

## CLOVE (*SYZIGIUM AROMATICUM*) – THE SPICY FLOWER BUD OF SIGNIFICANCE -A REVIEW

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### ABSTRACT

Clove is one of the most ancient and valuable spices of the world. It is used for culinary, pharmaceutical and perfumery purposes. It is native to Moluccas and in India it is cultivated in lower elevations of Western Ghats in Kerala, Tamil Nadu and Karnataka. The area, production and productivity in our country is very low and it is mainly due to the non adoption of improved crop management and post harvest handling technologies, decline in area under cultivation and incidence of pest and diseases. Hence, the innovations made in various crop improvements, production, protection and post harvest handling techniques are reviewed here.

**Key words:** Clove, *Syzgium aromaticum*, Crop improvement, Crop production, Crop protection, Post harvest handling

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The clove of commerce is the dried aromatic fully grown unopened flower buds of the clove tree (*Syzgium aromaticum*) belonging to the family Myrtaceae. Cloves have been used in India since ancient times as a culinary spice. Its fine aromatic flavour blends well with sweet and savory dishes. Clove is also used in medicine as carminative, stimulant and digestive. The oil is used as ingredient for many toothpastes and mouthwashes. The world production of clove is estimated to be around 63,700 t and Indonesia alone accounts for 66 per cent of the world production. India produces about 1013 tonnes of clove in an area of 1981 ha (DASD, 2008). TamilNadu, Kerala, Karnataka and Andaman and Nicobar Islands are the major producers of the country.

Though clove has been under cultivation in India for over 150 years, the area and production under the crop has not gone up to any appreciable extent and the quantity produced is not sufficient to meet the requirement of the country. Inadequacy of genuine and disease free planting materials of improved varieties/ genetically superior stock plants and non adoption of improved production technologies are the causes for the low productivity and quality. India depends on foreign countries notably Indonesia for supply of clove and the import has been increasing from year to year. Hence, to

attain self sufficiency and to arrest the drain on foreign exchange the area and production has to be increased through planting quality planting materials and adoption of improved production technologies.

### Genetic Resources

Clove belongs to the genus *Syzygium* with about 500 species. Many species of *Syzygium* occur in the Indian subcontinent and the more important ones are *S. aromaticum*, *S. cumini*, *S. fruticosum*, *S.jambos* and *S.zeylanicum*. However none of these species is closely related to the cultivable clove (Sasikumar *et al.*, 1999). The genetic base of the country is very narrow because the original number of introductions was few (Ravindran, 1999).

### Floral Biology

Flowers are hermaphrodite, borne at the terminals in small bunches. Each peduncle carries 3 or 4 stalked flowers at the end and each flower has cylindrical thick ovary clove consisting of four fleshy sepals. Above the sepals there are four whitish structures, petals, dome shaped in appearance. After fertilization stamens and styles invariably fall. The lower part of the flower, along with the calyx, develops in to a fleshy, dark one-seeded drupe. The sepals are reduced to triangular projections and this is popularly known as the mother clove (Sritharan and Bavappa, 1981; Bagade *et.al.*, 1996).

In clove anthesis takes place in the afternoon at 1.30 p.m. with a peak between 3.30 p.m. and 4.30 p.m. Anthers dehisce longitudinally. Anther dehiscence commences 24 hrs. before anthesis (Nair *et al.*, 1974). Maximum pollen germination and tube growth were obtained in 1% sucrose + 0.01% boric acid and it was observed after 33 hrs of dusting. The stainability of pollen was 81% and stained pollen grain was larger in size and gave a higher percentage of germination (Sritharan and Bavappa, 1981; Bagade *et al.*, 1996). Stigma receptivity was higher on the fifth day of anthesis. The best period for pollination is between fourth and sixth day after opening. Under artificial pollination the maximum fruit set obtained was 30%, while under bagged conditions it was 28%. Self-pollination appeared to be more probable in clove. A fertilized flower takes about three months for maturity (Krishnamoorthy and Rema, 1994 b; KAU, 2001; Nybe *et al.*, 2006)

