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Performance and profitability study of different mango based intercropping systems in Easternghat high land zone of Odisha

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ABSTRACT

An intercropping experiment comprising of nine treatements such as mango ginger, turmeric, tomato, cowpea, frenchbean, ragi, niger, upland paddy and control (without intercrop) was laid out in Randomized Block Design with three replications to assess the effect of various intercrops on the performance of mango in the rainfed uplands of Odisha. The results of the study revealed that the mango + guava +cowpea intercropping system exhibited better performance which has been reflected in the form of plant height, girth, canopy area, fruit weight and fruit yield of mango closely followed by mango + guava + frenchbean system. The mango plants, under study, however, did not exhibit any kind of variation in quality parameters in fruits. The leguminous intercrops, cowpea and frenchbean, were the most effective crop because of their desirable impact on improvement of nutrient status of soil and plant of mango orchard. Highest LER was obtained with mango + guava +cowpea intercropping system (4.17) followed by mango + guava + frenchbean. The highest benefit, cost ratio (2.02) was recorded in the mango + guava + cowpea intercropping systems, which was almost similar to that of mango + guava + turmeric, mango + guava + frenchbean and mango + guava + tomato .

***Keywords*:** Economics, LER, mango based intercropping systems, rainfed upland, soil fertility

Mango is one of the most important and widely cultivated tropical fruits of the world. In India, it is grown in an area of 23.78 lakh hectares with an annual production of 161.98 lakh tones (Indian Horticulture Database-2012). This contributes to 37.8 per cent of total area and 18.6 per cent of total production of fruit crops 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 10 × 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 (Bhattanagar *et al*.2007). Experimental evidences have also proved that yield stability is grater with intercropping than sole cropping. Intercropping can provide substantial yield advantages compared with sole cropping. However, the success of intercropping system depends mainly on selection of suitable crops. Therefore, an on-farm trial was conducted on intercropping in a junior adult bearing mango orchard under rainfed upland situation to study the effect of intercropping on main crop mango and filler crop guava and to select the most appropriate intercropping system.

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MATERIALS AND METHODS

The experiment was conducted during 2009-10 and 2010-11 in the mango orchard of Gopalput, an adopted village of Regional Research and Technology Transfer Station (RRTTS), Orissa University of Agriculture and Technology, Semiliguda, Koraput, Odisha. The mean maximum and mean minimum temperature during the period of investigation were 29.3 ºC and 16.9 ºC, respectively, with a total annual rainfall of 1877.8 mm and relative humidity of 88.3%. The experiment was carried out on a 8-year-old existing bearing mango orchard (cv. Totapori) along with 6-year-old filler tree guava (cv. Allahabad safeda). The main tree mango was planted with a spacing of 10 × 10m and the filler tree guava was planted in between the lines of mango trees. The experimental area was divided into 27 plots of 20 × 20m and each plot consisted of 4 bearing mango trees and 4 guava trees, thus accommodated 108 main trees mango and 108 filler trees guava in an area of 1.08 ha under the experiment. The experiment was laid out as per Randomized Block Design consisting of nine treatments with three replications. The location specific various profitable intercrops were grown in the mango orchard as treatments. The intercrops such

as mango ginger, turmeric, tomato, cowpea, frenchbean, ragi, niger, upland paddy were taken as treatments in mango orchard along with control (a treatment without intercrop). The treatment combinations are as follows:

T_1 : Mango + Guava + Mango ginger, T_2 : Mango + Guava + Turmeric, T_3 : Mango + Guava + Tomato, T_4 : Mango + Guava + Cowpea, T_5 : Mango + Guava + French bean, T_6 : Mango + Guava + Ragi, T_7 : Mango + Guava + Niger, T_8 : Mango + Guava + Paddy, T_9 : Mango + Guava + No intercrop

