

Original Research Article

Productivity and soil fertility status of Mango-Based Agroforestry System in Red and Laterite Zone of West Bengal

ABSTRACT

Aim: To find out suitable mango based agroforestry system.

Design: Randomized block design

Place and duration of study: Field experiment was conducted during 2015 and 2016 at Regional Research Station, Red and Laterite Zone, Bidhan Chandra Krishi Viswavidyalaya, Jhargram, West Bengal.

Methodology: The experiment involves fruit tree mango and silvi species lamboo and three arable crops viz. Pigeon pea, maize and lady's finger. The fruit plant was planted at a spacing of 10m × 10m (100 plants/ha) and lamboo were planted within the two fruit plants (300 tree/ha).

Results: Yield of mango (450 kg ha⁻¹) and lamboo (2 m³ ha⁻¹ year⁻¹) were highest when they are intercropped with pigeon pea followed by maize at the time of end of experiment.

yield of arable crops was highest during the second year when compared to first year. Studies of the soil fertility revealed that the percentage increase in available N (26.7%), P₂O₅ (30.09 %) and K₂O (12.47 %) as well as organic carbon percentage (21.74 %) were observed under all mango based agroforestry system and maximum productivity with better soil health improvement was under intercropped with pigeon pea.

Conclusion: That incorporation of pigeon pea in mango based agroforestry system will improve crop yield as well as soil fertility status.

Key words: agroforestry systems, intercrops, mango, fruit yield, soil fertility

1. INTRODUCTION

Agroforestry system is the traditional practice of growing trees on farms for the benefit of arable crops, fruit trees and silvi component. Agroforestry was brought from the main of indigenous knowledge into the forefront of agricultural research less than two decades ago, and was promoted widely as a sustainability-enhancing practice that combines the best attributes of forestry and agriculture. According to Dhyani *et al.* (2013) in India the current area under agroforestry is estimated at 25.32 m ha, or 8.2% of total geographical area of the country. Growing trees along with crops and livestock was postulated to enhance crop yield, conserve soil and recycle nutrients while producing fuel wood, fodder, fruit and timber. The different cropping sequences have been verified for producing desired level of production by raising different crops which can be grown successfully underneath fruit plant and tree early stage of growth due to less competition for natural resources like air, sunlight, moisture and nutrients (Pathak and Pathak, 2001).

Mango is one of the most important and widely cultivated tropical fruits of the world. In India the plant start bearing 4 to 5 years after planting and reach their maximum bearing capacity within 12-15 years after planting. The mango plants when planted at a spacing of 10m provide an ample scope for growing of short duration crops as intercrops during initial years. The inter row space in mango remains underutilized in the early growing period and during which short duration, location specific and market driven crops may be grown as intercrops and filler crops thus, allowing one to grow more than one crop and also to efficiently utilize the space and other natural resources. The intercrops not only generate an extra income but the practice also helps to check the soil erosion through ground coverage and improves the physico-chemical properties of the soil. Intercropping is one of the techniques of land utilization for optimum production (Bhattachanagar *et al.*, 2007; Giri Rao, 1999).

The fundamentals of agroforestry are combination of agricultural crops and horticultural crops with no damage and get high value attention for increasing productivity. Although intercropping in horticultural trees is practiced due to neither economic condition nor research result are available (Tejwani, 2008). Appropriate intercropping with combinations of arable crops and trees in agroforestry systems of immense importance for bringing in quick returns during first few years increase farm yields. It can yield positive results only if positive interactions outweigh the negative interactions (Singh *et al.*, 2013). Keeping above facts in view, a field experiment was undertaken to develop a mango-lamboo based agroforestry system for Red and Laterite Zone of West Bengal.

