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Performance of rice crop in mango based Agri-horticulture system in Chhattisgarh plain

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Abstract
An agri-horticulture system experiment of mango + rice crop was carried out at Pikridih village, Raipur in Chhattisgarh for two tears of observations (2017-18 & 2018-19). Mango plantation at spacing of 28 x 28 m and were intercropped with rice and wheat in 2017-18 & 2018-19. The growth performance of *oryza sativa* L. var. Saran at different treatments site located between four clumps along with a separate open field plot were studies for various growth, yield attributes, yields of rice, the plant and soil nutrient status and economics of mango based AHS. Growth parameter and yield of rice crop was found significantly maximum in open field crop than agri-horticulture system. Economics of rice-wheat cropping under mango based agri-horticulture system showed meager gains as compared to mono-cropping but found economically viable and technically feasible by sharing the inputs of irrigation, manure and fertilizer, weeding etc. applied to agriculture crops.
The result of this investigation showed that highest rice yield is found under open field as compared to other treatments under mango based agri-horticulture system.

Keywords: Population, No. of tiller, crop height, yield, and harvest index

Introduction

Agro-forestry the developing of trees and harvests in communicating blends, is presently perceived as a way to deal with increment ranch profitability in low info and asset circumstances. Later examinations in agro-forestry try to comprehend the working of associating segments and the systems by which relative preferred position happens through communications.

Agro-forestry service in numerous occasions tends to a fundamental issue in agro-ecology: the shortage of beneficial land for farming interests. Many, if not most, agro-forestry frameworks have created over significant stretches of time because of collaborations between agro-ecology conditions, plant assorted variety and rancher assets and necessities. As Nair (1998) notes, much starting examination in agro-forestry was enlightening or applied, and model innovations were created to address explicit creation constraints being developed "problem areas" were land quality and accessibility not overpowering restrictions, various issues, for example, crop yields, supplement accessibility, protection and environmental help capacities and fuelwood and timber creation would get disputable. The normal assets, for example, carbon and different components that are put away in environments, for example, woods and prairies are presently being removed and misused and the land that gets drained of its unique vegetation is then utilized either to attempt or produce wares for human needs, or are deserted as badlands. One goals of this proceeding with corruption is to keep up and upgrade the elements of woody perennials inside a streamlined agro-environment while improving the absolute profitability of the framework.

Chhattisgarh state is rich in forest (43.6%) and has a vast variety of minor forest products to favorable in each agro-climatic zone. Rice is the major crop (27.24% of geographical area of Chhattisgarh) cultivated with performance of on *Acacia nilotica*, *Butea monosperma*, *Gmelina arborea, Azadirachta indica*, *Delbergia sissoo* etc bunds of as part of traditional agroforestry system.

Agro-forestry can provide a sound ecological basis for increased crop and animal productivity, more dependable economic returns, and greater diversity in social benefits on a sustained basis (Rahim, 1997).

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Agro-forestry although not new in itself, requires new strategies and technologies as compared to traditional or modern agriculture and forestry (Dhyani *et al.*, 2009).

Materials and Methods

The investigation site Raipur, is arranged in Chhattisgarh extended between 22° 33' N to 21°14'N scope and 82° 6' to 81° 38'E longitude with a rise of 296 m over the mean ocean level. It is encompassed by Bilaspur in the north, Durg in the west, Baster in the south and Raigarh in the east. Topographical region of the state is 135,191 km2. The district is known for its crude horticulture practices and destitution as a result of the poor financial status and absence of education.

The climatic condition of test site is sub-moist dry tropical. The region gets a typical yearly precipitation of 1250 mm, of which 80% occurs during swirling season from June to end of September and discontinuous precipitation during October to February. The mean month to month most noteworthy temperature reaches out between 27.3°C in December and 42.3°C in May and least temperature varies between 13.2°C in December and 28.3°C in May. Raipur has three indisputable geological game plans *viz.*, Bijapur, Cuddapha, Dharwar and Archean, Lithographically, it is gathered into seven areas, to be explicit, Raipur shale and limestone, Gunderdhi shale, Khairagarh and ston, Cuddapa Chamar limestone, Chandrapur sand Stone coarseness, Dharwar rock, Granite and Gneisses. The dirt of Raipur has a place with four distinct requests *viz*; Entisols, Vertisols, Inceptisols and Alfisols.