The experimental site was prepared during first week of May of each year. The intercrops were sown 1.5 m away from mango tree and 1.0m away from guava tree in either side of the trunk leaving an area of $9m^2$ and 4.0 m^2 around each mango and guava tree, respectively. The recommended packages of practices were followed for the main crop, filler crop and intercrops. Besides natural incorporation of the foliages, the remaining biomass of the intercrops was incorporated immediately after harvest in the respective treatments. The bio-metric observations on main crop mango as influenced by the intercropping were recorded during the experimentation period *i.e.,* May, 2008 to July, 2010. The total soluble solids was found out by using ERMA hand refractometer of 0-32% range calibrated at 20 ^{0}C.The acidity of the fruit pulp samples were estimated by alkali titration method (A.O.A.C, 1984). Leaf samples collected before flowering from each treatment were used for study of the nutrient status of the main plant mango during end of the experiment. Four to seven months old leaves with petiole from middle of shoots were collected for analysis of foliar nutrient composition of mango (Chadha *et al.,*1980). The data recorded on various characteristics of bio-metrics and bio-chemicals were subjected to Fisher's method of analysis of variance and interpretation of data was taken up as per Sukhatme and Amble (1995). Economics of different mango based intercropping system was worked out taking into account the prevailing cost of inputs like labourer, seeds, manures and fertilizers, pesticides and sale price of produce during 2009-10 and 2010-11. The cost of various inputs and sale price of produce remained same during both the years of study. The details of cost of cultivation of different crops have been worked out as average of 2009-10 and 2010-11. The gross return was calculated by multiplying the average yield (q ha^{-1}) of different crops during the two years of study with prevailing market price per quintal and net return was worked out by deducting the cost of cultivation from gross return. The benefit-cost ratio (B : C) of intercropping systems were worked out to know the most remunerative and profitable intercropping system as below:

$$\text{B: C of intercropping system} = \frac{\text{Gross return of intercropping system}}{\text{Cost of cultivation of intercropping system}}$$

The biological efficiency of mango based intercropping systems was calculated through some indices such as Mango Equivalent Yield and Land Equivalent Ratio in order to know the yield advantages of associated crops over main crop. The Mango Equivalent Yield (MEY) of the intercropping system was calculated as given below:

$$\text{MEY} = \text{Yield of mango} + \frac{\text{Yield of intercrops/filler crops x price of intercrops/filler crops (Rs.kg}^{-1}\text{)}}{\text{Price of main crop mango (Rs.kg}^{-1}\text{)}}$$

The land equivalent ratio of mango based intercropping system was calculated by summing up the partial LER of component crops such as mango, guava and intercrops. It is calculated as per the following method:

$$\text{LER of crop} = \frac{\text{Yield obtained in intercropping}}{\text{Yield obtained in sole crop}}$$

RESULTS AND DISCUSSION

Plant growth of mango

The data recorded on tree height, girth and canopy area of mango has been presented as percentage of increase over each year of study (Table 1). The results of the studies revealed that the growth parameters of mango were significantly influenced by the intercropping. The maximum increase in tree height, girth and canopy area was found under mango + guava + cowpea intercropping system (T_4). The increase in tree height, girth and canopy area of mango under mango + guava + frenchbean intercropping system (T_5) was also comparable with that of mango+ guava + cowpea system (T_4). The minimum percentage increase in tree height, girth and canopy area was observed in mango + guava system without intercropping under both the year of study. Adoption of intercropping systems in mango orchard helps in efficient utilization of natural resources as well as it improves the input use efficiency in the system (Panda *et al*., 2003). This might be the reason for increase in growth parameters of main crop mango. Similar findings on increase in tree height, girth and canopy area of mango due to intercropping was reported by Bhuva *et al.* (1988), Singh *et al*. (1996), Mishra and Swain (2001), Vishal Nath *et al.* (2003) and Swain and Patro (2007). Intercropping with legume crops particularly with cowpea or frenchbean in mango orchard was more effective which might have helpful in substantial increase in nitrogen content of the soil as well as other physico-chemical properties of soil

Table 1: Effect of intercropping on plant growth, fruit weight and yield of mango

