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RESEARCH PAPER

Effect of intercropping systems on growth, yield, fruit quality and leaf nutrient status of mango under rainfed situation

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Abstract **:** An intercropping experiment comprised of nine treatements such as mango ginger, turmeric, tomato, cowpea, French bean, 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 growth of mango plants was appreciably influenced by the intercropping systems tried in the study which was evident from the incremental growth measured in terms of height, girth, canopy area and shoot growth of the concerned trees. Among different intercropping systems tried, mango + guava +cowpea exhibited better performance which has been reflected in the form of panicle production, fruit retention, fruit weight and fruit yield of mango closely followed by mango + guava + French bean system. The mango plants, under study, however, did not exhibit any kind of variation in quality parameters such as TSS and acidity in fruits. The leaf analysis result after completion of the study revealed that the N and P content of mango leaf were found to be maximum under mango + guava + cowpea intercropping system whereas the K content was estimated maximum in the mango + guava + French bean system.

Key Words **:** Intercropping, Mango, Rainfed upland

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INTRODUCTION

The mango plants start bearing 4 to 5 years after planting and reach their maximum bearing capacity within 10-12 years after planting. The mango plants when planted at a spacing of 10m x 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 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). Selection of suitable intercrops in mango orchard for maximum return as well as to improve the soil fertility status mainly depends upon the agro-climatic condition of the area where the crop is grown. Experimental evidences have also proved that yield stability is grater with intercropping than sole cropping. Although lot of research work has been done on fruit based intercropping system under irrigated conditions but information on guava based intercropping system in rainfed upland is lacking. Hence, an experiment on intercropping was carried out in a

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junior adult bearing mango orchard under rainfed upland situation to study the effect of intercropping on main crop mango and to select the most appropriate intercropping system.

MATERIALS AND METHODS

The experiment was conducted during 2005-2006 and 2006-2007 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 ^{0}C and 16.9 ^{0}C, respectively, with a total annual rainfall of 1877.8 mm and relative humidity of 88.3 per cent. The experiment was carried out on a 6-year-old existing bearing mango orchard (cv. TOTAPORI) along with 5-year-old filler tree guava (cv. ALLAHABAD SAFEDA). The main tree mango was planted with a spacing of 10m × 10m and the filler tree guava was planted in between the lines of mango trees. The experimental area was divided into 27 plots of 20m × 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 consisted 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, French bean, 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 and 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 1m away from guava tree in either side of the trunk leaving an area of 9m^2 and 4 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, 2005 to July, 2007. The total soluble solids was found out by using ERMA hand refractometer of 0-32 per cent 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).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

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 in terms of percentage of increase was found to be as 10.2 per cent , 7.8 per cent and 12.6 per cent during 2005-06 and as 12.1 per cent, 9.1 per cent and 14.6 per cent during 2006-07, respectively 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 T_9 in both the year of study. The data relating to the study on effect of intercropping with reference to the shoot growth indicated that the intercropping had no significant effect on the shoot growth in the year 2005-06. But, in the year 2006-07, the intercropping significantly influenced the shoot growth and higher growth was recorded in T_5 (18.9 cm), which was closely followed by T_4 (18.3 cm), T_1 (17.5 cm), T_8 (17.2 cm) and T_2 (17.1 cm). The lowest was recorded in T_9 (15.8 cm).

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), Nath *et al.* (2003) and Swain and Patro (2007). Intercropping with legume crops particularly with cowpea or French bean 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 resulting in better vegetative growth in mango crop. This corroborates with the findings of Nath *et*

Table 1 : Effect of intercropping on plant growth of mango

Treatments	Percentage increase in tree height		Percentage increase in tree girth		Percentage increase in tree canopy area		Shoot growth (cm)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	9.6	10.6	7.0	8.6	10.9	12.7	17.0	17.5
T_2	9.8	10.9	6.6	8.4	11.2	12.6	17.0	17.1
T_3	9.1	10.8	6.8	8.2	11.0	12.2	16.1	16.3
T_4	10.2	12.1	7.8	9.1	12.6	14.6	18.0	18.3
T_5	10.0	11.8	7.2	8.8	11.9	13.2	18.3	18.9
T_6	8.5	10.0	5.8	7.2	9.6	11.8	16.2	16.2
T_7	8.1	9.2	5.2	7.1	9.2	11.7	15.2	16.0
T_8	9.2	10.8	6.9	8.1	10.6	12.0	17.1	17.2
T_9	6.2	7.6	4.1	5.3	6.7	8.4	15.2	15.8
S.E. (m) ±	0.24	0.31	0.28	0.23	0.27	0.41	0.87	0.63
C.D. (P=0.05)	0.73	0.92	0.84	0.69	0.82	1.24	NS	1.88
C.V. (%)	4.7	5.08	7.56	5.10	4.53	5.89	8.66	6.34

NS=Non-significant

al. (2003) and Swain and Patro (2007).

Flowering and fruit retention of mango:

It was observed from the Table 2 that the mango + guava + cowpea intercropping system (T_4) recorded the highest number of panicles per square meter (39.4) as against 23.6 panicles per square metre in no intercropping system (T_9) during 2006-07. The mango + guava + cowpea intercropping system (T_4) had also a significant effect in producing perfect flowers and initial fruit setting during both the year of study. However, the fruit retention percentage at maturity stage was found to be influenced by the intercropping systems in the second year of study only and significantly maximum fruit retention was observed in the intercropping system involving cowpea. Efficient utilization of natural resources like solar radiation and soil moisture as a result of intercropping might helpful in producing more number of flowering panicles in the tree.