Experimental site: - Vimal Gupta farm at village Pikridih, Raipur (C.G.)
1. **Plantation:** Mango (Dasahari) plantation was done in July 2001
2. **Tree Spacing:** Mango plantation was done 28X28m. on bunds.
3. **Crop:** Tow season with Rice-Wheat rotation
   3a. Irrigation: Twice in a weak, as and when required.
   3b. Fertilizer (RDF)

Basal dose: 100 kg N, 60 kg P_2O_5 & 40 kg K_2O/ha in rice and wheat. Potash 60kg/ha and Zing Sulphate 20kg/ha, N is applied in 3 split dozes after 60 days 40 Kg and 120 days 40 Kg.

Table 1: Experimental details

Crops	:	Rice (*Oryza sativa*) and Wheat (*Triticum aestivum*) Kharif- Rice (var. Sarna) cropping period 100-120 day Rabi- Wheat (var. Sarbti) cropping period 90-130 days.
Design of Experiment	:	Randomized Block Design
Treatments	:	4 T_1 Centre of four Trees T_2 between East-West tree stands T_3 between North-South tree stands T_4 Open Field (Control)
Year	:	2
Replications	:	3
Design	:	RBD

Table 2: Statistical Configuration for both Rice

	Replication	Treatment	Year	Error	Total
n	3	4	2	-	24
df	2	3	1	17	23

Results and Discussion
Growth performance of rice crop
Plant population (m^{-2})

The growth parameters of Rice *viz.*, Plant population, plant height (cm), numbers of tillers per plant, number of leaves, root length (cm), shoot length (cm), Fresh & dry weight of leaves (gm) Fresh & dry weight of root (gm) Fresh & dry weight of shoot (gm) as observed during the course of investigations were recorded and presented in table-3.

a. **Effect of Treatments:** Effect of treatments pertaining to various crop growing location under mango trees as well as open field on plant population of rice crop was found statistically significant variations ($P<0.05$). The maximum average plant population was observed 62.9 m^{-2} in T_4 followed by 60.9, 59.8 and 56.1 m^{-2} in T_1, T_2 and T_3 respectively at 105 DAS. The overall percentage of plant population showed highest reduction by with 10.81 per cent, 4.93 and 3.18 percent in treatment T_3, T_2 and T_1 respectively as compared to open field crop condition at the time of crop maturity (Table-3).

b. **Effect of Year:** Effect of year on plant population showed statistically significant variations ($P< 0.05$). The maximum average plant height of rice crop was observed 61.8 m^{-2} in 2nd year and 58 m^{-2} in 1st year at 105 DAS. Over all plant population of rice crop was recorded less in 1st year as compare to 2nd year. The average plant population of rice crop increased much faster in 2nd year than 1st year.

c. **Effect of interaction of Treatment x Year:** The interaction of treatment and year was found statistically non-significant. The average plant population of rice crop at 105 DAS was recorded highest for T_4 x Y_2 (65.3 m^{-2}) followed by 62 m^{-2} in both of T_1 x Y_2 and T_2 x Y_2 with lowest height 54.3 m^{-2} for T_3 x Y_1 interaction, afterward it was remained higher in open field crop (T_4) in 2nd year at 105 DAS.