Treatment	Plant growth(Percentage increase)						Average fruit weight (g)		Fruit yield (kg tree^{-1})	
	Plant height		Plant girth		Canopy area					
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Mango+Guava+M. ginger	9.6	10.6	7.0	25.25	25.25	12.7	280.5	290.3	25.25	28.10
Mango+Guava+Turmeric	9.8	10.9	6.6	26.20	26.20	12.6	273.6	280.1	26.20	28.50
Mango+Guava+Tomato	9.1	10.8	6.8	25.30	25.30	12.2	282.4	292.3	25.30	27.82
Mango+Guava+Cowpea	10.2	12.1	7.8	32.50	32.50	14.6	295.5	304.6	32.50	34.10
Mango+Guava+Frenchbean	10.0	11.8	7.2	29.70	29.70	13.2	290.6	301.4	29.70	31.80
Mango+Guava+Ragi	8.5	10.0	5.8	24.41	24.41	11.8	273.3	283.4	24.41	24.00
Mango+Guava+Niger	8.1	9.2	5.2	22.12	22.12	11.7	270.4	279.6	22.12	22.30
Mango+Guava+Paddy	9.2	10.8	6.9	24.75	24.75	12.0	275.4	277.3	24.75	25.20
Mango+Guava+No intercrop	6.2	7.6	4.1	20.56	20.56	8.4	260.5	265.3	20.56	22.40
SEm (±)	**0.24**	**0.31**	**0.28**	**0.72**	**0.72**	**0.41**	**4.97**	**4.94**	**0.72**	**1.29**
LSD(0.05)	**0.73**	**0.92**	**0.84**	**2.14**	**2.14**	**1.24**	**14.91**	**14.81**	**2.14**	**3.88**
C.V. (%)	**4.7**	**5.08**	**7.56**	**4.82**	**4.82**	**5.89**	**3.10**	**2.99**	**4.82**	**8.29**

Table 2: Effect of intercropping on fruit quality of mango.

Treatment	TSS (°Brix)		Acidity (%)		Total sugar(%)		Vitamin C(mg 100 g pulp^{-1})	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Mango+Guava+M. ginger	13.8	13.9	0.25	0.26	12.3	13.0	15.0	16.0
Mango+Guava+Turmeric	14.2	13.9	0.25	0.26	12.8	12.4	15.1	16.3
Mango+Guava+Tomato	13.9	14.0	0.26	0.25	13.0	13.7	14.3	15.9
Mango+Guava+Cowpea	14.2	14.1	0.23	0.24	13.5	13.0	15.0	14.7
Mango+Guava+Frenchbean	14.1	14.2	0.24	0.24	13.1	12.9	14.3	15.3
Mango+Guava+Ragi	14.0	14.1	0.26	0.25	12.9	11.9	14.1	15.9
Mango+Guava+Niger	13.7	13.9	0.27	0.26	13.1	12.6	15.6	14.6
Mango+Guava+Paddy	13.8	13.9	0.24	0.25	12.4	13.8	15.8	16.0
Mango+Guava+No intercrop	13.7	13.6	0.27	0.26	12.0	13.3	14.0	15.6
S. E m. (±)	**0.17**	**0.70**	**0.01**	**0.01**	**0.60**	**0.58**	**0.53**	**0.46**
LSD(0.05)	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**
C.V. (%)	**2.06**	**8.83**	**8.17**	**7.76**	**6.67**	**7.70**	**8.0**	**6.8**

Table 3: Effect of intercropping on nutrient status of soil and mango plant.

Treatment	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})		Leaf nutrient status (% dry wt.)		
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	N	P	K
Mango+Guava+M. ginger	331.5	280.5	18.9	16.9	360.4	325.5	1.33	0.14	0.63
Mango+Guava+Turmeric	320.4	285.9	18.6	16.0	358.5	330.3	1.38	0.12	0.62
Mango+Guava+Tomato	321.7	272.3	16.3	14.5	350.4	317.4	1.35	0.13	0.62
Mango+Guava+Cowpea	356.7	317.3	18.4	16.3	380.7	345.3	1.42	0.15	0.74
Mango+Guava+Frenchbean	341.8	305.4	17.5	15.4	372.5	340.3	1.40	0.14	0.75
Mango+Guava+Ragi	317.4	270.3	16.4	13.5	350.0	315.6	1.28	0.13	0.52
Mango+Guava+Niger	315.3	265.5	15.8	13.0	342.4	310.6	1.20	0.11	0.50
Mango+Guava+Paddy	322.3	275.6	17.1	14.6	368.4	329.3	1.28	0.13	0.69
Mango+Guava+No intercrop	288.3	253.5	14.5	12.3	330.4	300.4	1.10	0.08	0.47
SEm (±)	**11.25**	**11.22**	**0.48**	**0.30**	**4.49**	**7.20**	**0.03**	**0.01**	**0.02**
LSD(0.05)	**33.76**	**33.67**	**1.45**	**0.91**	**13.47**	**21.60**	**0.09**	**0.02**	**0.05**
C.V. (%)	**6.02**	**6.93**	**4.90**	**3.56**	**2.18**	**3.85**	**4.05**	**7.63**	**4.89**

