TREE SPECIES USED AS SUPPORTS FOR BLACK PEPPER (*Piper nigrum* L.) CULTIVATION

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Abstract

The use of reliable supports (standards) for the successful establishment of black pepper plantations is a common practice in producing countries. Standards are of two types, living and non-living. The use of non-living (dead) standards (reinforced concrete posts, granite pillars and teak poles), though often resulting higher black pepper yields, is less widely practiced, mainly due to the high capital investment required. Therefore, cultivation of black pepper in producing countries is generally done by trailing the vines on live standards. A variety of trees are used as living standards. The most common ones are *Erythrina indica*, *E. lithosperma*, *Gliricidia sepium*, *Leucaena leucocephala* and *Garuga pinnata*. Other trees used are *Ailanthus malabarica* in lower altitudes and *Grevillia robusta* at higher elevations. In the homesteads of India, black pepper is mostly grown using standards such as mango, jackfruit, coconut, arecanut etc and when interplanted in cardamom and coffee plantations, pepper is trailed on shade trees such as the silver oak (*Grevillea robusta*) or natural forest trees of that locality. Various tree species used as supports, their effects on yield and their management for black pepper cultivation are discussed.

Keywords: *Ailanthus*, *Erythrina*, Live supports, *Piper nigrum* L., Tree species.

Introduction

In most producing countries, black pepper is a smallholders' crop and more than one million farmers depend on it for their livelihood. Cultivation varies from intensive monoculture to extensive homestead gardens. In India, 95% of production is from homesteads (Nair and Sreedharan, 1986) with promiscuous planting of black pepper along with perennials (Kandiannan *et al.*, 1988).

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It is well known that black pepper vines require a reliable support for proper growth, development and yield. These supports are usually called standards. Providing ideal support, therefore, plays an important role in successful establishment of black pepper holdings. In the homestead farms of India, black pepper is usually trained on arecanut and coconut trees, on shade trees in coffee and tea plantations and on avenue trees. A variety of trees are used as live standards for black pepper cultivation in India, Sri Lanka, Malaysia, Philippines, Indonesia and other pepper producing countries. However, not all are considered ideal. The ideal living support should have the following traits (Sivaraman *et al.*, 1999):

(i) Should establish easily and grow rapidly to provide shade and support the establishment of the crop;

(ii) Should be able to tolerate regular and heavy pollarding/ pruning ;

(iii) Should not compete for resources with the pepper plant;

(iv) Should not harbour pests and diseases;

(v) Should have a deeper root system without being allelopathic in the pepper rhizosphere;

(vi) Should have rough bark, strong enough to support the cling roots of pepper;

(vii) Preferably should provide useful products at the end of the pepper cropping cycle.

In this paper, we provide a short review on the various standards used for trailing black pepper in the producing countries. Published literature on interaction of tree species with pepper is scarce. However, from the literature available, we have attempted to identify the tree species that would serve as ideal supports for black pepper.

Current Scenario

The standards used for trailing black pepper vines are of two types, living and non-living. The non-living standards used include reinforced concrete posts, granite pillars and teak poles. Such non-living standards have been used in Malaysia, Brazil and Bangka in Indonesia (George, 1981), facilitating closer spacing and higher yields (Menon *et al.*, 1982; Kurien *et al.*, 1985; Reddy *et al.*, 1992). However, because of the high capital investment required for dead standards and because they are less easily available, a majority of pepper growers now resort to live standards. In Malaysia and parts of Indonesia, the preferred support material is the wooden pole of the Belian tree (*Eusideroxylon zwageri*, Lauraceae) otherwise called Borneo Ironwood, which is a high density, heavy, construction timber resistant to white ants. The ironwood poles are very durable and can remain undamaged for many years.