Number of tillers plant^{-1}

The number of tillers of rice crop was counted at after final harvesting and average number of tillers was presented in Table-3 for role of treatment, year and their interaction.

a. **Effect of treatments:** Effect of treatments on formation of per plant tillers in rice crop was found statistically significant ($P< 0.05$). The maximum average number of tillers was observed 11.9 plant^{-1} in T_4 followed by 11.1, 9.6 and 9 plant^{-1} in T_1, T_2 and T_3 respectively at 105 DAS. The increase in number of tillers was followed more or less similar pattern during crop season. The population of tillers Plant^{-1} showed reducing trend in T_3, T_2 and T_1 with 26.83, 21.95 and 9.76 per cent respectively as compared to crop grown in open field (12.3%) at the time of maturity (Table-3).

b. Effect of year: Effect of year on number of tillers showed statistically significant variations ($P<0.05$). The maximum plant^{-1} average number of tillers was observed 10.8 plan^{-1} in 2nd year and 10.1 plant^{-1} 1st year. Over all number of tiller of rice crop was recorded less in 1st year as compared to 2nd year. The average number of tillers of rice crop increased much faster in 2nd year than 1st year.

c. Effect of interaction of treatment x year: The interaction of treatment and year was also found statistically non-significant at all the observation for population of tillers plant^{-1} (Table-3). The average numbers of tillers at 105 DAS was recorded highest 12 plant^{-1} for T_4 x Y_2 followed by 11.8 plant^{-1} for T_4 x Y_1 with minimum numbers of tillers 8.3 plant^{-1} for T_3 x Y_1.

Table 3: Growth performance of Rice crop under Mango based Traditional Agri-horticulture system

Attributes	Plant population (m^{-2})	No. of tiller (plant^{-1})	Plant height (cm plant^{-1})
Treatments			
T_1	60.9±1.9	11.1±0.8	98.9±10.6
T_2	59.8±3.2	9.6±0.9	90.9±5.4
T_3	56.1±2.6	9±0.9	84.9±5.1
T_4	62.9±2.8	11.9±0.6	105.1±7.7
SEm±	0.24	0.26	0.22
SEd±	0.34	0.37	0.31
CD (at 5%)	0.72	0.77	0.65
Year			
Y_1	58±2.8	10.1±1.6	95±7.1
Y_2	61.8±3.0	10.8±1.1	94.9±10.9
SEm±	0.17	0.18	0.15
SEd±	0.24	0.26	0.22
CD (at 5%)	0.51	0.55	NS
Interaction of Treatment X Year			
T_1X Y_1	59.8±0.5	11±0.8	96.3±5.5
T_2 X Y_1	57.5±1.7	9.3±0.5	92.8±7.5
T_3 X Y_1	54.3±1.5	8.3±0.5	87±6.7
T_4 X Y_1	60.5±0.6	11.8±0.5	104±6.5
T_1 X Y_2	62±2.2	11.3±1.0	101.5±14.6
T_2X Y_2	62±2.6	10±1.2	89±1.4
T_3 X Y_2	58±2.2	9.8±0.5	82.8±1.7
T_4 X Y_2	65.3±1.7	12±0.8	106.3±9.6
SEm±	0.34	0.37	0.31
SEd±	0.48	0.52	0.44
CD (at 5%)	NS	NS	NS

Plant height (cm)

The plant height of rice crop was measured at final harvesting and it was presented in Table-3 for treatments, year and their interaction.

a. Effect of treatments: Effect of treatments on growth in plant height was found statistically significant ($P<0.05$) during crop growth period. The maximum plant height of rice crop was observed 105.1 cm in T_4 followed by 98.9, 90.9 and 84.9 cm in T_1, T_2 and T_3 respectively at 105 DAS. The growth pattern in plant height of rice crop was more or less similar during crop season. When the data compared with open field crop, there was maximum reduction was seen in crop height in T_3 (19.22 per cent) at crop maturity *i.e.* 105 DAS and it was 13.51 and 5.90 per cent in treatment T_2 and T_1 respectively. (Table-3).

b. Effect of year: The plant height of rice crop showed statistically non-significant ($P<0.05$). The maximum plant height was observed 95 and 94.9 cm in 1st year and 2nd year at 105 DAS. Over all the plant height was

recorded less in 2nd year as compared to 1st year. (Table-3).

c. Effect of interaction of treatment x year: The interaction of treatment and year was found statistically non-significant. The plant height of rice crop at 105 DAS was noted highest 106.3 cm for T_4 x Y_2 followed by 104 cm for T_4 x Y_1 with lowest height 82.8 cm for T_3 x Y_2. (Table-3).