resulting in better vegetative growth in mango crop. This corroborates with the findings of Vishal Nath *et al.* (2003) and Swain and Patro (2007).

Fruit weight and yield of mango

Intercropping in mango orchard had significant effect on fruiting of mango (Table 1). The average fruit weight and fruit yield per tree of mango were significantly influenced by the intercropping systems. After two years of study, the maximum average fruit weight (304.6 g) was found in mango + guava + cowpea intercropping system which was statistically at par with mango + guava + frenchbean (301.4 g), mango+ guava + tomato (292.3 g) and mango+ guava + mango ginger system (290.3 g) and the minimum was recorded in control (265.3 g). It was revealed that there was significant variation observed in fruit yield per tree of mango from 20.56 kg to 32.50 kg due to intercropping in the year 2005-06. The maximum fruit yield of 32.50 kg tree^{-1} was recorded in mango+ guava + cowpea system which was statistically superior to rest of the treatments. In the year 2006-07, the fruit yield per tree was also recorded to be highest (34.10 kg) in the above treatment which was significantly superior to rest of the intercropping systems except mango+ guava + frenchbean system where the results closely followed with mango+ guava + cowpea system. The minimum fruit yield per tree was recorded in mango+ guava + niger system (22.30 kg), which was statistically *at par* with that of the yield of control plot (22.40 kg tree^{-1}). The higher yield advantages particularly average fruit weight and fruit yield under intercropping systems were mainly attributed to efficient utilization of natural resources like solar radiation, soil moisture and nutrients because of complementary interaction between the component crops. The increase in fruit weight and yield as observed under different systems may be explained from the fact that some leguminous intercrops like cowpea and frenchbean have the capacity of fixing the atmospheric nitrogen to the soil and there by main crop would have got additional nitrogen, which agrees well to the findings of Ghosh (2001) in guava. The other non-leguminous intercrops helped the main crop (Mango) through indirect way like creating a micro climate that may have resulted in improvement of fruit weight and fruit yield. Besides, floor management for the intercrops like land preparation for sowing, weeding, etc. seemed to be beneficial for higher production of fruits. The intercropping that helped to improve the fruit production of the main crop was also reported by Ghosh *et al*.(1997) in sweet orange, Ghosh(2001) in guava and Rath and Swain (2006) in mango.

Fruit quality of mango

The analysis of quality parameters of mango fruits (Table 2) indicated that fruit quality of mango was not significantly affected by intercropping during both the years of study. Similar findings, that the quality of fruits were not affected due to growing of intercrops, in mango, citrus and guava orchards were also reported by Kanwar *et al.* (1993), Ghosh *et al.* (1997) and Ghosh (2001), respectively.

Nutrient status of orchard soil and mango plant

From the data in table 3, it is clear that among different intercropping systems tried, the mango + guava + cowpea (T_4) and mango + guava + frenchbean (T_5) systems resulted in improvement of nitrogen status of the soil. The effect of cowpea and frenchbean intercropping in mango based cropping system in increasing the available nitrogen content of soil might be due to greater recycling of bio-mass in the inter space with higher percentage of nitrogen as compared to other treatments (Manna and Singh, 2001). The improvement in available nitrogen content of the soil under *in situ* incorporation of intercrops residues 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. Similar results of increased available nitrogen content of the soil through intercropping in mango orchard have been reported by Swain and Patro (2007). In the present study it was interesting to observe that the N content of each intercropped plot decreased with the soil depth which might be due to lower leaching losses as reported by Sharma and Choudhury (2002).

