Intercropping of Maize with Mango and Teak- An Overview

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Abstract

Agroforestry is a collective word for all land-use practices and systems where woody perennials, annual crops, or animals are deliberately grown/raised on the same land management area. For intercropping, the crops in focus were major export cash crops like bananas, coffee, cocoa, coconuts, rubber, and oil palms. Mango and Teak form a potential component in many agroforestry systems due to its versatility play a key position in multistory, multispecies systems such as tropical traditional home gardens. Mango and maize crop is intercropping because of improved soil fertility and reduced soil erosion of surrounding soil. This combination may be recommended for maximizing and doubling the farmer's income.

Keywords: Agroforestry, intercropping, mango, soil.

Introduction

ICRAF in 1981 defined Agroforestry as "a collective word for all land-use practices and systems where woody perennials, annual crops/or animals are deliberately grown/raised on the same land management area". The importance of agroforestry models in the agricultural sector has been more because it promotes and increase the land utilization ratio in farmers' fields. According to Ong and Huxley, (1996), Agroforestry was defined as adapted, researched, and promoted land use. The main focus in the first category was based on limited intercropping with monoculture production. Intercropping is one of the land utilization techniques for optimum production (Bhattanagar*et al*., 2007). Experimental evidence, too, proved the more excellent yield stability than the sole cropping.For intercropping, the crops in focus were major export cash crops like bananas, coffee, cocoa, coconuts, rubber, and oil palms. Sometimes, crops like papaya, mango and vanilla were used, but to a lesser extent. At that time, several countries promoted these crops for smallholder production. This cropping proves to be beneficial in the future where intercropping of woody perennials with subsistence ground crops is equivalent to growing regular purpose crops with regard to agroforestry and agriculture. This intercropping model of Agroforestry with agronomical research and commercial agriculture products has been gaining importance to increase the land utilization ratio in the country.

Land use approach simultaneously increases livelihood security while reducing susceptibility to environmental and climatic changes. It is founded on resource optimization and long-term management in a geographical region. Agroforestry systems combine the production of food and animals with the growth of trees (Ashok *et al.* 2016). Agroforestry may be a viable choice for small-scale farmers if done correctly. Agroforestry systems often include two or more plant species and one woody perennial, and always provide two or more outputs. Each cycle frequently lasts more than a year, and even the most essential systems are more complicated than monocropping systems. This method uses low-cost, environmentally friendly technologies that help agricultural communities in terms of the environment, economy, and social well-being. Outside the forest, India has 14,224 million to 24,602 million trees that cover an area of 17 million hectares and provide 49 percent of wood for fuel and 48 percent of lumber consumed annually. This is a fantastic resource for various things, including food production, fuelwood, and other items including lumber, fodder, food, fruits, cattle, and bioenergy. Given the potential scope of agroforestry in India, the area might be expanded to 25.36 million hectares from the existing 7.45 million ha during the next two decades, contributing to the augmentation and stabilization of output.

Agroforestry is the imitation of natural ecosystems in terms of function. Before intercropping commercial crops with Agroforestry, the time period was dominated by monoculture systems, which hid Agroforestry. To boost large-scale agricultural productivity in the industrialized world, intercropping in agroforestry has recently resurfaced. Intercropping under the agroforestry paradigm can assist restore damaged soil quality, preserving dryland crops, and offering commercial and forest goods (Nuberg *et al*. 2009).

They studied indigenous tribes in Brazil's Amazonian woods. They discovered that they used trees to diversify their agriculture and benefited from the goods and other services that resulted from this sustainable management. These practices are a collection of skills established by indigenous people through observation and experimenting. Home gardens are famous in the Lavrado (Savanas) area of Roraima, northern Brazil, and include many fruit-yielding plants and trees. From an ecological and biological standpoint, selecting suitable tree species is essential to the viability of such agroforestry systems. As part of silvopastoral systems, they also play an indispensable role. In Amazonia, 60 percent of native legumes are nodulating species, indicating that they have a lot of promise for agroforestry. Other tree species might be selected based on ecological or production purposes. However, cash flows must be considered for effective agroforestrysystems, and suitable species must be chosen appropriately (Pinho, 2012).

Andrade*et al.*indicated that legume species-*Stryphnodendronguianensis* has a positive effect on the production of forage and productivity of the soil. However, this canbe attributed to the tree's crown architecture, which does not create an excess of shade.