This corroborates with the findings of Swain and Patro (2007) who obtained maximum number of panicles in mango tree due to intercropping of cowpea and French bean. The improvement in the availability of nitrogen and potassium in the orchard soil due to recycling of biomass might have increased perfect flowers, setting percentage and final fruit retention in mango trees. Maheswarappa *et al.* (1998) also reported that NPK content under different coconut based cropping systems increased over the initial status indicating that addition and recycling of organic matter added considerable amount of nutrients into the system. They also stated that the beneficial effect of intercropping in improving

Table 2 : Effect of intercropping on flowering and fruit retention of mango

Treatments	No. of panicles per sq. m.		Percentage of perfect flowers per panicle		Initial fruit setting (%)		Final fruit retention (%)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	25.35	29.60	16.3	16.5	22.0	22.8	1.13	1.16
T_2	26.67	31.70	16.2	16.8	21.5	22.0	1.12	1.17
T_3	25.92	30.20	16.3	16.5	21.4	22.3	1.12	1.18
T_4	30.74	39.40	18.5	18.6	24.3	26.0	1.32	1.36
T_5	29.97	35.60	17.6	17.3	23.4	24.5	1.22	1.24
T_6	25.30	28.70	15.2	15.0	20.0	21.0	1.01	1.17
T_7	24.70	27.30	15.0	14.8	18.3	19.2	1.02	1.10
T_8	27.20	28.50	16.1	16.0	19.3	21.9	1.10	1.12
T_9	19.70	23.60	14.2	14.0	16.3	17.2	0.92	1.02
S.E. (m) ±	0.41	0.71	0.44	0.51	1.37	1.07	0.09	0.03
C.D. (P=0.05)	NS	2.14	1.31	1.52	4.10	3.21	NS	0.08
C.V. (%)	3.01	4.82	4.67	5.42	11.43	8.47	14.82	3.74

NS=Non-significant

the soil physical, chemical and biological environment favoured the higher uptake from the nutrient pool in the soil. This is in line with the studies of Rath and Swain (2006) and Swain and Patro (2007) in mango based intercropping system.

Fruit weight, yield and quality of mango:

Intercropping in mango orchard had significant effect on fruiting of mango (Table 3). 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 T_4 which was statistically at par with T_5 (301.4 g), T_3 (292.3 g) and T_1 (290.3 g) and the minimum was recorded in T_9 (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 T_4 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 T_4 which was significantly superior to rest of the treatments except T_5 where the results closely followed with T_4. The minimum fruit yield per tree was recorded in T_7 (22.30 kg), which was statistically at par with that of the yield of control plot (22.40 kg tree^{-1}) *i.e.* T_9. 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 French bean 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 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.

The analysis of quality parameters of mango fruits (Table 3) indicated that TSS and acidity were not significantly affected by intercropping during both the years of study. Similar findings, that the TSS and acidity 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.

Leaf NPK status of mango:

The leaf analysis result after completion of the study (Table 4) 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 + French bean 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).

Table 3 : Effect of intercropping on fruit weight, yield and quality of mango

Treatments	Average fruit weight (g)		Fruit yield (kg tree^{-1})		TSS (^{0} brix)		Acidity (%)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	280.5	290.3	25.25	28.10	13.8	13.9	0.25	0.26
T_2	273.6	280.1	26.20	28.50	14.2	13.9	0.25	0.26
T_3	282.4	292.3	25.30	27.82	13.9	14.0	0.26	0.25
T_4	295.5	304.6	32.50	34.10	14.2	14.1	0.23	0.24
T_5	290.6	301.4	29.70	31.80	14.1	14.2	0.24	0.24
T_6	273.3	283.4	24.41	24.00	14.0	14.1	0.26	0.25
T_7	270.4	279.6	22.12	22.30	13.7	13.9	0.27	0.26
T_8	275.4	277.3	24.75	25.20	13.8	13.9	0.24	0.25
T_9	260.5	265.3	20.56	22.40	13.7	13.6	0.27	0.26
S.E. (m) ±	4.97	4.94	0.72	1.29	0.17	0.70	0.01	0.01
C.D. (P=0.05)	14.91	14.81	2.14	3.88	NS	NS	NS	NS
C.V. (%)	3.10	2.99	4.82	8.29	2.06	8.83	8.17	7.76

NS=Non-significant

Table 4 : Effect of intercropping on leaf NPK status of filler crop mango

Treatments	Leaf nutrient status of guava (% dry wt.)		
	N	P	K
T_1	1.33	0.14	0.63
T_2	1.38	0.12	0.62
T_3	1.35	0.13	0.62
T_4	1.42	0.15	0.74
T_5	1.40	0.14	0.75
T_6	1.28	0.13	0.52
T_7	1.20	0.11	0.50
T_8	1.28	0.13	0.69
T_9	1.10	0.08	0.47
S.E. (m) ±	0.03	0.01	0.02
C.D. (P=0.05)	0.09	0.02	0.05
C.V. (%)	4.05	7.63	4.89

Conclusion:

The results of the investigation revealed that the intercropping was found effective in increasing the plant growth, flowering and fruit yield of main crop mango. The plant growth, panicle production, fruit retention and fruit yield of mango was observed maximum in mango + guava +cowpea intercropping system followed by mango + guava + French bean system. Fruit quality of mango was not affected by the different intercropping systems. The leaf analysis result after completion of the study revealed that the N and P content of mango leaf were found to be maximum under mango + guava + cowpea intercropping system whereas the K content was estimated maximum in the mango + guava + French bean system. 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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