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Performance of Wheat Crop in Mango Based Traditional Agri-horticulture System in Chhattisgarh Plain

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A B S T R A C T

Traditional Agroforestry is very common in Chhattisgarh with forest tree crops, now fruit tree crops are introduced to increase the farmer's income. Hence the current on farm study was conducted under mango plantation of 28m x 28m spacing, where wheat (var; Sarbati) crop was cultivated as traditional agri-horticulture system in plains of Chhattisgarh at Pikridih village of Raipur district in Chhattisgarh for two years (2017-19). The growth performance and yield of wheat under different set of treatments *viz.*, T-1 (centre of four trees), T-2 (north-south stands), T-3 (east –west stands) was recorded along with open field (T-4) having variable microclimatic status. Growth parameter and yield of wheat crop was found significantly maximum in open field crop than treatments under mango plantations and it was 4.5, 5.0 and 7.6 % higher from T-1 T-2 and T-3 respectively. The yield of grain and husk was 11.01 and 8.95 q ha^{-1} in crop of open field. The micro climatic features available to growing wheat crops at different locations had very little variations but they were found to be very effective under traditional agri-horticulture system.

Introduction

Chhattisgarh is a tribal dominating state stretched from 17° 47' and 24° 06' N latitude and from 80° 15′ to 84° 24′ E longitude with geographical area of 135,191 km^2 having sub-humid tropic climate which supported the rich in forest (43.6%) cover as well as tree crops on bunds of crop fields as part of traditional agro-forestry system (Naugraiya, 2012).

Agro-forestry service in numerous occasions tends to a fundamental issue in agro-ecology mechanism; however it can provide a sound ecological basis by management to increase crop and animal productivity with more dependable economic returns, and greater diversity in social benefits on a sustained basis. The horticultural tree species in crops field has been found to be the most appropriate filler plant for improving the overall productivity (Nath *et al.,* 2008).

Naugraiya (2013) assessed the turmeric cultivation under multitier tree crops of *Acacia mangium*, *Emblica officinalis* and *Murraya koinghii* for progressive financial addition in small back yard garden area of Chhattisgarh. Traditional agro-forestry particularly with fruit trees frameworks are further needed to be more standardized for suitable filler crop and here the intercrop combinations with mango based agri-horticultural systems is studied.

Materials and Methods

The study was conducted on farmer's field having vertisols soil at Pikridih village of Raipur district where Mango plantation of 2000 years growth exist at 28m x 28m spacing in 1 ha area. Wheat (*Triticum sativa L.*) var; "Sarbati" was cultivated as per recommended package and practices in Rabi season. Under mango plantations area among the four tree was divided in to 9 blocks of 9 m 9 m and three treatments *viz;* T_1 - Middle center area, T_2 - Middle area between South –West, T_3 - Middle area between North – East side were framed, while T_4 - open field *i.e.* area without trees were laid down to assess the growth and yield performance of wheat crop affected by micro- climatic condition available to wheat crop at maturity and crop harvest. The observations were made for plant population, Crop height, Number of effective tillers, Panicle length, Number of locules, Number of healthy and undeveloped seeds per panicle, Test weight (1000 seeds) alongwith per plot yield of gain and husk. The dry weight of samples was estimated after drying of the samples at 75^0C for 24 hours.

The microclimate observations *viz;* PAR, Temperature and RH were recorded fortnightly by using LICOR-Photometer, digital thermometer and hygrometer at 0800, 1200 and 1600 hours in each replication of the treatments during the crop period.

The soil of experimental area was analyzed for organic carbon, pH, electric conductivity (EC), nitrogen, phosphorus and available potassium after harvesting of crop as per standard methods of Jackson, 1957, Piper, 1967, Olsen *et al.* 1954 and AOAC (2002). The whole study was conducted in RBD with four replications for statistical analysis (Panse and Sukhatme, 1961).

Results and Discussion

Climate

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. The climatic condition of the 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.

Micro climatic observations

The microclimate observation viz: PAR, Temperature and Relative humidity were recorded fortnightly at 0800, 1200 and 1600 hours in each replication of the treatments during the crop period and the average of the day is presented in figure-1.

