

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, BidhanChandra KrishiViswavidyalaya, Jhargram, West Bengal.

Methodology: The experiment involves fruit tree mango and tree 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⁻¹) and lamboo were planted within the two fruit plants (300 trees ha⁻¹).

Results: Yield of mango (450 kg ha⁻¹) and lamboo (1.96 m³ ha⁻¹ year⁻¹) were highest when they are intercropped with pigeon pea followed by maize at the time of end of experiment. The 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 (36.46 %), P₂O₅ (43.04 %) and K₂O (14.25 %) as well as organic carbon percentage (27.78 %) were observed under all mango based agroforestry system and maximum productivity with better soil health improvement was under intercropped with pigeon pea.

Conclusion: That intercropping 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

25 1. INTRODUCTION

26 Agroforestry system is the traditional practice of growing trees on farms for the benefit of
27 arable crops, fruit trees and tree component. Agroforestry was brought from the main of indigenous
28 knowledge into the forefront of agricultural research less than two decades ago, and was promoted
29 widely as a sustainability-enhancing practice that combines the best attributes of forestry and
30 agriculture. According to Dhyani *et al.* (2013) [1] in India the current area under agroforestry is
31 estimated at 25.32 mha, or 8.2% of total geographical area of the country. Growing trees along
32 with crops and livestock was postulated to enhance crop yield, conserve soil and recycle nutrients
33 while producing fuel wood, fodder, fruit and timber. The different cropping sequences have been
34 verified for producing desired level of production by raising different crops which can be grown
35 successfully underneath fruit plant and tree during early stage of growth due to less competition for
36 natural resources like air, sunlight, moisture and nutrients (Pathak and Pathak, 2001) [2].

37 Mango is one of the most important and widely cultivated tropical fruits of the world. In India
38 the plant start bearing 4 to 5 years after planting and reach their maximum bearing capacity within 12-
39 15 years after planting. The mango plants when planted at a spacing of 10 m × 10m provide an ample
40 scope for growing of short duration crops as intercrops during initial years. The inter row space in
41 mango remains underutilized in the early growing period and during which short duration, location
42 specific and market driven crops may be grown as intercrops and filler crops thus, allowing one to
43 grow more than one crop and also to efficiently utilize the space and other natural resources. The
44 intercrops not only generate an extra income but the practice also helps to check the soil erosion
45 through ground coverage and improves the physico-chemical properties of the soil. Intercropping is
46 one of the techniques of land utilization for optimum production (Bhattachanagaret *et al.*, 2007 [3]; Giri
47 Rao, 2009 [4]).

48 The fundamentals of agroforestry are combination of agricultural crops and horticultural crops with
49 no damage and get high value attention for increasing productivity. Although intercropping in
50 horticultural trees is practiced due to neither economic condition nor research result are available
51 (Tejwani, 2008) [5]. Appropriate intercropping with combinations of arable crops and trees in
52 agroforestry systems of immense importance for bringing in quick returns during first few years
53 increase farm yields. It can yield positive results only if positive interactions outweigh the negative
54 interactions (Singh *et al.*, 2013) [6]. The fertility status of Red and Laterite zone of West Bengal is poor
55 due to low organic carbon content and highly erodibility, whereas the rainfall pattern is also erratic and
56 unstable, resulting in very low and uneconomical arable crop production. Productivity of crops under
57 red and laterite soil in rainfed condition is low and unstable; and often optimum yield cannot be
58 achieved because of aberrant monsoon behavior and erosion problems. Therefore, some alternate
59 land use systems are to be developed for such lands. Fruit-based agroforestry system is an
60 alternative land use system that integrates the cultivation of arable crops, fruit trees and silvi
61 components (Dhara and Sharma, 2015) [7]. Giri Rao (2009) [4] opined that the dry land horticultural
62 fruit trees like, mango, guava etc. integrated with short duration arable crops like, pulses, vegetables,
63 groundnut etc. proved to be the most profit oriented among different agro-production system. Keeping
64 in view the above facts, a field experiment was undertaken to develop a *Mangifera indica* (Mango) -

Dysoxylumbinectariferum (Lamboo) based agroforestry system to increase the productivity and income of Red and Laterite Zone of West Bengal in rainfed situation.