Similarly Bisaria *et al.* (1995) reported lower growth and yield of wheat crop under agro-forestry system and higher result of growth in yield in sole crop as compared to agro-forestry system due to less competition for available resources.

Yields attributes and yield of rice crop
Length of panicle
The length of panicle (cm) of rice crop was measured final harvesting and it was presented in Table-4 for treatments, year and their interactions.

a. Effect of treatments: The effect of treatment on length of panicle was found statistically non-significant ($P<0.05$) results during growth period. The maximum length of panicle was observed 22.9 cm in T_4 followed by 22.8, 22.3 and 22.1 cm in T_2, T_1 and T_3 respectively at 105 DAS. Where the reduction in length of panicle as compared to open field crop (T_4) was noticed 3.49 per cent in T_3 followed by 2.62, 0.44 per cent in T_1 and T_2 respectively at the time of maturity (*i.e.* 105 DAS) (Table-4).

b. Effect of year: The length of panicle showed statistically significant ($P<0.05$) results for 105 DAS observation. The maximum length of panicle was observed 23.4 cm in 1st year and 21.6 cm 2nd year at 105 DAS time of crop maturity (Table-4).

c. Effect of interaction of treatment x year: The interaction of treatments and year was also found statistically non-significant ($P<0.05$) results for the observations period. The length of panicle in rice crop at 105 DAS was recorded highest for T_4 x Y_1 (24.0 cm) followed by 23.8 cm for T_1 x Y_1 and T_2 x Y_1 with minimum 20.9 cm for T_1 x Y_2 interaction. It was remained higher in T_4 (open) in both 1st and 2nd year of crop.

No. of locules
The formation of number of locules (panicle^{-1}) of rice crop was counted at time of crop maturity (105 DAS) and it was presented in Table-4 for treatments, year and their interaction.

a. Effect of treatments: The effect of treatments on number of locules was found statistically non-significant ($P<0.05$) results during growth period. The maximum number of locules was observed 217.4 panicle^{-1} in T_4 followed by 200.6, 189.5 and 183.4 panicle^{-1} in T_2, T_1 and T_3 respectively. The number of locules was found less in order of (15.64%) in T_3 which was followed by in T_1 (12.83%), and T_2 (7.73%) compared to the open plot crop (T_4). (Table-4).

b. Effect of year: The number of locules panicle^{-1} showed statistically significant ($P<0.05$) results. The maximum locules were observed 223.9 panicle^{-1} in 1st year and 171.5 panicle^{-1} 2nd years at time of crop maturity (105 DAS) (Table-4).

c. Effect of interaction of treatment x year: The interaction of treatments and year was found statistically non-significant ($P<0.05$) during growth period. The number of locules was recorded highest in T_4 x Y_1 (251.3 panicle^{-1}) followed by 231.3 and 221.5 panicle^{-1} for T_1 x

Y_1 and T_2 x Y_1 respectively with minimum 147.8 panicle^{-1} for T_1 x Y_2 interaction. However it was remained higher in open field crop (T_4) for 1st and 2nd year at time of crop maturity.

Table 4: Yield attributes and yield of rice crop under Mango based Traditional Agri-horticulture system