Photo-synthetically active radiation (µmol cm^{-2}s^{-1})

The sun light available to the crop was measured for PAR only by using the photo quantum sensor for both the cropping year and overall it was recorded in order of T_4< T_1<T_2<T_3. The PAR in open field was 1340.7, 1381, 1379, 1620, 1186, 1164 and 1123 µ mol cm^{-2} s^{-1} at 15, 30, 45, 60, 75, 90 and 105 DAS respectively during 1st year and it was available 87.8 to 94.8% in T1, 80.4 to 88.7% in T2 and 70 to 79% in T3 under mango plantation against the open field. The PAR available for open field during 2nd year was recorded in range of 789.7 to 1296.9 µ mol cm^{-2} s^{-1} for open field crop and the reduction in PAR under mango tree followed more or less similarly trends of 1st year. The availability of PAR a regulatory factor to affect the growth and flowering mechanism of plants.

Temperature (^{o}C)

Air temperature around the crop during 1st and 2nd year was influenced by different treatments in different time interval. The temperature around the crop in open filed was higher during 1st year and it was 27.2, 28.6, 29.2, 31.0, 29.8, 31.4 and 32.2 ^{o}C at 15, 30, 45, 60, 75, 90 and 105 DAS. During 2nd year the temperature fell down under mango plantation in range of 0.6 to 1.3 ^{o}C in T_1, 0.8 to 1.8 ^{o}C in T_2 and 0.9 to 1.9 ^{o}C from 45 to 105 DAS respectively as compare to open field (27.0 to 33 ^{o}C)

Relative humidity (%)

Relative humidity was recorded high during 2nd year in range of 22 to 54% as compare to 1st year (22 to 43%) in open field area and it was high at 15 DAS afterward get decreased upto 60DAS (22%) than it boosted by cent percent at 75 DAS due to winter rains. Relative humidity get dropped at sequentially at 90 and 105 DAS. Under mango plantation, the relative humidity get increased in order T1 < T2 < T3 against the open field in both year.

The PAR, temperature and relative humidity showed similar trend at its availability during both the year. However the available value of these are found little wit varied.

Soil characteristics

Electrical conductivity of soil was found in range of 0.18 to 0.23 m mhos and it was increased successively from 1st year (0.19) to 2nd year (0.21 m mhos) and 3rd year (0.22 m mhos). It was found in high range 7.2 to 7.5 in open plot area (T_4) as compared to areas under mango tree (6.9 to 7.5). The level of pH was almost neutral before the 1st year crop (0.69 to 7.2) and it get increased toward alkaline side in range of 7.1 to 7.4 and 7.3 to 7.5 during 2nd year and 3rd year crop respectively. The organic carbon was varied from 0.42 to 0.66 % during three years. Overall results showed that the higher level of organic carbon was found in under tree T_1< T_2< T_3 (0.54 to 0.56 %) as compare to open field T_4 (0.52%).The level of available nitrogen was initially maximum 159.8 kg ha^{-1} in T_1 followed by T_2 (158.2 kg ha^{-1}) and T_3 (154.8 kg ha^{-1}) with minimum of 128.8 kg ha^{-1} in T_4. It increased from 1st to 3rd year where it was found higher under tree in order of T_1< T_2 < T_3, *i.e.* 169.35, 168.15 and 165.27 kg ha^{-1} respectively than open field T_4 (139.88 kg ha^{-1}).In the beginning the available phosphorus was analyzed maximum 11.7 kg ha^{-1} in T1/T2 followed by T3 (11.6 kg ha^{-1}) and T4 (9.2 kg ha^{-1}) which get increased in 2nd and 3rd year. It was found higher in order of T_2< T_1< T_3 *i.e.* 13.23, 13.04 and 12.99 kg ha^{-1} respectively under tree than open field T_4 (10.23 kg ha^{-1}).The quantity of potassium during 1st year was found in order of T_1 (288.2 kg ha^{-1}) < T_2 (276.0 kg ha^{-1}) < T_3 (270.0 kg ha^{-1}) which gradually increased in 2nd and 3rd year. The higher potassium content was found under tree in order of $T_1 < T_2 < T_3$ *i.e.* 346.34, 337.14 and 323.25 kg ha^{-1}) than open field T_4 (278.16±20.76 kg ha^{-1}) (Table 1).