According to *Kashyap et al.* 2014, *Hippophaerhamnoides*(Sea buck thorn) is well known in Leh Ladakh, which is a cold desert ecosystem, attributing to its environmental benefits, desertification control, and land reclamation. It has resulted in the development of a sea buck thorn-based agroforestry system where its plantation is used as windbreaks. Its fruit pulp was sold at a whooping INR 14 million in 2007, also having medicinal value. It also serves to fix nitrogen by symbiotic association with microorganisms like*Frankia* to about 180kg/ha/yr. In a Hyper Arid ecosystem, the zone is dominated by the presence of*Lasiurus sindicus* grassland with a few shrubs or trees. The primary source of income is based on livestock. Here, 20-30 quintals per hectare of dry fodder is produced even in scanty rainfall due to resprouting of*L. sindicus* and if appropriately reseeded, then 40-45 quintal per hectare fodder can be harvested by cultivating guar in between grass rows. Using this grass legume system, the productivity of livestock can be increased.

Satish and Kushalappa (2007) studied the coffee-based agroforestry systems of Kodagu, Karnataka. In the coffee plantations of the district, most species of treesused for shade occur naturally. Recently, a few exotic tree species *viz*., *Greveliarobusta*,*Acrocarpusfraxinifolius*have been planted with coffee. Results indicate that these trees support plenty of biodiversity and provide for much more timber. These coffee-based agroforestry systems have come to be known as Managed agroforestry.

Teak (*Tectona grandis*) is a high-value wood used to make furniture and other items. More than 95 percent of the world's natural and planted teak resources, as well as more than 80% of the world's cultivated teak resources, are found in Asia, with India (38 percent), Indonesia (29 percent), and Myanmar (9 percent) leading the way (Kollert and Cherubini, 2012). Teak wood has been in high demand across the world for some years. In the last 15 years, the FAO estimates that demand for all wood forms has surged by more than 50%. (FAO 2009). Producing high-quality wood that fulfills export requirements, which usually necessitates rigorous silvicultural management, is a great difficulty for small-holder teak farmers. Smallholder producers have a critical dilemma due to a lack of forestry management, knowledge, and skills connected to the current market incentive structure (Roshetko and Manurung, 2009). Most teak growers still rely on natural regeneration to maintain their plantations. The intercrops are the ones who are weeded and fertilized the most.

Most of the commercial cultivars of mango of India exhibit lower orchard efficiency as compared to many other fruit crops, giving an average yield of 8 to 10 tons/ha as against 20 to 40 tons/ha obtained from banana and grapes. Various limiting factors like lack of flower induction, alternate bearing, flower and fruit drop, malformation, adverse climate, insect pests, and diseases are lower orchard efficiency. All these factors limit the horizontal expansion of the mango crop. Therefore, it is necessary to generate additional income from per unit area of orchard land by growing suitable intercrops without any adverse effect on the health of orchard soil and bearing mango trees. Intercropping system has various advantages like insurance against failure of base crop, higher gross return per unit area, efficient use of environmental factors (light, water and nutrients), reduction in weed population, intensive utilization of labor throughout the year, protecting soil from erosion, diversity of diet and improvement of socio-economic status of growers. Besides, intercropping also provides more excellent stability in production and helps the farmers maintain the soil fertility level.

Most of the research work available on intercropping systems based on mango in irrigated conditions is done Bhuva *et al*. (1989) and Singh *et al*. (2003). Other than that, literature available about this is scarce. Therefore, in the present study, an experiment was conducted to determine the remunerative value of the mango-based intercropping system in the rainfed agro-ecosystem**.**

Maize intercropping with mango tree

Mango is often treated as the king of tropical fruits, having a dominant position in land use both in terms of diversity and extent. As it is a deep-rooted plant prefers deep soils. Mangoes are well adapted to cultivation and have been grown commercially for centuries as a source of fruit, medicine, fodder, firewood, timber, poles, and shade (Rocheleau*et al*., 1988).

Mango (*Mangifera indica* L.) thrives in intense light, grows at an average temperature of about 24-26°C, and requires minimum rainfall of about 1000 - 1200 mm. Mangoes are usually planted at broader spacing for higher fruit yields and provide ample scope for intercropping. During the early non–competitive phase of mango, various intercrops can be cultivated. Mango forms a potential component in many Agroforestry systems due to its versatility plays a key position in the multistory, multispecies systems such as tropical traditional home gardens. Mango-based agri–horticultural systems and alley cropping systems are proven to have improved land-use systems both economically and ecologically.

According to the research carried out by (Dennis *et al*. 2013) it was found that the maize yield output was more in agro-forestry system (11.06 kg/ha) than in non- agroforested areas (7.57 kg/ha). Litter from plants plays a crucial role in preserving the physical soil properties like aggregate stability and water holding capacity. A similar role is played by trees present in agroforestry systems that provide litter and plant residues, increasing the biological activity in the rhizosphere zone. Mango and maize crop is intercropped because a) Source of extra income due to sale of fruits of the mango tree, b) Improved soil fertility and reduced soil erosion of surrounding soil, c) Better nutrient cycling and more output of maize.