2. MATERIAL AND METHODS

2.1. EXPERIMENTAL SITE:

A field experiment was conducted at Regional Research Station (Red and Laterite Zone) of Bidhan Chandra Krishi Viswavidyalaya at Jhargram, in two consecutive years of 2015 and 2016. The experimental site was situated at 22.5° N latitude and 87.0 E longitudes and at an elevation of 78.77m above mean sea level. The experiment was carried out, where the soils are coarse textured and acidic (pH 5.5) and poor in organic matter, available phosphorus, potassium and lime content, and highly susceptible to erosion hazards. About 90% of the annual rainfall was received from June to last week of September.

2.2. EXPERIMENTAL DESIGN AND TREATMENTS:

The experiment was laid out in Randomized Block Design having 6 different farming-system models with four replications. The AFS treatments details: (T₁) *Dysoxylum binectariferum* (Lamboo) + Mango + Pigeon pea; (T₂) Lamboo + Mango + Maize; (T₃) Lamboo + Mango + Lady's finger; (T₄) Lamboo + Mango; (T₅) Sole Lamboo and (T₆) Sole Mango. One-year-old saplings of mango (Amrapali) were planted during July, 2009 at 10 m spacing. At the same time, 2 months old saplings of Lamboo were planted in between 2 fruit crops (300 trees/ha). Three arable crops viz. Pigeon pea (var, UPAS 120), Maize (var, Kanchan -K-25) and Lady's finger (Parvani Kranti) were grown under mango-based Agroforestry System during rainy (Kharif) season of 2015 and 2016. Inter crops were grown with Systematic approaches of agronomic package of acquisition practices.

2.3. SAMPLING AND STATISTICAL ANALYSES

Different growth parameters of silviculture tree / fruit tree (height, diameter at breast height / basal diameter and fruit yield) were recorded. The volume yield calculation (for tree species) was done by quarter girth formula postulated by Chaturvedi and Khanna (1982). Soil nutrient buildup in terms of available nitrogen, phosphorus, potassium and organic carbon was measured from each treatment after the completion of two cycles of inter cropping following standard procedures. Economics of the system were calculated on present price of inputs and outputs. The data collected during both the years of experimentation were analyzed following the method of analysis as described by Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1. TREE GROWTH AND FRUIT YIELD

Experimental result showed that all the growth attributing characters of Lamboo were on higher side where the crops were cultivated in the inter-spaces in mango-based agroforestry system as compared to trees under control (sole cropping of lamboo and mango) and thus exhibiting a positive effect of intercropping on tree growth. Table-1 represents the different growth characters of Lamboo viz. height, diameter at breast height (dbh) and volume yield were increased under agroforestry system. Maximum height, dbh and volume yield of the tree (6.52 m, 3.99 cm and 2.00 m³ha⁻¹year⁻¹ respectively) were obtained with Lamboo + Mango + pigeon pea agroforestry system model closely followed by Lamboo + Mango + Maize and Lamboo + Mango + Lady's finger agroforestry system model during November, 2016. Whereas least height, dbh and volume yield were recorded in case of sole tree plantation (3.84m, 2.22cm and 0.60 m³ha⁻¹year⁻¹ respectively) during November, 2016. Table-2 represents Mango tree height and yield, which were increased under agroforestry system. Maximum height and yield of the tree (4.44 m and 450 Kg ha⁻¹ respectively) were obtained with Lamboo + Mango + pigeon pea agroforestry system model closely followed by Lamboo + Mango + Maize and Lamboo + Mango + Lady's finger agroforestry system model during July, 2016. Whereas least height and yield were recorded in case of sole tree plantation (2.50 m and 296 Kg ha⁻¹ respectively) during July, 2016. The increment of growth was on higher side where the crops were cultivated in the inter spaces in mango-based agro-forestry systems compared to trees under control and thus exhibiting a positive effect of intercropping on tree growth. The results were corroborated with the findings of Gill and Ajit (2005). Under rainfed situation, fruit tree based framing system

resulted in reduced risk. Singh (1997) observed that intercropping of rainfed legume crops in ber orchard at Pali in Rajasthan gave 3 times higher yield as compared to sole crops.