Attributes	Panicle length (cm)	No. of Locules (panicle^{-1})	Number of effective tiller (plant^{-1})	Grain (qha^{-1})	Straw (qha^{-1})	Harvest index (%)
Treatments						
T_1	22.3±2.7	189.5±52.6	8.8±1.0	37.8±10.4	50.8±26.0	42.66
T_2	22.8±1.6	200.6±32.7	8.1±1.4	36.4±8.7	55.6±21.0	39.58
T_3	22.1±1.4	183.4±50.0	7.0±1.3	25.1±9.9	45.6±18.1	35.51
T_4	22.9±1.6	217.4±42.7	8.8±1.3	44.3±7.9	75.9±18.2	36.86
SEm±	0.2	0.3	0.2	0.1	0.1	
SEd±	0.3	0.4	0.2	0.2	0.2	
CD (at 5%)	NS	NS	0.5	0.4	0.4	
Year						
Y_1	23.4±0.8	223.9±24.8	7.9±0.9	32.2±9.7	40.6±15.3	44.23
Y_2	21.6±0.5	171.5±16.2	8.4±0.7	39.7±6.5	73.3±11.6	35.15
SEm±	0.2	0.2	0.1	0.1	0.1	
SEd±	0.2	0.3	0.2	0.1	0.1	
CD (at 5%)	0.5	0.6	NS	NS	0.3	
Interaction of Treatment X Year						
T_1 X Y_1	23.8±2.5	231.3±26.3	8.5±1.3	35.0±12.9	30.0±16.3	53.85
T_2 X Y_1	23.8±1.3	221.5±11.1	8.0±1.6	32.1±7.7	40.0±14.1	44.54
T_3 X Y_1	22.3±1.0	191.8±69.4	6.5±1.3	19.3±6.2	30.0±8.2	39.09
T_4 X Y_1	24.0±0.8	251.3±23.8	8.5±1.7	42.5±9.6	62.5±15.0	40.48
T_1 X Y_2	20.9±2.3	147.8±33.4	9.0±0.8	40.5±8.2	71.5±12.6	36.16
T_2 X Y_2	21.9±1.3	179.8±34.9	8.3±1.3	40.8±8.3	71.3±13.5	36.38
T_3 X Y_2	22.0±1.8	175.0±28.6	7.5±1.3	31.0±9.9	61.3±6.7	33.60
T_4 X Y_2	21.8±1.3	183.5±24.9	9.0±0.8	46.7±5.8	89.3±8.3	34.33
SEm±	0.3	0.4	0.2	0.2	0.2	
SEd±	0.5	0.6	0.4	0.2	0.3	
CD (at 5%)	NS	NS	NS	NS	NS	

No. of effective tiller (plant^{-1})

The number of effective tiller plant^{-1} in rice crop was counted at crop maturity period and it was presented in Table-4 for treatments, year and their interactions.

a. Effect of treatments: The effect of treatment on strength of effective tiller was found statistically significant ($P<0.05$) during growth period. The maximum effective tiller was observed 8.8 plant^{-1} in both T_1 and T_4 followed by 8.1 and 7.0 plant^{-1} in T_2 and T_3 respectively at 105 DAS. Where populations of effective tiller showed reduction by 20.45 per cent in T_3 and 7.95 per cent in T_2 respectively from highest value *i.e.* 8.8 tillers plant^{-1}. (Table-4).

b. Effect of year: The strength of effective tiller showed statistically non-significant ($P<0.05$) results for both the observation. The effective tiller was observed 8.4 plant^{-1} in 2nd year and 7.9 plant^{-1} 1st year at 105 DAS (Table-4).

c. Effect of interaction of treatment x year: The interaction of treatments and year was found statistically non-significant ($P<0.05$) observations during growth period. The population of effective tillers at 105 DAS was recorded highest 9.0 plant^{-1} for both T_4 x Y_2 and T_1 x Y_2 followed by 8.5 plant^{-1} for T_1 x Y_1 with minimum 6.5 plant^{-1} for T_3 x Y_1 interaction (Table-4).