2. MATERIAL AND METHODS

2.1. EXPERIMENTAL SITE:

A field experiment was conducted at Regional Research Station (Red and Laterite Zone) of Bidhan Chandra KrishiViswavidyalaya 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. The annual rainfall received during 2015 and 2016 were 1606.6 mm and 2506.5 mm respectively.

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) *Dysoxylumbinectariferum* (Lamboo) + *Mangifera indica* (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 10m x 10 m spacing. At the same time, 2 months old saplings of Lamboo were planted in between 2 fruit crops (300 trees ha⁻¹). Three arable crops viz. Pigeon pea (*Cajanus cajan* cv. UPAS 120), Maize (*Zea mays* cv. Kanchan -K-25) and Lady's finger (*Abelmoschus esculentus* cv. Parvati 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 practices. As there was enough rain fall during the season no separate irrigations were given the crops. To control borers and caterpillars in the intercrops, chlorpyrifos 20 EC @ 2.5ml L⁻¹ was sprayed.

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) [8]. The basal area of individual Lamboo tree by using given equation

$$BA = \pi \times \frac{(DBH)^2}{4}$$

The volume yield of per tree was estimated by given equation then convert to on per hectare basis.

$$Y_{vol} = BA \times h_t \times 0.5.$$

Soil nutrient buildup in terms of available nitrogen (Jackson, 1973) [9], phosphorus (Jackson, 1973) [9], potassium (Jackson, 1973) [9] and organic carbon (Walkley and Black, 1934) [10] 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) [11].

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 1.96 m³ha⁻¹year⁻¹ respectively) were obtain 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 0.43 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 obtain 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) [12]. Under rainfed situation, fruit tree based framing system resulted in reduced risk. Singh (1997) [13] 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 18.23% in pigeon pea, 14.12% in maize and 23.08 % in lady's finger. Evidence from any agroforestry system is one option with multifunctional value of multiple benefits. The increase in yield in second year was might be due to the addition of nutrients from crop residues from first year and micro flora activity in the rhizosphere. The result corroborated with that of Khattaket *al.* (1981) [14] and Wannawonget *al.* (1991) [15].

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 Fof 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 8.7 to 36.46 %, soil P from 6.12 to 43.04 %, soil K from 2.16 to 14.25 % 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) [16]. Rangasamy *et al.*, (1994) [17] and Jayanthi *et al.*, (2003) [18] 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) [19]. 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 solubilizers 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)[20] and Datta and Dhiman (2001) [21].

3.4. ECONOMICS

Fruit crops are deep rooted, hardy and tolerant to abnormal monsoon e.g. early or late onset, intermittent dry spell, early withdrawal, uneven distribution of rainfall etc. when compared to short duration 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 ha⁻¹) followed by lamboo + mango + maize (Rs. 85300 ha⁻¹) and lamboo + mango + pigeon pea (Rs. 73375 ha⁻¹) whereas minimum was obtained from sole lamboo (Rs. 1500 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) [22].

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 Laterite zone of West Bengal. In red and laterite zone of West Bengal, 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 and higher profitability without affecting mango yields. Soil fertility indicates that a more favorable environment for immediate need for 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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- 223

224 **Table 1. Performance of *Dysoxylumbinectariferrum* as influenced by different**
 225 **intercropping systems**

Treatments	Height (m)	D.B.H (cm)	Volume yield (m ³ ha ⁻¹ year ⁻¹)
T ₁ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Cajanus cajan</i>	6.52	3.99	1.96
T ₂ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Zea mays</i>	5.96	3.68	1.52
T ₃ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Abelmoschus esculentus</i>	5.90	3.69	1.51
T ₄ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i>	4.32	2.46	0.49
T ₅ : Sole <i>Mangifera indica</i>	-	-	-
T ₆ : Sole <i>Dysoxylumbinectariferrum</i>	3.84	2.22	0.43
CD(P=0.05)	0.13	0.14	0.01