Performance of wheat crop

Plant population (m^{-2})

The growth parameters of wheat *viz*., Plant population, crop height (cm), and numbers of tillers per plant, were recorded and presented in table-2.

Effect of treatments pertaining to various treatments of crop growing under mango trees as well as in open field on plant population was statistically insignificant ($P<0.05$). The maximum average plant population was observed 75.3 m^{-2} in T_4 followed by 71.9, 71.5 and 69.6 m^{-2} in T_1, T_2 and T_3 respectively at 105 DAS. The role of year on plant population showed statistically significant variations by the difference 4.9 tillers m^{-2}. The interaction of Treatment x year was found statistically non-significant and it was recorded highest for T_4 x Y_2 (76.8 m^{-2}) followed by 75.5 m^{-2} for T_2 x Y_2 with lowest height 66.5 m^{-2} for T_3 x Y_1 interaction, afterward it was remained higher in open field crop (T_4) in 2nd year.

Number of tillers plant^{-1}

The effect of treatments on formation tillers in a plant was found statistically non significant ($P<0.05$). The maximum number of tillers was observed 6.6 $plant^{-1}$ in T_4 followed by 6.3, 6.1 and 5.9 $plant^{-1}$ in T_2, T_3 and T_1 respectively. The role of year on plant population showed statistically significant variations and it was 6.6 and 5.9 tillers $plant^{-1}$ in 1st and 2nd year respectively. The interaction of treatments x year was found statistically non-significant. The numbers of tillers per plant was recorded highest 6.8 $plant^{-1}$ for T_4 x Y_1, T_2 x Y_1 and T_3 x Y_1 followed by 6.5 $plant^{-1}$ for T_4 x Y_2 with minimum of 5.5 $plant^{-1}$ for T_3 x Y_2 (Table-2).

Crop height (cm)

The effect of treatments on crop height was found statistically significant ($P<0.05$) and the maximum crop height was observed 95.9 cm in T_4 followed by 93.0, 91.9 and 87.3 cm in T_2, T_1 and T_3 respectively (Table-2). The role of year on crop height showed the insignificant variation with crop height of 92.6 and 91.4 cm in 2nd year and 1st year at 105 DAS. The interaction of treatment x year was found statistically non-significant. The crop height was noted highest 96.0 cm for T_4 x Y_2 followed by 95.8 cm for T_4 x Y_1 with lowest height 85.5 cm for T_3 x Y_1.

Bisaria *et al.*, (1995) also reported Similar trend of 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. The growth pattern in plant height of wheat crop was more or less similar during crop growth period, however the data compared with open field crop, there was maximum reduction was seen in crop height in T_3 (9.0 per cent) at crop maturity *i.e.* 105 DAS and it was 4.2 and 3.0 per cent less in treatment T_1 and T_2 respectively. Bijalwan (2011) narrated that agricultural crop production and biomass production was generally decreases under trees due to competition with trees.

Yields attributes and yield of wheat crop

The performance of yield attributing characters is very important to produce grain and these are observed and present as follow (Table-3).

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

The number of effective tiller $plant^{-1}$ in wheat crop was counted at crop maturity period, where the effect of treatment on strength of effective tiller was found statistically non significant ($P<0.05$). The maximum effective tiller was observed 3.8 plant^{-1} in T_4 followed by 3.0 and 2.8 plant^{-1} in both T_1 and T_2 and T_3 respectively. The populations of effective tiller get reduced by 26.3 per cent in T_3 and 21.1 per cent in both T_1 and T_2 respectively than open field (T_4) crop (3.8 tillers plant^{-1}). The effective tiller was observed 3.2 and 3.1 plant^{-1} during 1st and 2nd year respectively with insignificant variations. The interaction of treatments x year was also found statistically non-significant for count of effective tillers and it was recorded highest 4.0 plant^{-1} for T_4 x Y_2 followed by 3.5 plant^{-1} for T_4 x Y_1 with minimum 2.8 plant^{-1} for T_3 x Y_1 and T_3 x Y_2 interaction (Table-3).