### **Crop Improvement**

Breeding trees for dwarf, bushy, early bearing nature with bold buds and high oil content is the main objective in the crop improvement programme. But it is not easy to achieve these aims due to lack of considerable variability in the existing population (Krishnamoorthy and Rema, 1994a) and being a perennial crop with long juvenile period. The present day clove population is originated from a few trees introduced to our country (Nybe *et al.*, 2006). Selections with distinct morphological and bud variations were made based on the survey conducted at Maramalai and Keeriparai areas of Kanyakumari District and two king clove types (KC-1, KC-2) and one dwarf clove (DC-1) collected from this region are being evaluated at HRS, Yercaud and Pechiparai, Tamil Nadu Agricultural University (Balakrishnamoorthy and Kennedy, 1999). A few such collections are being studied at IISR also (Kuriachen *et al.*, 1992; Krishnamoorthy *et al.*, 2005).

### **Germplasm conservation**

Survey conducted in the major clove growing regions of TamilNadu and Kerala and a total of about 200 accessions were made. Accessions with extra bold clove buds (King clove) dwarf and bushy cloves with narrow leaves are three notable collections. Two exotic collections one each from Srilanka and Zanzibar are also maintained (Sasikumar *et al.*, 1999).

### **Variability**

Variability in clove has been observed in the shape of trees, bearing habits, cropping season, yield, colour, shape and dimension of clove. Tree girth and leaf area are the two important morphological traits for assessing the productivity (Balakrishnan *et al.*, 1998; Kennedy and Nageswari, 2000). At IISR, Calicut, Krishnamoorthy and Rema (1992) differentiated 35 elite clove trees based on their morphological and yield traits while Balakrishnamoorthy and Kennedy (1999) identified 12 high yielding types. Variation on morphological and yield attributes was observed among the 22 clove accessions being maintained at HRS, Pechiparai (AICRPS, 2007).

### **Crop Ecology**

**Soil and climate:** Deep black loam soil with high humus content found in the forest region is best suited for clove cultivation. It grows satisfactorily on laterite soils, clay loams and rich black soils having good moisture and good drainage. The soil pH should range from 4.0 to 5.6 (Nair, 1970; Pillai, 1972; Pruthi, 2001)

Clove is strictly a tropical plant and requires a warm humid climate. Humid condition and a well distributed annual rainfall of 150 to 250 cm with a mean temperature range of 20-35°C are the other ideal requirements for the normal growth and commercial production of the crop (Purseglove *et al.*, 1981; Nybe *et al.*, 2006). Elevation between 700 and 900m is reported to be favoured by the crop. Too much moisture does not allow normal flowering. Alternate periods of dry and wet are desirable for higher production. However, plants thrive well if they are periodically irrigated, provided shade and wind break during early stages of growth (Balakrishnamoorthy and Kennedy, 1999; Sharma and Singh, 2000; Pruthi, 2001).

### **Propagation**

The common method of propagation is by seeds (Pillai, 1972; Kannan, 1972; Nayar *et al.*, 1979; Amma, 1981; Krishnamoorthy and Rema, 1988; Martin and Poultney, 1992; Nazeem *et al.*, 1992; Sabale *et al.*, 1992). Seeds are extracted from ripe fruits and sown immediately (Rema *et al.*, 2004). Viability of the seeds is short and it can be maintained for about two weeks if they are stored under moist conditions (Nair *et al.*, 1977; Sabale *et al.*, 1992). The seeds are sown directly in the

nursery beds or in pots during June by using dehusked seeds (Kannan, 1972; Amma, 1981) germinate within two to six weeks (Rema *et al.*, 2004). According to Kumar *et al.* (1992) medium to large sized dehusked seeds (>1.4g) gave 46% success in germination. A trial on sowing the seeds by different methods with and without the pulpy seed coat and with radical upwards and downwards indicated that clove seeds sown in the horizontal position with micropylar end of the seed facing sideways registered increased germination (Gunasekaran and Krishnasamy, 1999). At Dapoli clove seeds treated with IAA at 20ppm gave 93.3 % germination within 14 days (Sabale, 1991). Dehusked seeds treated with 0.1 per cent carbendazim resulted in highest percentage of germination (Chezhiyan and Ananthan, 1997).