226

227 **Table 2. Performance of *Mangifera indica* tree as influenced by different intercropping**
 228 **systems**

Treatments	Height (m)	Yield of mango fruit (kg ha ⁻¹)	
		First bearing (2015)	Second bearing (2016)
T ₁ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Cajanus cajan</i>	4.44	-	450
T ₂ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Zea mays</i>	4.36	-	440
T ₃ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Abelmoschus esculentus</i>	4.24	-	436
T ₄ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i>	2.90	-	360
T ₅ : Sole <i>Mangifera indica</i>	2.50	-	296
T ₆ : Sole <i>Dysoxylumbinectariferrum</i>	-	-	-
CD(P=0.05)	0.507	-	49.456

229

230 **Table 3. Yield of different arable crops grown under *Mangifera indica* +**
 231 ***Dysoxylumbinectariferrum* based AFS**

Treatments	Yield(t ha ⁻¹) of arable crops during <i>kharif</i>			
	Name of inter crops	2015	2016	Increase (%)
T ₁ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Cajanus cajan</i>	<i>Cajanus cajan</i>	1.7	2.01	18.23
T ₂ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Zea mays</i>	<i>Zea mays</i>	8.5	9.7	14.12
T ₃ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Abelmoschus esculentus</i>	<i>Abelmoschus esculentus</i>	5.2	6.4	23.08
T ₄ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i>	-			
T ₅ : Sole <i>Mangifera indica</i>	-			
T ₆ : Sole <i>Dysoxylumbinectariferrum</i>	-			

232

Table 4. Soil nutrient build up for *Mangifera indica* + *Dysoxylumbinectariferrum* based AFS after two experiment

Treatments	Soil nutrient build up (%) after experiment							
	Organic Carbon (%)		N (kg ha ⁻¹)		P ₂ O ₅ (kg ha ⁻¹)		K ₂ O(kg ha ⁻¹)	
	2009-10	2015-16	2009-10	2015-16	2009-10	2015-16	2009-10	2015-16
T ₁ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Cajanus cajan</i>	0.36	0.46 (27.78)	161.8	220.8 (36.46)	15.8	22.6 (43.04)	171.9	196.4 (14.25)
T ₂ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Zea mays</i>	0.35	0.44 (25.71)	162.7	214.6 (31.89)	15.5	20.8 (34.19)	173.4	190.6 (9.92)
T ₃ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Abelmoschus esculentus</i>	0.34	0.41 (20.59)	165.4	204.4 (23.58)	15.8	19.6 (24.05)	171.5	186.4 (8.69)
T ₄ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i>	0.33	0.37 (12.12)	169.8	188.2 (10.84)	12.1	13.4 (10.74)	165.8	176.2 (6.27)
T ₅ : Sole <i>Mangifera indica</i>	0.34	0.37 (8.82)	170	184.8 (8.70)	9.8	10.4 (6.12)	167	170.6 (2.16)
T ₆ : Sole <i>Dysoxylumbinectariferrum</i>	0.34	0.37 (8.82)	170	186 (9.41)	9.7	10.6 (9.28)	164.5	172.8 (5.05)
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 (*Mangifera indica*)-based AFS models

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>	Summer		
T ₁ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Cajanus cajan</i>	65000	3375	5000	73375
T ₂ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Zea mays</i>	78000	3300	4000	85300
T ₃ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i> + <i>Abelmoschus esculentus</i>	95000	3270	4000	102270
T ₄ : <i>Dysoxylumbinectariferrum</i> + <i>Mangifera indica</i>	-	2700	2000	4700
T ₅ : Sole <i>Mangifera indica</i>	-	2220	-	2220
T ₆ : Sole <i>Dysoxylumbinectariferrum</i>	-	-	1500	1500
CD(P=0.05)	-	-	-	143.10

Selling price: Wood *Dysoxylumbinectariferrum* = Rs. 5,000m⁻³, *Cajanus cajan*= Rs.50kg⁻¹, *Zea mays* = Rs.40 kg⁻¹,
Abelmoschus esculentus= 15 kg⁻¹, *Mangifera indica*= Rs. 15 kg⁻¹