Length of panicle (cm)

The length of panicle (cm) of wheat crop was found statistically significant ($P<0.05$) for treatments and the maximum length of panicle was observed 14.3 cm in T_4 followed by 12.9, 12.7 and 12.2 cm in T_1, T_2 and T_3 respectively. Where the reduction in length of panicle as compared to open field crop (T_4) was noticed 15.1 per cent in T_3 followed by 5.7, 1.9 per cent in T_2 and T_1 respectively The length of panicle was 11.7 cm and 14.3 cm in 1st and 2nd year respectively with significant variations. The interaction of treatments x year was also found statistically non-significant, where the length of panicle was recorded highest for T_4 x Y_2 (15.9 cm) followed by 14.2 cm for T_2 x Y_2 with minimum 11.0 cm for T_3 x Y_1 interaction. It was remained higher in T_4 (open) in both 1st and 2nd year of crop (Table-3).

No. of locules

The formation of number of locules (panicle^{-1}) in wheat crop was counted at time of crop maturity where the effect of treatments on number of locules was found statistically significant. The maximum number of locules was observed 41.1 panicle^{-1} in T_4 followed by 32.6 and 29.0 panicle^{-1} in T_1, T_2 and T_3 respectively. The number of locules was found less by 29.4% in both T_3 and T_2 followed by 20.7% in T_1 as compared to the open plot crop (T_4). The variation in locules count for both year crops was 28.0 and 37.9 locules panicle^{-1} in 1st and 2nd year respectively. The interaction of treatments x year was showed statistically non-significant results. The number of locules was recorded highest in T_4 x Y_2 (46.5 panicle^{-1}) followed by 36.5 and 35.8 panicle^{-1} for T_1 x Y_2 and T_4 x Y_1 respectively with minimum 23.3 panicle^{-1} for T_2 x Y_1 interaction. However it was remained higher in open field crop (T_4) for 1st and 2nd year (Table-3).

No. of seed per panicle (Healthy and unhealthy)

The mechanisms of seed setting is completed after pollination, fertilization and embryo genesis and all these process have been governed by availability of ambient resources *i.e.* climate, nutrient and water. Thus the quantity and quality of seed inside the flower/fruits get finalized (Table-3).

Number of healthy seed (panicle^{-1})

The number of healthy seed (panicle^{-1}) in wheat crop was counted in harvested crop; where the effect of treatment was found non-statistically significant. The maximum number of healthy seed was 32.9 panicle^{-1} in T_4 followed by 32.4, 31.4 and 26.3 seeds panicle^{-1} in T_1, T_2 and T_3 respectively, thus the number of healthy seed was found less by 20.1% in T_3 and by 4.6% and 1.5% in T_2 and T_1 respectively as compared to the open plot crop (T_4). The 34.9 seeds panicle^{-1} was available in 2nd year and 26.6 seeds panicle^{-1} in 1st year with significant differences and it was 23.8% less in 1st year than 2nd year. The interaction of treatments x year was found statistically non-significant. The number of healthy seed was recorded highest for T_2 x Y_2 (36.8 panicle^{-1}) followed by 35.3 and 34.8 panicle^{-1} for T_4 x Y_2 and T_1 x Y_2 and lowest 19.8 panicle^{-1} for T_3 x Y_1 interaction, however it was remained higher in open field crop (T4) for 1st year (Table-3).

Number of un-healthy seed (panicle^{-1})

The effect of treatments on availability of number of un-healthy seed per panicle was found statistically non-significant (P<0.05). The maximum number of un-healthy seeds was counted 3.8 seeds panicle^{-1} in T_2 followed by 3.5, 2.8 and 2.5 seeds panicle^{-1} in T_1, T_4 and T_3 respectively, (Table-3). The count of un-healthy seed panicle^{-1} showed statistically significant, for year with maximum of 4.1 seeds panicle^{-1} in 1st yr and 2.2 seeds panicle^{-1} 2nd yr which was 46.3% less than 1st year crop. The interaction of treatments x year was also found statistically non-significant. The number of un-healthy seed was recorded highest in T_2 x Y_1 (4.8 seeds panicle^{-1}) followed by 4.5 and 3.5 seeds panicle^{-1} for T_1 x Y_1, T_3 x Y_1 and T_4 x Y_1 respectively with lowest 1.5 seeds panicle^{-1} for T_3 x Y_2 interaction, however it was remained higher in open field crop T_4 in 1st year (Table-3).