The effect of different germination media on germination and seedling growth showed that, the sand and sand +FYM (1:1) is best suited for early, uniform and higher germination (Sabale *et al.*, 1995). Age, colour of cotyledon and height of seedlings determine the time of transplanting. Nine to twelve months (Amma, 1981) to two year old seedlings (Krishnamoorthy and Rema, 1988) are normally used for transplanting. Transferring the seedlings from primary nursery to coconut husk pots filled with pot mixture containing soil, sand and powdered cow dung at second month and transplanting them to the main field with the container intact at ninth month gave higher rate of survival (KAU, 2001). According to Rema *et al.* (2004) the pot mixture containing soil, sand and powdered cowdung exhibited better growth of seedlings. Bagade and Shinde (1993) reported that clove seedlings can be made ready for field planting in one year by foliar application of GA 200ppm. Nawale *et al.* (1995) observed that three months old clove seedlings sprayed with 45ppm IBA triggered the growth considerably followed by 300ppm GA<sub>3</sub>.

Due to low meristematic activity, it is very difficult to propagate clove plants vegetatively. Moreover, clove is reported to be a very slow growing tree (Mathew, 1994). Among the various methods of vegetative propagation, air layering, approach and soft wood grafting were found to be successful during spring (Rema and Krishnamoorthy 1994 b; AICRPS, 2001; Singh and Singh 2008). In air layering 20%

success and in approach grafting 12 % success was noticed at HRS, Pechparai (AICRPS, 2001). At IISR, Calicut, about 80% success was obtained in the initial trials with approach grafting (Rema and Krishnamoorthy 1994a). Rema and Nair (1992) reported soft wood grafting in clove. The trial on soft wood grafting of clove on Jamun rootstock conducted at Dapoli showed 20-50% success one month after grafting, however survival of grafts after three months was nil (AICRPS, 2007). The current seasons shoots proved better as scion material than the terminal past seasons (Dufournet and Rodriguez, 1972). Pool *et al.* (1992) reported the possibility of budding in clove.

### **In vitro propagation**

Callus initiation could be observed from axillary buds, leaf and inter nodal segments from bearing tree as well as seedlings when cultured in MS medium supplemented with high concentration of NAA (3.5mg/l) and low concentration of BAP (0.5mg/l). Low concentration of NAA plus high concentration of BAP seemed to promote further growth and multiplication of callus without any differentiation (Mathew *et al.* 1987; Mathew, 1994; Rao *et al.*, 1997).

### **Crop production**

**Planting and after care:** Planting of clove is generally done during the monsoon (IISR, 1991; Kumar *et al.* 1993). For planting pits of 90 cm<sup>3</sup> may be dug at a spacing of 6-7m with the onset of monsoon and filled with topsoil and compost and planting is done after the receipt of sufficient rains (Krishnamoorthy, 1998). Dufournet and Rodriguez (1972) recommended spacing of 8x7m, with 178 trees/ha. Hasnam and Sukatma (1981) reported yield reduction with closer spacing of 3-4m. Shade is essential to protect the crop from adverse weather conditions. Banana, *Acacia sp.*, *Albizia sp.* and subhabool (Krishnamoorthy, 1998), are the common shade plants to be established 6-12months prior to clove planting. Artificial shade with plaited coconut leaves (Pillai, 1972) is also useful. From third year onwards shade is not needed and windbreaks like jack fruit, casuarinas and Japanese bamboo may be planted at the border of the plots (Singh and Singh, 2008). When the plant starts growing, the tender shoots are subject to breaking or the root may also break due to grinding action by winds; therefore,



tie the plants with good support of two standards till the plants get free form after 20 or 25 years (Nair, *et al.*, 1979).

### Mixed Cropping

Clove can be conveniently grown mixed with commercial crops like pepper arecanut, tea, coconut, sweet oranges, coffee, banana, pineapple and tapioca since the spacing adopted is 6 m which is quite open in the field in the early stages. The shade cast by these plants will provide enough protection to clove from the hot sun (Mathavan *et al.*, 1986; Kuriakose, 1989; Korikanthimath *et al.*, 1994; Reddy *et al.*, 2000; Remany, 2004; Thangaselvabai *et al.*, 2007).