3.2. INTERCROPS YIELD

Yield of intercrops grown under different mango-based agroforestry systems were slightly increased in second year (2016) as compared to first year (2015) (Table 3). Yield was increased by 31% in pigeon pea, 120% in both Maize and Lady's finger. Evidence from any agroforestry system is one option with multifunctional value of multiple benefits. The result corroborated with that of Khattak *et al.* (1981) and Wannawong *et al.* (1991).

3.3. SOIL NUTRIENT BUILDUP

Investigation of plant-soil interactions in different AFS components are organic C, soil N, P and K nutrients compared with the different AFS components model E and F of tree and fruit tree alone at the end of study in 2016 (Table 4). Under mango-based agroforestry system model, the soil N improved from 8.0 to 26.7 %, soil P from 5.77 to 30.09 %, soil K from 2.11 to 12.47 % and organic C from 0.37 to 0.46 % during the 2 years. The fact that interaction between tree species and legume crop helps to improve the fertility status of the soil. The findings are in conformity with Biswas *et al.* (2003). Rangasamy *et al.*, (1994) and Jayanthi *et al.*, (2003) reported the effect of integration different components along with cropping for better utilization of resources. The increase in available nitrogen might also be due to fixation of atmospheric nitrogen through increased enzymatic and microbial activity in the rhizosphere by the aforesaid legume crops and release of bound nutrient after their decomposition in the soil Swain (2014). The increase in the availability of phosphorus content in the soil by intercropping might be due to increase in the total micro-flora population, particularly phosphorus solublizers in the rhizosphere of plant. More or less, similar findings on beneficial effect of intercropping in increasing phosphorus availability in the soil have been reported by Swain and Patro (2007) and Dhiman (2001).

3.4. ECONOMICS

Fruit crops are deep rooted, hardy and tolerant to abnormal monsoon e.g. early or late onset, intermittent dryspell, early withdrawal, uneven distribution of rainfall etc. when compared to short rotation field crops. Thus it brings stability in farm income. The income from different intercrops and fruit and gross income under each treatment are presented in Table 5. Among the different Fruit based Agroforestry system model the maximum gross income was obtained from Lamboo + Mango + Lady's finger model (Rs. 102270.00 ha⁻¹) followed by Lamboo + mango + Maize (Rs.85300.00 ha⁻¹) and Lamboo + mango + Pigeon pea (Rs.73375.00 ha⁻¹) whereas minimum was obtained from sole lamboo (Rs.1500.00 ha⁻¹). The integration of crops with components of tree and fruit gave higher gross income than tree and fruit tree alone (Basanda *et al.*, 2017).

4. CONCLUSION

From the present experiment it may be concluded that Fruit-based agroforestry systems play an important role, not only in improving the productivity and overall returns under Red and Leterite zone of West Bengal. In red and laterite zone of west benal, India, the interspaces in established mango orchards can efficiently be utilized through lamboo + pigeon pea combinations resulting in

higher total productivity, positive rhizosphere colonization, improved soil fertility  higher profitability without affecting mango yields. Soil fertility indicate that a more favorable environment for immediate need for **taking up agriculture which** soil structural improvement, and more efficient nutrient cycling together with fruit, tree and different crops for attaining maximum and sustainable gross monetary returns apart from improving soil health under erosion prone area of West Bengal for marginal and resource-poor farmers.

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Table 1. Performance of 6 years old Lamboo as influenced by different intercropping systems

Treatments	Height (m)	D.B.H (cm)	Volume yield (m ³ /ha/ year)
T ₁ : Lamboo + mango + Pigeon pea	6.52	3.99	2.00
T ₂ : Lamboo+ mango + Maize	5.96	3.68	1.60
T ₃ : Lamboo + Mango + Lady's finger	5.90	3.69	1.60
T ₄ : Lamboo + Mango	4.32	2.46	0.80
T ₅ : Sole Mango	-	-	-
T ₆ : Sole Lamboo	3.84	2.22	0.60
CD(P=0.05)	0.13	0.14	0.07

Table 2. Performance of 6 years old mango tree as influenced by different intercropping systems