Test weight of seeds

The test weight of 1000 seeds found statistically significant for treatment. The effect of treatment gave maximum test weight of seed for T_4 (41.5 gm 1000 seed) followed by 39.2, 34.0 and 32.7 gm 1000 seed in T_1, T_2 and T_3 respectively. The test weight was found 21.3% less in T_3, 18.1% in T_2 and 5.5% in T_3 as compared to the open plot crop (T_4). The test weight showed statistically non-significant results for cropping year with maximum of 36.9 gm/1000 seeds in 2nd year and 36.8 gm/1000 seeds 1st year and it was 0.3% less in 1st year crop. The interaction of treatments x year was also found statistically insignificant. The test weight was recorded highest inT_4 x Y_1 (43.2 gm/1000 seeds) followed by 40.0 and 39.8 gm/1000 seeds for T_1 x Y_2 and T_4 x Y_2 respectively with minimum of 31.2 gm/1000 seeds for T_3 x Y_1 interaction (Table-3).

Grain yield

The grain yield **(**qha^{-1}) of wheat crop was recorded after harvesting it showed statistically significant results for treatments and year and insignificant results for their interaction. In case of treatment the maximum grain yield was observed 11.0 q ha^{-1} in T_4 followed by 8.3, 8.1 and 8.0 qha^{-1} in T_2, T_3 and T_1 respectively. The grain yield was found less by 27.3% in T_1 followed by T_3 (26.4%) and T_2 (24.5%) as compared to the open plot crop (T_4). The cropping year showed significant variation for grain yield and the maximum grain yield was observed 9.4 qha^{-1} in 2nd year and 8.2 qha^{-1} in 1st year and it was 12.8% less in 1st year crop. The insignificant results of treatment x year interaction for grain yield showed highest yield in T_4 x Y_2 (11.7 qha^{-1}) followed by 10.4 and 9.0 qha^{-1} for T_4 x Y_1 and T_2 x Y_2 with minimum of 7.4 qha^{-1} for T_3 x Y_1 interaction respectively (Table-3).

Husk yield

The effect of treatments on husk yield was found statistically significant where the maximum husk yield was observed 9.0 q ha^{-1} in T_4 followed by7.3, 7.2 and 6.7 q ha^{-1} in T_2, T_1 and T_3 respectively. The husk yield was found less in order of T_3 (25.6%) < T_1 (20%) < T_2 (18.9%) as compared to the open plot crop (T_4). In case of year the husk yield (qha^{-1}) was recorded of 8.3 q ha^{-1} in 2nd year and 6.8 qha^{-1} in 1st year and it was 18.1% less in 1st year crop with statistically significant results. The interaction of treatments x year was also found statistically non-significant and it was recorded highest in T_4 x Y_2 (9.4 qha^{-1})

followed by 8.5 qha^{-1} for both T_4 x Y_1 and T_1 x Y_2 with minimum of 5.8 qha^{-1} in both T_1 x Y_1 interaction respectively, however it was remained higher in (T_4) open field crop for 2nd year (Table-3).

Table.1 Soil physical and chemical status of during crop periods (2017-18 to 2018-19)