### Inter culture / Pruning, Thinning

Removal of weeds is essential when weed intensity is high. This not only facilitates growth of clove plant but also prevents pests and diseases (Martin, 1990). Application of chemical weedicides is found beneficial (Anandaraj, *et al.*, 1989). Arif and Putrawan (1980) recommended three applications of chemical weedicide dalapon (0.75%) at interval of 3-4 weeks with out any contact on clove. Cover crops and green manure crops like *Calapagonium sp.* (Krishnamoorthy, 1998), *Tephrosia candida*, *Mimosa sp.*, *Stylosanthus sp.* and *Vigna hosei* (Balakrishnamoorthy and Kennedy, 1999) can be used to enrich and conserve the soil. The basins of productive trees are to be mulched with dry leaves at the end of rainy season to conserve moisture (Pillai, 1973a; Rao, 1991; Sharma and Singh, 2000). As the branches of full grown up trees have a tendency to over crowd, thinning them occasionally may keep growth within manageable proportion. Dead and diseased shoots should also be removed periodically (Pillai, 1973b; KAU, 1993).

### Manuring

Clove trees are to be manured regularly and judiciously for their proper growth and flowering (Sivaraman, 1970; Martin, 1990). About 15kg of well rotted cattle manure or compost may be applied per plant in the initial stage. The quantity should be increased gradually so that a well established tree of 15 years and more should get 40-50 kg of organic manure. Fish and prawn refuses are used as manure (Pillai, 1972). Clove responds to application of inorganic fertilizer. Shanmugavelu and Madhava Rao (1977) suggested application of 50 kg compost,

one kg each of ammonium sulphate, superphosphate and muriate of potash for bearing clove trees, where as Nair (1979) recommended 40-50kg cattle manure or compost, 150g nitrogen, 125g phosphorus and 375g potassium per plant for bearing trees of 15years old and above. Nutrient removal by adult clove tree showed the following trend.  $K > N > Ca > Mg > S > Mn > P > Fe > Cu > B > Zn$  (Nazeem, 1989). The Kerala Agricultural University has recommended a fertilizer schedule of 20:18:50g of NPK per year during the first year of planting which is to be gradually increased to 300:250:750 g NPK/plant/year from 15<sup>th</sup> year onwards (KAU, 1993). Addition of 50g each of *Azospirillum* and *Phosphobacteria* along with 100 kg of FYM and 400:350:1200 g of NPK per tree per year is advantageous as per the recommendation of Kennedy and Balakrishnamoorthy (2000). Nazeem (1989) has described the nutrient deficiency symptoms in clove. Gnanadas (1989) standardized the index leaves for assigning the nutritional status of clove in relation to soil fertility.

The fertilizers are to be applied in 2 equal split doses, first in May- June along with the organic manures and the other in September – October. For manuring shallow trench to a depth of 10-15 cm is dug around the plant about 1-1.5 m away from the base or a radius roughly equal to canopy spread and manures and fertilizers are scattered (Pillai, 1973 b).

### Irrigation and Water management

Irrigation is necessary in the initial stages up to 2 years. Although the trees can survive without irrigation, it is advantageous to irrigate grown up trees also on all non rainy days for proper growth and yield. Each plant requires not less than 30 litres of water per day (Pruthi, 2001). Dripping of eight litres of water/plant/day through drip irrigation system is highly useful for the enhancement of growth and yield (TNAU, 1996).

### Soil moisture conservation

If the clove garden has been raised in slopes, terraces are to be formed along the contour with 1.5m wide inward slope. These terraces are to be reformed once in 13years and if possible, all the terraces, are to be strengthened by contour wall. This measure will protect the wash of rich top-soil, avoid formation of gullies and improve moisture

condition of the ground. In addition to that, the terraces supported by contour wall will provide a permanent level ground which will be much more convenient for watering and for all other cultural operations (Pruthi, 2001).

### Plant Protection

The insects attacking clove are mainly the black scale (*Saissetia nigra*), masked scale (*Mycetaspis personata*), green scale (*Lecanium sp.*) and the mealy bug (*Pulvinaria psidii*) (Abraham *et al.*, 1970; Nair *et al.*, 1978; Vishalakshi *et al.*, 1981; Chandramani *et al.*, 2001). The infestation could be managed by removal and destruction of affected leaves followed by application of demethoate 2 ml/l or monocrotophos 1.5 ml/l. (Nair *et al.*, 1978; Vishalakshi and Mohandoss, 1986; Vidyasagar *et al.*, 1989; Rema *et al.*, 2004).