The study revealed that intercropping had significant effect in increasing the available phosphorus content of the orchard soil. The available phosphorus content of soil under mango + guava + mango ginger (T_1), mango + guava + turmeric (T_2) and mango + guava + cowpea (T_4) systems were increased to 18.9, 18.6 and 18.4 kg ha^{-1} within 0-15cm and 16.9, 16.0 and 16.3 kg ha^{-1} within 15-30cm soil depth, respectively. 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).

From the result it was noted that the mango + guava + cowpea intercropping system (T_4) also proved advantageous in increasing the available potassium

contents of soil to 380.7 and 345.3 kg ha^{-1} within 0-15 cm and 15-30 cm soil depths, respectively. The results of mango + guava + french bean (T_5) intercropping system were quite similar with that of aforesaid treatment. This corroborates with the findings of Swain and Patro (2007). The increase in availability of potassium contents in the soil might be due to increase in humus content of soil after decomposition of biomass of intercrops that builds up total population of beneficial microbes in the orchard soil. Similar results of improvement in nutrient status of soil due to intercropping have been reported by, Maheswarappa *et al.* (1998).The leaf analysis result after completion of the study (Table 3) indicated that the N and P content of mango leaf were found to be maximum under mango + guava + cowpea intercropping system (T_4) whereas the K content was estimated maximum in the mango + guava + frenchbean system (T_5). It was observed that the N, P and K content in leaves of mango was found higher with leguminous group of crops and lower in case of non-legume crops. The increase in NPK status of mango leaf in all the cases as compared to control might be due to increased availability of nutrients in the soil because of *in situ* incorporation of huge amount of bio-mass produced under the treatments. The incorporation of bio-mass of intercrops might helpful in improving the soil physical, chemical and biological environments which favoured the higher uptake from the nutrient pool in the soil, which agreed well to the findings of Maheswarappa *et al.* (1998). It was observed from the study that the improvement of NPK status of leaf and soil of mango orchard were positively correlated.

Yield and biological efficiency of mango based intercropping systems

The average yield of different component crops such as main crop mango, filler crop guava and intercrops in the mango based intercropping systems over the two years of study has been calculated in order to find out biological efficiency and economics of the systems(Table 4).The highest mango equivalent yield (238.54 q.ha^{-1}) was obtained from mango + guava + turmeric (T_2) followed by mango + guava + mango ginger (T_1) and lowest in mango + guava system without any intercrop *i.e.* T_9 (35.34q.ha^{-1}) (Table 5). Land Equivalent Ratio of intercropping systems indicated that mango + guava + cowpea (T_4) intercropping system recorded highest LER(4.17) followed by mango + guava + frenchbean (3.95) and mango + guava + turmeric(3.92). Lowest LER was obtained with mango + guava system without any intercrop (2.17).Since the LER value in all the cases was recorded > 1, the intercropping was found to be advantageous. Such advantages was also noted by Haque *et al.(*2001).

Economics of mango based intercropping systems

Among different mango based intercropping systems studied, the mango + guava + turmeric (T_2) and mango + guava + mango ginger (T_1) incurred maximum average cost of cultivation of Rs. 1,19,100 and Rs. 1,09,100 ha^{-1}, respectively(Table 6). The higher cost of cultivation in the aforesaid systems was mainly due to higher expenditure of turmeric and mango ginger intercrops towards utilization of labourers (44.30% and 48.39%) as well as planting materials (25.18% and 18.33%), respectively, as compared to other intercrops. The average gross return of mango + guava + turmeric (T_2) was found to be highest (Rs. 2,38,540 .ha^{-1}.) followed by mango + guava + mango ginger i.e. T_1 (Rs. 1,99,700.ha^{-1}). This was possible due to higher yield performance of the intercrops like turmeric and mango ginger in the mango orchard. Although intercropping in mango orchard was profitable in all cases, the highest average net return of Rs. 1,19,440 ha^{-1} and Rs. 93,310 ha^{-1} was obtained with mango + guava + turmeric (T_2) and mango + guava + tomato (T_3) systems (Table 7). The higher net returns involving tomato (Jain and Rout, 2004), mango ginger (Rath and Swain, 2006) and turmeric (Swain and Patro, 2007) as intercrops have been reported in the mango based intercropping systems. Bhuva *et al.* (1988) also reported that mango intercropped with tomato and cluster bean gave greatest financial return per hectare. The poor average net return was realized when ragi, niger and paddy were taken as intercrops under mango based intercropping systems. This was attributed to comparatively low production of the above intercrop.