Parameters	Year	T_1	T_2	T_3	T_4	AV
EC (m mhos)	**Y_1**	0.19	0.18	0.18	0.20	**0.19±0.01**
	Y_2	0.22	0.21	0.20	0.22	**0.21±0.01**
	Y_3	0.22	0.23	0.23	0.22	**0.22±0.01**
	AV	**0.21±0.02**	**0.21±0.02**	**0.20±0.02**	**0.21±0.01**	
pH	**Y_1**	7.0	7.0	6.9	7.2	**7.0±0.13**
	Y_2	7.1	7.1	7.2	7.4	**7.2±0.13**
	Y_3	7.3	7.3	7.4	7.5	**7.3±0.09**
	AV	**7.1±0.16**	**7.2±0.15**	**7.2±0.26**	**7.2±0.16**	
OC (%)	**Y_1**	0.46	0.44	0.44	0.42	**0.44±0.02**
	Y_2	0.57	0.57	0.54	0.50	**0.55±0.03**
	Y_3	0.65	0.66	0.63	0.63	**0.64±0.01**
	AV	**0.56±0.09**	**0.56±0.11**	**0.54±0.09**	**0.52±0.10**	
N (kg ha^{-1})	**Y_1**	159.8	158.2	154.8	128.8	**150.40±14.55**
	Y_2	173.0	172.0	169.0	142.3	**164.08±14.60**
	Y_3	175.3	174.3	172.0	148.5	**167.50±12.74**
	AV	**169.35±8.35**	**168.15±8.69**	**165.27±9.19**	**139.88±10.08**	
P (kg ha^{-1})	**Y_1**	11.7	11.7	11.6	9.2	**11.03±1.23**
	Y_2	13.4	13.7	13.3	10.0	**12.60±1.72**
	Y_3	14.1	14.3	14.1	11.5	**13.49±1.34**
	AV	**13.04±1.24**	**13.23±1.36**	**12.99±1.29**	**10.23±1.16**	
K (kg ha^{-1})	**Y_1**	288.2	276.0	270.0	254.4	**272.15±14.05**
	Y_2	353.3	332.7	315.0	287.3	**322.08±27.97**
	Y_3	397.5	402.8	384.8	292.8	**369.44±51.68**
	AV	**346.34±54.98**	**337.14±63.49**	**323.25±57.82**	**278.16±20.78**	

Note- T_1- Centre of four trees, T_2- Between East-West trees stands, T_3- Between North- south tree stands, T_4–control, Y_1- initial of crop in 1st year, Y_2- Initial of crop in 2nd year or end of 1st year crop, Y_3- End of 2nd year crop

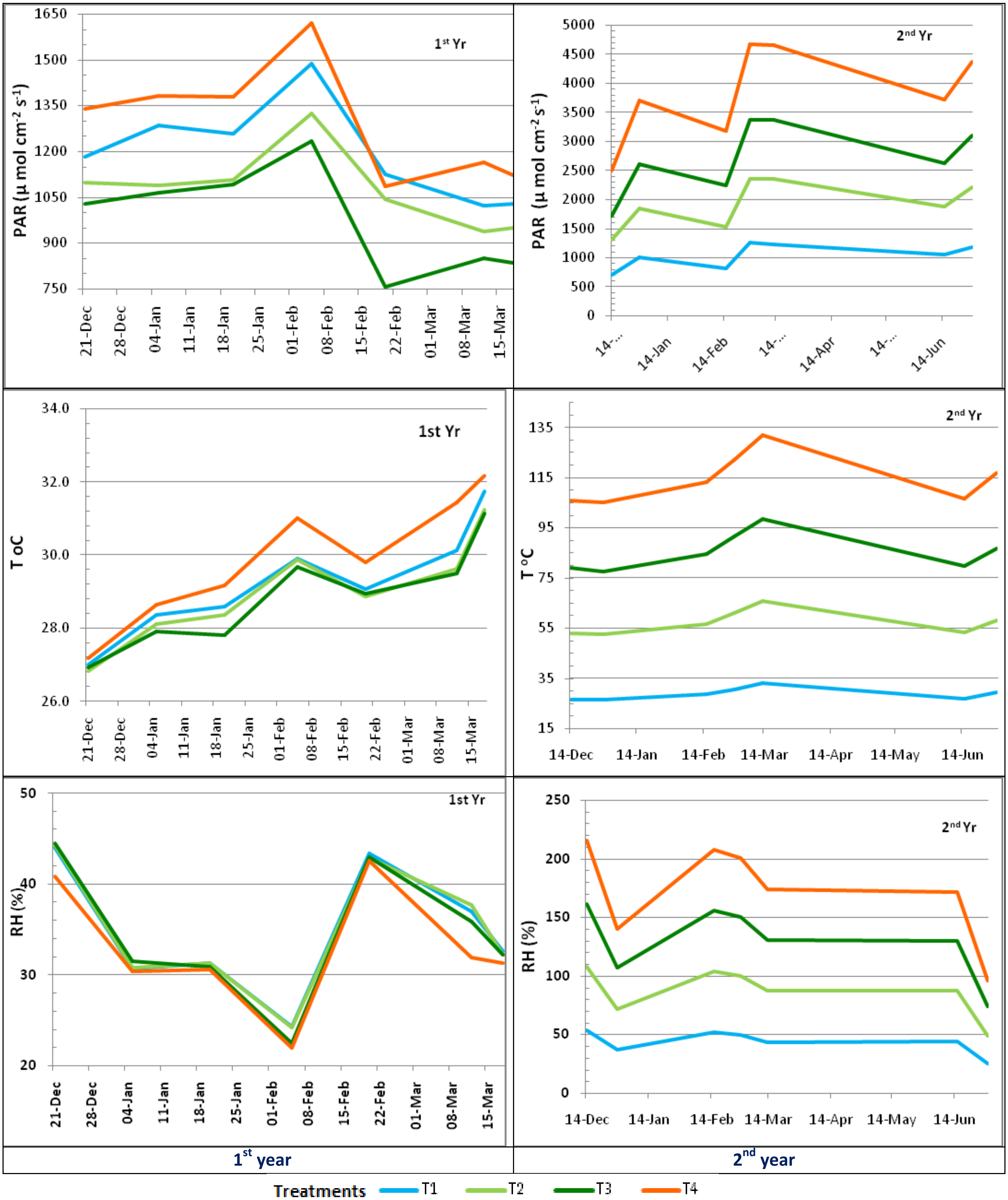
Table.2 Growth performance of wheat crop under Mango based Traditional Agri-horticulture system