The other insects reported to infest the crop include crickets, leaf eating caterpillars and termites that damage nursery plants. Coffee stem borer (*Zeuzera coffeae* and teak sapling borer (*Sahyadrassus malabaricus*) are reported to damage the adult trees (Simpson, 1970; Kannan, 1972; Nair *et al.*, 1978; Kumaresan *et al.*, 1988, TNAU, 2006). Soil application of phorate @ 60g/ tree or trunk implantation of monocrotophos 1ml/tree was found to be effective for the management of stem borer (TNAU, 2006).

The most serious disease of clove is the sudden death-disease caused by *Valsa eugeniae*. For the management of this disease cut off the branch cleanly below the infected area and paint the cut surface with copper oxy chloride paste (Rajappan *et al.*, 2000).

Leaf rot, leaf spot, seedling wilt, little leaf and twig blight are some of the other important diseases (.Balasubramanyam, 1957; Jose and Paily, 1966; Nair *et al.*, 1977; Sharma and Nambiar, 1978; Wilson *et al.*, 1979; Wilson and Vijayan, 1980; Karunakaran and Nair, 1980; Karunakaran *et al.*, 1980; Saikia and Sarbhoy, 1981; Chandramohan and Kaveriappa, 1986)

Leaf rot caused by *Cylindrocladium quinqueseptatum* is noticed both in the nursery as well as in grown up plants. In nursery the disease becomes severe occasionally resulting in heavy defoliation and death of seedlings. Removal of the affected seedlings and timely spray with 1%

Bordeaux mixture or 0.2% carbendizim reported to keep the disease under check (Sharma and Nambiar, 1978; Wilson *et al.*, 1979; Rema *et al.*, 2004)

The mortality of seedlings due to seedling wilt in the nursery was reported to range from 5-40%. Several pathogens (*Rhizoctonia bataticola*, *Cylindrocladium sp* and *Phytophthora sp.*) were reported to be responsible for this disease (Nair *et al.*, 1977). Spraying of 1% Bordeaux mixture/ Copper oxy chloride is reported to control the disease effectively (Joshi and Raut, 1995)

*Gloeosporium sp*, *Colletotrichum sp*, *Corynespora cassiicola* were recorded in clove which cause leaf spots (Saikia and Sarbhoy, 1981; Chandramohan and Kaveriappa, 1986; Suharbon, *et al.*, 1990). *Glomerella cingulata* is reported to cause twig blight and flower shedding (Joshi and Raut, 1992; Karunakaran *et al.*, 1980). Leaf spot and flower bud shedding can be effectively managed by pre monsoon spray of *Pseudomonas fluorescens* 0.25% along with 5% *Lawsonia* leaf extract (TNAU, 2006)

### Harvest yield and Post harvest Handling

Clove trees flower from fourth year onwards under good management conditions and full bearing stage is reached only after 15 years (Palani, 1988; Kumar *et al.*, 1993). Flowering season varies from September-October in plains to December-January at high altitudes. Flower buds are produced on young flush and it takes about 4-6 months for the buds to become ready for harvest. Flower buds are harvested when they turn pink (Pillai, 1973 b). Clove oil obtained from flower buds, harvested at lower maturity stages has more of eugenol acetate and less of eugenol (Gopalakrishnan *et al.*, 1982) Harvesting is done using a stepladder and care must be taken not to break the branches. Three to four kilograms of dried buds can be harvested on an average from 15-20 year old clove trees (Palani, 1988; Krishnamoorthy, 1998). For harvesting seed, the optimum time has been identified as 78-91 days after fruit set (Nair, 1979).

The harvested flower buds are separated from the clusters by hand and spread in the drying yard for drying. It takes normally 4-5 days for drying. Fully dried buds develop characteristic dark brown colour, crisp and not contain more than 12% moisture. The dried buds yield 14-21

per cent oil which contains 70-90% eugenol and 5-12 % eugenol acetate (Gopalakrishnan *et al.*, 1982).

### CONCLUSION

The literature reviewed in this paper highlighted the improved production protocol for

clove. Since, increasing productivity and extending area to non traditional regions are going to be the major thrust areas for the future; all these emerging positive developments provide strength to profitable clove farming and to meet the challenges of global competition.

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