The cost-benefit analysis of various mango based intercropping systems (Table 7) was worked out in order to find out the most remunerative system for the agro climatic zone. The results revealed that the highest benefit, cost ratio (2.02) was recorded in the mango + guava + cowpea (T_4) intercropping system, which was almost similar to that of mango + guava + turmeric (T_2), mango + guava + frenchbean (T_5) and mango + guava + tomato (T_3). The higher cost-benefit ratio in the above systems was attributed to higher biological productivity. While studying the economics of mango based intercropping systems, Bhuva *et al* (1988) worked out the highest B:C of 1.22 under mango + tomato + cluster bean system and Girija Devi and Wahab (2007) found the highest benefit, cost ratio in the coconut + banana + ginger system (1.30) followed by coconut + banana + elephant foot yam (1.28). The B:C ratio in case of other intercropping systems were

Table 4: Yield of different component crops in the mango based intercropping systems.

Treatment	Yield (q ha $^{-1}$)								
	Main crop mango			Filler crop guava			Intercrops		
	2009-10	2010-11	Avg.	2009-10	2010-11	Avg.	2009-10	2010-11	Avg.
Mango+Guava+M. ginger	25.25	28.10	26.67	24.40	28.40	26.40	162.60	146.50	154.55
Mango+Guava+Turmeric	26.20	28.50	27.35	25.60	29.40	27.50	156.50	163.40	159.95
Mango+Guava+Tomato	25.30	27.82	26.56	22.90	27.10	25.50	177.00	188.50	182.75
Mango+Guava+Cowpea	32.50	34.10	33.30	27.50	31.90	29.70	78.50	83.40	80.95
Mango+Guava+Frenchbean	29.70	31.80	30.75	26.40	30.70	28.55	69.60	73.50	71.55
Mango+Guava+Ragi	24.41	24.00	24.21	22.10	26.40	24.25	18.80	19.00	18.90
Mango+Guava+Niger	22.12	22.30	22.21	20.80	24.60	22.70	4.80	5.10	4.95
Mango+Guava+Paddy	24.75	25.20	24.97	23.10	27.50	25.30	26.80	28.40	27.60
Mango+Guava+No intercrop	20.56	22.40	21.48	19.30	20.30	19.80	-	-	-
SEm (±)	**0.72**	**1.29**	—-	**0.41**	**0.71**	—-	**-**	**-**	**-**
LSD(0.05)	**2.14**	**3.88**	—-	**1.23**	**2.14**	—-	**-**	**-**	**-**
C.V. (%)	**4.82**	**8.29**	—-	**3.01**	**4.51**	—-	**-**	**-**	**-**

Table 5: Mango Equivalent Yield and LER of different mango based intercropping systems.

Treatment	Yield (q.ha^{-1})				Partial LER for			LER of
	Mango	Guava	Intercrop	Mango Equivalent	Mango	Guava	intercrop	inter-cropping system
Mango+Guava+M. ginger	26.67	26.40	154.55	199.70	1.33	1.47	1.03	3.83
Mango+Guava+Turmeric	27.35	27.50	159.95	238.54	1.37	1.53	1.02	3.92
Mango+Guava+Tomato	26.56	25.50	182.75	117.51	1.33	1.42	0.91	3.65
Mango+Guava+Cowpea	33.30	29.70	80.95	110.76	1.67	1.65	0.85	4.17
Mango+Guava+Frenchbean	30.75	28.55	71.55	107.98	1.54	1.59	0.83	3.95
Mango+Guava+Ragi	24.21	24.25	18.90	56.31	1.21	1.35	0.88	3.44
Mango+Guava+Niger	22.21	22.70	4.95	47.01	1.11	1.26	0.78	3.15
Mango+Guava+Paddy	24.97	25.30	27.60	59.24	1.25	1.41	0.88	3.53
Mango+Guava+No intercrop	21.48	19.80	—-	35.34	1.07	1.10	—-	2.17

Table 6: Cost of cultivation and gross return of mango based intercropping systems.