Attributes	Plant population (m^{-2})	No. of tiller ($plant^{-1}$)	Crop height (cm $plant^{-1}$)
Treatments			
T_1	71.9±3.6	5.9±0.8	91.9±6.6
T_2	71.5±5.6	6.3±1.0	93.0±4.4
T_3	69.6±6.9	6.1±1.0	87.3±3.6
T_4	75.3±3.8	6.6±0.5	95.9±3.0
SEm±	**0.25**	**0.2**	**0.2**
CD (at 5%)	**NS**	**NS**	**0.5**
Year			
Y_1	69.6±3.3	6.6±0.4	91.4±4.5
Y_2	74.5±1.9	5.9±0.4	92.6±2.9
SEm±	**0.18**	**0.2**	**0.1**
CD (at 5%)	**0.53**	**0.5**	**NS**
Interaction of Treatment x Year			
T_1X Y_1	70.8±4.3	6.0±0.8	90.8±3.3
T_2 X Y_1	67.5±4.5	6.8±1.0	93.8±4.0
T_3 X Y_1	66.5±8.4	6.8±1.0	85.5±4.4
T_4 X Y_1	73.8±3.5	6.8±0.5	95.8±2.6
T_1 X Y_2	73.0±2.9	5.8±1.0	93.0±9.4
T_2X Y_2	75.5±3.3	5.8±1.0	92.3±5.3
T_3 X Y_2	72.8±3.8	5.5±0.6	89.0±1.4
T_4 X Y_2	76.8±3.9	6.5±0.6	96.0±3.7
SEm±	**0.35**	**0.3**	**0.2**
CD (at 5%)	**NS**	**NS**	**NS**

Table.3 Yield attributes and yield of wheat crop under Mango based Traditional Agri-horticulture system