Grain yield

The grain yield (qha^{-1}) of rice crop was recorded at time of crop maturity and it was presented in Table-4 for treatments, year and their interaction.

a. Effect of treatments: The effect of treatments on grain yield was found statistically significant results ($P<0.05$). The maximum grain yield was observed 44.3 qha^{-1} in T_4 followed by 37.8, 36.4 and 25.1 qha^{-1} in T_1, T_2 and T_3 respectively. The grain yield was found less in order of T_3 (43.34%) which was followed by T_2 (17.83%) and T_1 (14.67%) as compared to the open plot crop (T_4). (Table-4).

b. Effect of year: The grain yield (qha^{-1}) showed statistically non-significant ($P<0.05$), with maximum grain yield was observed 39.7 qha^{-1} in 2nd year and 32.2 qha^{-1} in 1st year and it was 18.9% less in 1st year crop (Table-4).

c. Effect of interaction of treatment x year: The interaction of treatments and year was found statistically non-significant ($P<0.05$) for all the observation. The grain yield was recorded highest in T_4 x Y_2 (46.7 qha^{-1}) followed by 42.5 and 40.8 qha^{-1} for T_4 x Y_1 and T_2 x Y_2 with minimum of 19.3 qha^{-1} for T_3 x Y_1 interaction respectively. However it was remained higher in open field crop (T_4) for 1st and 2nd year at time of crop maturity.

Straw yield

The straw yield (qha^{-1}) of rice crop was recorded at time of crop maturity and it was presented in Table-4 for treatments, year and their interaction.

a. Effect of treatments: The effect of treatments on straw yield was found statistically significant results ($P<0.05$). The maximum straw yield was observed 75.9 qha^{-1} in T_4

followed by 55.6, 50.8 and 45.6 qha^{-1} in T_2, T_1 and T_3 respectively. The straw yield was found less in order of T_3 (39.92%) which was followed by T_1 (33.07%) and T_2 (26.75%) as compared to the open plot crop (T_4). (Table-4).

b. **Effect of year:** The straw yield (qha^{-1}) showed statistically significant results ($P<0.05$), with maximum of 73.3 qha^{-1} in 2nd year and 40.6 qha^{-1} in 1st year and it was 44.6% less in 1st year crop (Table-4).

c. **Effect of interaction of treatment x** *year:* The interaction of treatments and year was found statistically non-significant ($P<0.05$). The straw yield was recorded highest in T_4 x Y_2 (89.3 qha^{-1}) followed by 71.5 and 71.3 qha^{-1} for T_1 x Y_2 and T_2 x Y_2 with minimum of 30.0 qha^{-1} in both T_1 x Y_1 and T_3 x Y_1 interaction respectively. However it was remained higher in (T_4) open field crop for 2nd year at time of crop maturity.

Harvest index (%)
The harvest index (%) of rice crop was recorded at time of crop maturity and it was presented in Table- 4 for treatments, year and their interaction.

a. **Effect of treatments:** The effect of treatments on harvest index was found statistically significant results ($P<0.05$). The maximum harvest index was observed 42.66% in T_1 followed by 39.58%, 36.86% and 35.51% in T_2, T_4 and T_3 respectively. The increase in harvest index of rice crop was more or less same during crop season. (Table-4).

b. **Effect of year:** The harvest index (%) showed statistically significant ($P<0.05$), with maximum harvest index was observed (44.23%) in 1st year and (35.15%) in 2nd year and it was 20.5% less in 2nd year crop (Table-4).

c. **Effect of interaction of treatment x year:** The interaction of treatments and year was found statistically significant ($P<0.05$). The average harvest index was recorded highest for T_1 x Y_1 (53.85%) followed by 44.54% and 40.48% for T_2 x Y_1 and T_4 x Y_1 with minimum of 33.60% for T_3 x Y_2 interaction at time of crop maturity**.**

The yield result of the present study has also been supported by the finding of many earlier workers (Dhillon *et al.,* 1997 and Sharma *et al.,* 1994) [9, 10], they also observed that agricultural crop yield was increased with increasing the crop distance from the tree base under AFS.

Similarly, Khan and Ehrenriech (1994) [11] studied on effect of increasing the crop distance from *Acacia nilotica* trees the growth of wheat crop was lowest near the trees and increased with for distance from tree. The test weight of grain was found minimum in crop at 1m distance and it gradually increased up to 11 m., similarly the grain yield was lowest near the trees and gradually increased with for distance from the trees.

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