Treatments	Height (m)	Yield of mango fruit (kg ha ⁻¹)	
		First bearing (2015)	Second bearing (2016)
T ₁ : Lamboo + mango + Pigeon pea	4.44	-	450
T ₂ : Lamboo+ mango + Maize	4.36	-	440
T ₃ : Lamboo + Mango + Lady's finger	4.24	-	436
T ₄ : Lamboo + Mango	2.90	-	360
T ₅ : Sole Mango	2.50	-	296
T ₆ : Sole Lamboo	-	-	-
CD(P=0.05)	0.507	-	49.456

208 **Table 3. Yield of different arable crops grown under Mango + *Lamboo* based AFS**

Treatments	Yield(t ha^{-1}) of arable crops during <i>kharif</i>			
	Name of inter crops	2015	2016	Increase (%)
T ₁ : Lamboo + mango + Pigeon pea	Pigeon pea	1.7	2.01	31
T ₂ : Lamboo+ mango + Maize	Maize	8.5	9.7	120
T ₃ : Lamboo + Mango + Lady's finger	Lady's finger	5.2	6.4	120
T ₄ : Lamboo + Mango	-			
T ₅ : Sole Mango	-			
T ₆ : Sole Lamboo	-			

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Table 4. Soil nutrient build up for Mango + *Lamboo* based AFS after two experiment

Treatments	Soil nutrient build up (%) after experiment							
	O.C		N (kg ha ⁻¹)		P(kg ha ⁻¹)		K(kg ha ⁻¹)	
	2009-10	2015-16	2009-10	2015-16	2009-10	2015-16	2009-10	2015-16
T ₁ : Lamboo + mango + Pigeon pea	0.36	0.46 (21.74)	161.8	220.8 (26.7)	15.8	22.6 (30.09)	171.9	196.4 (12.47)
T ₂ : Lamboo+ mango + Maize	0.35	0.44 (20.45)	162.7	214.6 (24.2)	15.5	20.8 (25.48)	173.4	190.6 (9.02)
T ₃ : Lamboo + Mango + Lady's finger	0.34	0.41 (17.07)	165.4	204.4 (19.1)	15.8	19.6 (19.39)	171.5	186.4 (7.99)
T ₄ : Lamboo + Mango	0.33	0.37 (10.81)	169.8	188.2 (9.8)	12.1	13.4 (9.70)	165.8	176.2 (5.90)
T ₅ : Sole Mango	0.34	0.37 (8.11)	170	184.8 (8.0)	9.8	10.4 (5.77)	167	170.6 (2.11)
T ₆ : Sole Lamboo	0.34	0.37 (8.11)	170	186 (8.6)	9.7	10.6 (8.49)	164.5	172.8 (4.80)
CD(P=0.05)		0.283		0.35		0.286		0.286

*Values in parentheses are build up (%) after experiment;

Table 5. Gross income from different Fruit (Mango)-based AFS models during 2 year

Treatments	Income from crops(Rs.ha ⁻¹)	Income from fruit(Rs.ha ⁻¹)	Income from tree(Rs.ha ⁻¹)	Gross income (Rs.ha ⁻¹)
	<i>Kharif</i>	<i>Summer</i>		
T ₁ : Lamboo + mango + Pigeon pea	65000.00	3375.00	5000.00	73375.00
T ₂ : Lamboo+ mango + Maize	78000.00	3300.00	4000.00	85300.00
T ₃ : Lamboo + Mango + Lady's finger	95000.00	3270.00	4000.00	102270.00
T ₄ : Lamboo + Mango	-	2700.00	2000.00	4700.00
T ₅ : Sole Mango	-	2220.00	-	2220.00
T ₆ : Sole Lamboo	-	-	1500.00	1500.00
CD(P=0.05)	-	-	-	143.10

Selling price: Wood Lamboo = Rs. 5,000.00/m³, Pigeon pea = Rs.50.00/Kg, Maize = Rs.40.00/Kg,

Lady's finger= 15.00/Kg, Mango = Rs.15.00/Kg