Attributes	No. of effective tiller (plant^{-1})	Panicle length (cm)	No. of locules (panicle^{-1})	No. of seed per panicle		Test wt of Seed (g /1000 S)	Yield (qha^{-1})		Harvest index (%)
				Healthy	unhealthy		Grain	Straw	
Treatments									
T_1	3.0±0.8	12.9±1.4	32.6±5.7	32.4±6.5	3.5±1.8	39.2±2.5	7.96±0.97	7.16±1.91	52.64
T_2	3.0±0.8	12.7±2.0	29.0±7.7	31.4±8.3	3.8±2.3	34.0±4.1	8.29±1.21	7.26±0.96	53.33
T_3	2.8±0.7	12.2±1.5	29.0±6.0	26.3±8.1	2.5±1.4	32.7±2.3	8.06±1.01	6.75±1.06	54.43
T_4	3.8±0.5	14.3±2.1	41.1±9.5	32.9±3.8	2.8±1.3	41.5±4.3	11.01±0.77	8.95±1.25	55.16
SEm±	0.2	0.3	0.2	0.3	0.2	0.3	0.09	0.27	
CD (at 5%)	NS	0.8	0.5	0.4	0.2	0.4	0.26	0.80	
Year									
Y_1	3.1±0.3	11.7±0.7	28.0±5.7	26.6±5.0	4.1±0.7	36.8±5.2	8.22±1.44	6.80±1.22	54.75
Y_2	3.2±0.6	14.3±1.2	37.9±5.9	34.9±1.7	2.2±0.6	36.9±3.4	9.44±1.49	8.26±0.89	53.32
SEm±	0.1	0.2	0.1	0.2	0.1	0.2	0.06	0.19	
CD (at 5%)	NS	0.6	0.4	0.3	0.2	0.3	0.18	0.57	
Interaction of Treatment X Year									
T_1X Y_1	3.0±0.8	12.1±1.6	28.8±4.7	30.0±8.2	4.5±2.1	38.4±2.5	7.53±1.18	5.80±1.74	56.47
T_2 X Y_1	3.0±0.8	11.3±1.6	23.3±5.2	26.0±2.9	4.8±2.6	34.3±4.2	7.63±1.37	6.74±0.68	53.08
T_3 X Y_1	2.8±0.5	11.0±0.8	24.3±4.4	19.8±3.0	3.5±1.3	31.2±0.9	7.37±0.67	6.13±1.20	54.62
T_4 X Y_1	3.5±0.6	12.6±1.4	35.8±9.6	30.5±2.1	3.5±1.3	43.2±5.6	10.38±0.52	8.53±1.77	54.89
T_1 X Y_2	3.0±0.8	13.7±0.5	36.5±3.7	34.8±4.1	2.5±0.6	40.0±2.6	8.40±0.54	8.53±0.73	49.63
T_2X Y_2	3.0±0.8	14.2±0.8	34.8±4.6	36.8±8.8	2.8±1.7	33.7±4.7	8.96±0.59	7.78±0.99	53.55
T_3 X Y_2	2.8±1.0	13.3±0.9	33.8±1.7	32.8±5.6	1.5±0.6	34.2±2.4	8.75±0.81	7.37±0.38	54.27
T_4 X Y_2	4.0±0.0	15.9±1.0	46.5±6.5	35.3±3.9	2.0±0.8	39.8±1.8	11.65±0.13	9.38±0.13	55.39
SEm±	0.2	0.4	0.2	0.4	0.2	0.4	0.12	0.38	
CD (at 5%)	NS	NS	NS	0.6	0.3	0.5	NS	NS	

Fig.1 Microclimate observation available for wheat crop



Harvest index (%)

The harvest index of wheat crop was estimated and it was found maximum 55.16 % in T_4 followed by 54.43%, 53.33% and 52.64% in T_3, T_2 and T_1 respectively. The increase in harvest index of wheat crop was more or less same during both the cropping year. In case of year it was observed 54.75 % in 1st year and 53.32 % for 2nd year which was 2.6% less in 2nd year crop. The interaction of treatments x year showed the highest harvest index for T_1 x Y_1 (56.47 %) followed by 54.89% and 54.62% for T_4 x Y_1 and T_3 x Y_1 with minimum of 49.63% for T_1 x Y_2 interaction. (Table-3).

The yield results of present study has also been supported by the finding of many agroforesters (Dhillon *et al.*, 1997 and Sharma *et al.*, 1994), they additionally determined that crop yield under trees get sequentially increased with increasing the crop distance from the tree base Similarly, Khan and Ehrenriech (1994) also reported that the increasing the crop distance from *Acacia nilotica* trees change the growth and yield pattern of wheat crop and the performance of crop was lowest near the trees and it increased with far distance from tree. Sarvade *et al.* (2014) also narrated the impact of tree crop species on development and yield of wheat in Terai area and they recorded higher grain yield under Poplar (44.60 q ha^{-1}) and 42.60 q ha^{-1} with Melia.

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