In comparison to maize monoculture, four more factors were researched like determining the effect of existing mango-maize intercropping systems on soil fertility, modeled erosion, run off and yield of maize and mango at field scale, assessing the difference in mango yield of current mango tree management and improved tree management and computing the economic payoffwhere it was found that agroforestry model produced higher biomass, yield and economic output (Hageman *et al.*, 2014).

Tiwari *et al.* (2018) studied mango cultivar Dashehari orchard and different crops in 3 other intercropping systems of mono, companion and sequential intercrops to identify the most suitable profitable intercrops. The trees were 7 years old and grown at the spacing of 7X7m, under rainfed conditions and in medium fertile, well-drained soils of black clay loam. The different intercrops grown weremaize, Bengal gram, pigeon pea, okra, tomato, black gram, mustard, cluster bean, soybean, cowpea and coriander. The highest net return in the study was calculated from the combination of mango + pigeonpea + tomato (Rs. 81077.50) which was followed by combination of mango + cowpea-bengal gram (Rs. 71677.13) and thirdly, mango + tomato combination(Rs. 67034.38).

Maize intercropping with Teak

Teak (*Tectona grandis*) is a member of the Lamiaceae family.It is a tropical hardwood tree species that commonly occurs in mixed hardwood forests and propagates *via* seeds.

The studies revealed that the overall maize yield in the first five years of teak growth increased 10–38 % when tree density was reduced. It was also seen that all the simulated intercropping practices resulted in a higher wood volume than in a monoculture. This was because the trees benefited from crop fertilization.

Pachas *et al*. (2019) conducted a study on the companion cropping model. The results indicated a normal to a below-average yield of maize when grown with Teak when the spacing between trees exceeded 8m length. When spacing was 8m, the maize yield was 2 t/ha. These results demonstrated that when the row spacing is between 8-10m, increased periods of companion cropping i.e. after 2-6 years after planting, can be achieved. It was also observed that growth rates of teak trees could be increased, individual tree volumes could be increased, thereby leading to decreased time to commercial harvest by using reduced initial stocking rates for Teak (i.e. below 1000 trees/ha).

In a study done byQuarkoo (2010), the results revealed that there was no significant correlation between Teak age and the intercrop spacing because it was seen that it did not produce any significant difference in treatment means in maize-height of plant, total leaf count, LAI (Leaf Area Index) and grain dry weight at 2 and 4 DOF (Degree of Freedom). However, the results revealed best crop biomass growth and dry maize grain yield was observed.

In Verinumbe (1985) study, an experiment was conducted on the effects on the soil of canopy and roots of coppiced Teak (*Tectona grandis* L.). The results demonstrated that during re-growth in a maize-teak mixture by trenching and coppice shoot control, N, K, Mg, and Ca content of soil were not significantly affected by either treatment throughout the first season of cropping the soil with maize. It was further reported that soil nutrient changes due to canopy or surface roots of Teak could least influence the performance of intercropped maize in the first season following coppicing.

Khasana *et al.* (2015) used a three-factorial design to study intercropped teak and maize in different densities with different spacing's, including initial teak density (1600 trees ha^{-1} (2.5 m 2.5 m), 1111 trees ha^{-1} (3 m X 3 m), and 625 trees ha^{-1} (4 m X 4 m), thinning intensity (light (25%), moderate (50%), and heavy (75%) of tree density), and pruning intensity (40 percent and 60 percent of crown biomass). When tree density was lowered in the first five years of teak development, cumulative maize output rose 10–38 percent. At an initial tree density of 625 trees ha^{-1}, maximum wood volume (m3 ha^{-1}) was attained with 25% of the crown thinned in year 5 and another 25% in year 15, with 40% of the crown trimmed in years 4, 10 and 15. It's also been stated that obtaining a larger stem diameter by additional thinning is rewarded with a better market price per volume of wood. The system with 50% thinning produced the highest net present value and return to labor in year 5, according to a profitability study that took into account the cost of labor (for maize production, thinning, and pruning) and its influence on extra wood income.

Conclusion

To maximise the benefits of synergy between crop and tree, trees can be used in a wide range of methods in agro-ecosystems. Generally, increased species diversity means more space above and below the soil. Also, litter variation can help maintain soil biodiversity and hence soil fertility. Aside from soil improvement and environmental benefits, many of their advantages are challenging to quantify immediately or overtime, which is why many farmers are still reluctant to invest in trees. Understanding the benefits of trees on agroforestry systems and their monetary, nutritional, and other economic worth is crucial to promoting tree use on farms. Land deterioration can be reduced via agroforestry. Existing systems are based on factual and non-quantitative local practitioner experiments. Institutional Agroforestry is a modern idea supporting public and private agroforestry enterprises. Export orders helped fund government expenditures and provided work for natives in India during colonial times. Mango and teak intercropping in a rainfed system can solve both issues.