Dead standards are not used in India, though trials have shown that pepper trailed on teak poles gave higher yield (Menon *et al.*, 1982). The use of reinforced concrete (RCC) posts at closer spacing (2.0 X 1.0 m) accommodated 5000 plants per hectare and recorded higher yields (Reddy *et al* 1992). However, farmers have not adopted this technology because of the higher investment required. Reports from Indonesia indicate that RCC poles are not good for trailing pepper. Wahid and Sitepu (1987) observed poor growth and productivity in pepper trailed on concrete poles. Apparently concrete poles are likely to heat up during summer resulting in drying of clinging roots and, therefore, register poor crop growth under exposed conditions (Sivaraman *et al.*, 1999). Instead, in Lampung, Indonesia, live tree supports such as erythrina and gliricidia are commonly used as standards with planting distances of 2 m x 2 m or 2.5 m x 2.5 m (Zaubin and Manohara, 2004). Similarly, in Sri Lanka and Philippines only live standards are used. In Sri Lanka, gliricidia is the most common support tree. In addition to providing support, the shade provided by gliricidia is essential for growth of young pepper vines and reduces stress for mature vines during dry periods (Gunaratne and Heenkenda, 2004). In the Philippines, gliricidia, leucaena, erythrina and acacia are the most commonly used live standards (Sadanandan, 2000).

Various methods of cultivation have been described using live supports. Extensive cultivation systems prevail in India, Indonesia and in Madagascar on naturally fertile soils with shade trees as supports. Intensive cultivation is common in Malaysia, Indonesia and Brazil (Kandiannan *et al.*, 1998). George (1981) observed similarities in black pepper cultivation in India, Madagascar and Lampung in Indonesia where live supports are used at a wider spacing. This decreases plant population and yield, whereas in Malaysia, Brazil and Indonesia, dead wood supports are used, facilitating closer spacing resulting in higher yields. More recently, however, higher cost and scarcity of suitable dead wood has forced farmers to shift to live supports (Azmil and Yan, 1993; Varughese and Ghawas, 1993; Wong and Paulus, 1993).

The commonly used tree species for black pepper cultivation and their relevant details are provided in Table 1, from which it is apparent that a variety of trees are used as living standards (Wardell 1991; Salam *et al.*, 1991). Some of the common living standards used are *Erythrina indica* Lamk., (current name: *Erythrina variegata* L), *E. lithosperma* Blume ex. Miq., *Garuga pinnata* Roxb., and *Gliricidia sepium* (Jacq.) Steud. Also used are *Ailanthus malabarica* (current name-*Ailanthus triphysa)* in the lower altitudes and *Grevillia robusta* in the higher elevations.

Management of Live Standards

Seedlings are preferred to rooted cuttings for raising live standards, since seedlings have a tap root system and do not compete with black pepper for resources. Living standards should be planted 3 - 4 years in advance so as to attain sufficient height at the time of planting of black pepper (Sivaraman *et al.*, 1999). The stems/stem

cuttings of the suitable standard are prepared from March to April and stacked in shade. The stacked stems start sprouting in May. After the first rain in May or June, the sprouted stems are planted at the edge of the pits dug for planting pepper vines. Seedlings of subabul and silver oak are to be planted 2-3 years before planting pepper.

The cuttings of standards are planted in narrow holes of 40 to 50 cm depth. The spacing recommended is 3 x 3 m on flat land. On sloping land, there should be 2 m between plants in rows across the slope with 4 m between rows. The soil should be well pressed around the standards to avoid air pockets and to keep the standards firm in the soil. Whenever *Erythrina indica* is used as standard, carbofuran @30g may be applied once each year to control nematodes and root grubs (Kerala Agricultural University, 2002).

