clean water. Drying of seeds is done in shade. Seeds are sown as soon as possible or else germination is reduced (Krishnamoorthy & Rema 1988). The seeds are sown either in nursery beds, boxes, pots or basins. Beds of 1.2 m width are prepared with light soil incorporated with organic matter or a mixture of sand and coir dust or coir dust alone. After sowing, nursery beds are mulched to hasten germination. Dried leaves, straw, paper and damp

sacks are used as mulch. Watering is done using a fine spray. Germination takes place between 9 to 10 days (Purseglove *et al.* 1981), or sometimes 15 days after sowing (Krishnamoorthy & Rema 1991). Devadas & Manomohandas (1988) observed differences in germination by storing seeds for different periods in polythene bags and 70-93 per cent germination was obtained when sown 3 weeks after collection at a temperature of 21.5-30.5°C. Vegetative propagation by bottle grafting (Shanmugavelu & Rao 1977), budding, approach grafting (Chapman 1965) and topworking (Purseglove *et al.* 1981) are also possible. Propagation by tissue culture is not reported.

Seedlings of 6 months (Shanmugavelu & Rao 1977) or 9-10 months old having 25-30 cm height are ready for field planting (Purseglove *et al.* 1981). Seedlings are planted at a spacing of 6m either way and in poor soils a closer spacing is preferred (Shanmugavelu & Rao 1977). Chapman (1965) suggested a female to male ratio 2:1 or 8:1, but Purseglove *et al.* (1981) recommended 1

Table 4. Fertilizer schedule for allspice at Jamaica

Year after planting	Fertilizer mixture (g)		Period
	10:10:10 NPK*	15:15:15 or 12:10:18 or 10:10:20 NPK**	
1	113	900	Feb. & Sept.
2	170	1130	Feb. & Sept.
3	227	1360	Feb. & Sept.
	Gradually increased	Gradually increased	
10	2270	2300	Feb. & Sept.

* Chapman 1965

** Purseglove *et al.* 1981

male tree for 10 females. Addition of well rotten cattle manure or compost and filling with top soil in the planting hole, is the usual practice in Jamaica (Purseglove *et al.* 1981).

Aftercare

After planting, temporary shade, irrigation and weeding are essential for reducing casualties (Krishnamoorthy & Rema 1991). Fertilizer schedules have been recommended by Chapman (1965) and Purseglove *et al.* (1981) in Jamaica (Table 4). Fertilizers are applied in two splits during May-June and September-October through soil or foliar application (Purseglove *et al.* 1981). The most serious disease of pimento in Jamaica is leaf rust. Application of fungicides (Blitane, Copper Oxychloride, Dithane-M 45 and Manzate) along with fertilizers is economical to control pimento rust (Naylor 1966). Proper selection of site, planting, careful pruning and removal of infected limbs are also suggested as control measures against canker and wilt diseases.

Harvesting and yield

Male trees flower early when compared to females and the usual flowering time in India is during March to June (Krishnamoorthy & Rema 1991). From flowering, 3-4 months are taken for fruit maturity. For bearing, 5-6 years are taken under good management conditions and 12 years under poor management (Purseglove *et al.* 1981). Pre-bearing period for grafted plants is around 3 years. Fully developed greenish berries are harvested for spicing (Shanmugavelu & Rao 1977; Purseglove *et al.* 1981). A well grown tree yields

20-25 kg dry berries per year under good management (Krishnamoorthy & Rema 1991).

Cropping system with tree spices

Clove is cultivated as a monocrop or as an intercrop with annuals or perennials (Bavappa & Ruettimann 1981 a). Annuals like yams, cassava and colocasia are cultivated successfully as intercrops with clove up to 12 years. Perennials like coconut, arecanut, guava, sapota, citrus, coffee and cocoa (Pillai 1973) can also be grown in clove gardens. Beneficial effects were observed when clove was grown in intercropping systems (Kemala 1981; Madhavan, Gunasena & Bavappa 1985 a & b ; Dwiwarni, Yuhono & Kemala 1987; Anilkumar & Pillai 1988). Nutmeg is suitable to be grown in homestead gardens and in cool situations in orchards along with coffee, tea, coconut, arecanut, rubber, black pepper and cardamom (Abraham 1958). It is the most suitable intercrop in coconut gardens (Sefanaia, Chandra & Etherington 1982; Rao 1991). Cinnamon is recommended as an intercrop in mature coconut gardens in India. The crop is a suitable component for multi-tier cropping systems consisting of shade trees, arecanut, coffee and black pepper at Andaman and Nicobar Islands (Rao 1991).

Conclusion

Vegetative propagation techniques in clove, cinnamon and nutmeg have been developed to reduce long bearing periods. Little attention has been paid to many other aspects of tree spices. No distinct varieties have been developed. Propagation techniques in allspice, agro-techniques like optimum spacing, mulching, fertilizers, weed and water manage-

ment are to be formulated. Studies on physiology of flowering in nutmeg, clove and allspice, flower drop in clove and fruit drop in nutmeg are to be undertaken. Development of effective methods and cultural practices to manage irregular bearing in clove, standardisation of pruning in cinnamon to increase bark yield and studies on root distribution and absorption pattern through radioisotopes are also areas for future research.

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