References

1. Amadi, Dennis & Afo, Damasus & Sobola, Oluronke. (2013). Agroforestry Technique and Its Influence on Maize Crop Yield in Gombi Local Government, Adamawa State, Nigeria. *Journal of Agriculture and Veterinary Sciences*. 4. 52-55.
2. Ashok, ShantappaTirakannanavar, Vithal Navi, Ratnakar M Shet, ShivanandHongal, Raju Chavan, G.K.Halesh. (2016). Sustainable Silvi based cropping systems for improving socioeconomic status of horticulture farmers – A Review. *Int. J. Adv. Res. Biol. Sci.* 3(7): 99-104
3. Bhatnagar, P., Kaul, M. K. and Singh, J. (2007).Effect of intercropping in Kinnow based production system. Indian J. Arid Hort., 2:15-17.
4. Bhuva, H.P., Ktrodia, J.S., Patel, G.L. and Chundawat, B.S. (1989). Response of Intercropping on Economics and Effects on main crop of Mango under South Gujarat Conditions. *Acta. Hort.*231:316-320.
5. Hagemann, M. H., Roemer, M. G., Kofler, J., Hegele, M., & Wünsche, J. N. (2014). A new approach for analyzing and interpreting data on fruit drop in mango. *HortScience*, 49(12), 1498-1505.
6. Kashyap, S.D., Dagar, J.C., Pant, K.S, and Yewale, A.G. 2014. Soil conservation and ecosystem stability: Natural resource management through agroforestry in Northwestern Himalayan region. Agroforestry Systems in India: Livelihood Security & Ecosystem Services, *Advances in Agroforestry.* Springer India, 2014.
7. Khasanah, Y., Ratnayani, Ditahardiyani, P, Angwar, M., Ariani, D. Nutritional Characteristic of Enteral Food From Local Food, 2009, Prosiding Seminar Nasional Kimia dan Pendidikan Kimia, 634-638
8. Kollert, W. and Cherubini, L. (2012). Teak resources and market assessment 2010 (*Tectona grandis* Linn. F.). Food and Agriculture Organization, Rome.
9. Nuberg, I., George, B. and Reid, R. eds.(2009). *Agroforestry for natural resource management*. CSIRO publishing.
10. Ong and Huxley.(1996). Tree–Crop Interactions. A Physiological Approach, eds C. K. Ong & P. A. Huxley. xiv 386 pp. Wallingford: CAB International (1996).*The Journal of Agricultural Science. 128*(2): 247-249.
11. Pachas, A. N. A., Sakanphet, S., Soukkhy, O., Lao, M., Savathvong, S., Newby, J. C. & Dieters, M. J. (2019). Initial spacing of Teak (*Tectona grandis*) in northern Lao PDR: Impacts on the growth of teak and companion crops. *Forest Ecology and Management*, 435, 77-88.
12. Pinho, R.C., Miller, R.P., Alfaia, S.S. (2012). Agroforestry and the Improvement of Soil Fertility: A View from Amazonia. Applied and Environmental Soil Science Volume 2012, Article ID 616383, 11 pages doi:10.1155/2012/616383
13. Quarcoo, B. (2010). *Effect of Teak (Tectona grandis) on the Growth and Yield of Maize (Zea Mays) at Different Inter-Crop Spacing* (Doctoral dissertation).
14. Rocheleau, D., Weber, F., Field-Juma, A.(1988).Agroforestry in dryland Africa. International Council for Research in Agroforestry, Nairobi (Kenya)
15. Roshetko, J.M., G.S. Manurung. (2009). Smallholder teak production systems in Gunungkidul, Indonesia. Poster. Second World Congress of Agroforestry, Nairobi.
16. Satish BN, Kushalappa CG (2007) Agroforestry systems of Karnataka – an overview. In: Agroforestry Systems and Practices. Sunil Puri and Pankaj Panwar (eds). New India Publishing agency, New Delhi, pp.451-457.
17. Singh, T.P. (2003) Potential of Farm Forestry in Carbon Sequestration. Indian Forester 129: 839-843.
18. Tiwari, P., K. S. Pant, A. Guleria and R. P. Yadav. (2018). Socioeconomic characteristics and livelihood of agroforestry practitioners in north-west Himalayas, India. Range Management and Agroforestry 39: 289-295
19. Verinumbe, I., & Okali, D. U. U. (1985). The effect of coppiced teak regrowth on soil in a teak-maize agroforest. *Forest Ecology and Management*.*12*(1): 37-41.