During establishment, the side branches are pruned to enable the standard to grow erect. After complete establishment, periodical pruning is important to allow sufficient light penetration into the black pepper canopy (Sivaraman *et al.*, 1999). Shade regulation of live standards is an important cultural practice during rainy or cloudy weather, to allow sufficient light for crop growth; otherwise a 50% reduction in yield is not uncommon. Normally pruning of live standards is carried out a week prior to fertilizer application. At the beginning of the rainy season, heavy pruning is done, leaving only one or two twigs at the top of the trees. At the end of the rainy season, a moderate pruning is carried out, leaving three or four twigs at the top of support trees (Zaubin and Manohara, 2004). (Ramadasan, 1987). Since the photosynthetic pathway in black pepper is C3 (Das *et al.*, 1976), it essentially requires 50-75% light intensity for optimal growth (Wahid, 1984). In Lampung, Indonesia, support trees are pruned only at the beginning of the rainy season (Zaubin and Manohara, 2004). This seriously hampers diffusion of light to the black pepper vines, thereby reducing plant metabolism and nutrient absorption, which is why pruning of live standards a week prior to fertilizer application is recommended. Pruning reduces leaf density on the live support and stimulates growth of new leaves, which reduces root activity and places the support trees in a weaker position to compete for light, water and nutrients, relative to the pepper vines (Zaubin, 2002).

Discussion

Though earlier studies on appropriate standards for black pepper cultivation are very few, available literature indicates that the selection of standards varies with location. In the State of Kerala (India), more than 80% of the pepper holdings belong to the small (<0.5 acre) and the medium (0.5 to 2.00 acres) categories. Here, black pepper is mostly grown as a homestead crop using standards such as mango, jack fruit, arecanut, coconut, etc.

Such standards, however, are not ideal for establishing large plantations under organized cultivation, as a monocrop, at the normal spacing of 2.5 x 2.5 m. Therefore, on a plantation scale, *Erythrina indica* is the common live standard planted for trailing pepper. Around 31 tree species that support the growth of pepper have been identified under homestead agroforestry in Kerala, India (Salam *et al.*, 1991). Among these, the most popular live standard is *Erythrina indica*. Other common standards used are *Garuga pinnata*, *Gliricidia sepium*, *Leucaena leucocephala*, *Ailanthus malabarica* etc. Less common support trees include *Mesopsis eminii*, *Leucaena leucocephala*, *Pajanalia rheedii*, *Macaranga peltata*, *Salmalia malabarica*, mango and jack.

When interplanted in cardamom and coffee plantations, pepper is trailed on forest trees. In Coorg, in the Chickmagalur area of Karnataka State, which is the second largest producer of pepper in India, pepper vines are allowed to climb on shade trees in coffee plantations. Pepper is cultivated both as a pure and mixed crop along with arecanut in the plains of Uttar and Dakshin Kannada districts. In Andhra Pradesh, a newly emerging pepper growing region in India, pepper vines are allowed to climb on coconut and oil palm trees.

Raising black pepper on such live standards reduces the capital cost, apart from increasing productivity on a long-term basis (Azmil and Yau, 1993; Varughese and Ghawas 1993; Wong and Paulus, 1993). However, under organized monocrop cultivation, where black pepper is planted at a spacing of 2.5 x 2.5 m, the use of live trees at wider spacing decreases plant population and yield (George 1981). Kurien *et al.* (1994) recorded the highest competition between living standards and black pepper at a closer spacing of 2 x 2 m.

Contradictory reports, however, exist on the effects of various standards on black pepper yield. Sadanandan *et al.* (1992) reported that pepper plants trailed on *Erythrina indica* yield better than those trailed on other standards. However, erythrina suffers from several inherent drawbacks. Firstly, it is more of a surface feeder and its feeder roots extend laterally over 60 cm into the pepper vine rhizosphere (Sankar *et al.*, 1988). Secondly, the tree is often susceptible to root grub and root knot nematode infestation; thirdly it is prone to wind and wild animal damage and lastly, the tree sheds its leaves during summer exposing the vine to the scorching sun.

In a study on absorption and partitioning of applied ^{15}N in a black pepper with erythrina system in Kerala, India (Wahid et al., 2004) it was found that the fertilizer use efficiency in black pepper vines was very low, ranging from 6-12%. Contrarily, the contribution of applied urea towards N uptake by erythrina support trees was 24-40%. Poor utilization of the applied N by the vine was mainly attributed to severe root competition from erythrina.