Treatment	Cost of cultivation (Rs. ha^{-1})				Gross return (Rs. ha^{-1})			
	Mango	Guava	Intercrops	Total	Mango	Guava	Intercrops	Total
Mango+Guava+M. ginger	13,400	10,800	84,900	1,09,100	26,670	18,480	1,54,550	1,99,700
Mango+Guava+Turmeric	13,400	10,800	94,900	1,19,100	27,350	19,250	1,91,940	2,38,540
Mango+Guava+Tomato	13,400	10,800	34,300	58,500	26,560	17,850	73,100	1,17,510
Mango+Guava+Cowpea	13,400	10,800	30,480	54,680	33,300	20,790	56,665	1,10,755
Mango+Guava+Frenchbean	13,400	10,800	29,840	54,040	30,750	19,985	57,240	1,07,975
Mango+Guava+Ragi	13,400	10,800	10,500	34,700	24,210	16,975	15,120	56,305
Mango+Guava+Niger	13,400	10,800	6,668	29,800	22,210	15,890	8,910	47,010
Mango+Guava+Paddy	13,400	10,800	10,982	33,700	24,970	17,710	16,560	59,240
Mango+Guava+No intercrop	13,400	10,800	-	24,200	21,480	13,860	-	35,340

Sale price: *Mango- Rs.1000q^{-1}, Guava- Rs.700 q^{-1}, Mango ginger- Rs.1000 q^{-1}, Turmeric- Rs.1200 q^{-1}, Tomato-Rs.400 q^{-1}, Cowpea- Rs.700 q^{-1}, Frenchbean-Rs.800 q^{-1}, Ragi- Rs.800 q^{-1}, Niger-Rs.1800 q^{-1}, Paddy-Rs.600 q^{-1}*

Table 7: Net return and benefit cost ratio of mango based intercropping systems.

Treatment	Net return (Rs.ha^{-1})				Benefit-cost ratio
	Mango	Guava	Intercrops	Total	
Mango+Guava+Mango ginger	13,270	7,680	69,650	90,600	1.83
Mango+Guava+Turmeric	13,950	8,450	97,040	1,19,440	2.00
Mango+Guava+Tomato	13,160	7,050	73,100	93,310	2.00
Mango+Guava+Cowpea	19,900	9,990	26,185	56,075	22.02
Mango+Guava+Frenchbean	17,350	9,185	27,400	53,935	1.99
Mango+Guava+Ragi	10,810	6,175	4,620	21,605	11.62
Mango+Guava+Niger	8,810	5,090	2,242	16,142	1.57
Mango+Guava+Paddy	11,570	6,910	5,578	24,058	1.75
Mango+Guava+No intercrop	8,080	3,060	—	11,140	1.46

almost similar and little bit higher than the mango + guava system without any intercrop indicating that all the intercrops could be grown profitably and suitably under the mango orchard with the filler crop guava. But the better economic efficiency could be realized by taking the leguminous vegetable crops like cowpea and frenchbean or spices like turmeric and tomato under the rainfed upland situation.

The results of the investigation revealed that the intercropping was found effective in increasing the plant growth and fruit yield of main crop mango. The plant growth, fruit weight and fruit yield of mango was observed significantly maximum in mango + guava +cowpea intercropping system closely followed by mango + guava + frenchbean system. Fruit quality of mango was not affected by the different intercropping systems. The leguminous intercrops, cowpea and frenchbean, were the most effective crop because of their desirable impact on improvement of nutrient status of soil and plant of mango orchard. Land Equivalent Ratio of intercropping systems indicated that mango + guava + cowpea (T_4) intercropping system recorded the highest (4.17). The highest benefit, cost ratio (2.02) was recorded in the mango + guava + cowpea (T_4) intercropping systems, which was almost similar to that of mango + guava + turmeric (T_2), mango + guava + frenchbean (T_5) and mango + guava + tomato (T_3). The study will help the farmers/scientists to select the appropriate intercropping systems in the risk prone rainfed uplands. However, further studies are necessary for inclusion of various other intercrops which are location specific and to confirm the long term effect of intercropping as suggested above.

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