Since black pepper remains productive for more than 15 years, reestablishment of a mature vine on a new support following collapse of the earlier support is very difficult. Hence, selection of the standard assumes great significance.

Subsequent studies indicate that ailanthus is a better standard compared to erythrina (Rajagopalan and Mammootty, 1996; Kandiannan *et al.*, 1988). The study conducted by Rajagopalan and Mammootty (1996) indicated that pepper vines trailed on ailanthus produced the maximum number of spikes per vine (1279.3), followed by gliricidia (909.0) and erythrina (783.3). Pepper trailed on ailanthus also registered significantly greater green berry and dry pepper yield (Table 2). In fact dry pepper yields in ailanthus plots were higher by 48.9% compared to erythrina.

At high elevations, *Grevillia robusta* (silver oak) is the most commonly used standard, especially where pepper is intercropped with coffee. A study conducted at Madhikeri (Karnataka State, India), a high altitude region, recorded the yield of black pepper (Panniyur-1, mix-cropped with robusta coffee) in the eighth year of planting on four species of standards (Korikanthimath and Ankegowda, 1999). The standards were *Erythrina lithosperma* Bl. Ex Miq. (uniform small trunk diameter of 30-40 cm), *Ficus glomerata* Roxb. (medium trunk, diameter of 40-60 cm), *Grevillea robusta* A. Cunn. (very rough trunk surface, diameter of 40-50 cm), and *Terminalia bellerica* Roxb. (huge tree, 95 cm in diameter). The study revealed that black pepper yield was significantly higher with vines trailed on *T. bellerica* and lowest with vines trailed on *E. lithosperma* (Table 3). The study further indicated that the total surface area available for the vine to cling to the support trees and the distribution of sunlight under the trees are important factors influencing yield for black pepper trailed on live supports. Vines trailed on *G. robusta* yielded 19.16 kg per vine, suggesting that it can also be recommended as a suitable standard in high altitudes and for high density planting of black pepper.

A study was conducted by the Academy of Finland in East Usambaras, Tanzania to examine present cultivation practices, to record the support tree (ST) species used and their effects on the success of black pepper production (http://honeybee.helsinki.fi/mmeko/vitri/studies/theses/hvihemaki.htm). Altogether 77 tree species were used as living supports for black pepper in 27 farms, located in three villages and on two elevational regions. The most common tree species used were *Cedrela odorata* and *Toona ciliate*, both belonging to the *Meliaceae* family. Together they represented nearly 50% of the number of support trees on the farms studied. Other common species were *Gliricidia sepium*, forming 14% of supports at the lower altitude, and *Spathodea campanulata*, forming 34% of supports at the higher altitude. Of the tested species, black pepper's viability was best with *G. sepium, M. excelsa and C. odorata.* With the two species belonging to the *Meliaceae* family, the viability was best with the trees smallest in diameter, whereas with *S. campanulata,* black pepper succeeded best with the tallest trees. Of the support tree species used, *G. sepium* has also been recommended as live support for the higher elevations.

Conclusions

The use of live standards for trailing pepper is significant for good yield, but the task is relatively complex and needs careful management (Zaubin and Manohara, 2004). The intricacies involved in the interrelationships between the various components, which include pepper vines, live support, light intensity, nutrient requirement and pest and disease management need to be managed effectively to maximise yields. The little published literature available suggests that *Ailanthus malabarica* is a better standard compared to the commonly used *Erythrina indica* in the lower elevations of India, while at higher elevations silver oak (*Grevillea robusta*) and dadap (*Erythrina lithosperma*) can be successfully used as standards. In Sri Lanka, Indonesia, Malaysia and Philippines, *Gliricidia sepium* and to some extent *Erythrina indica* are commonly used. Comprehensive studies on various facets of tree species-pepper interaction are, however, required to pinpoint the ideal living standard for black pepper cultivation in various locations.

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