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COMPARATIVE EFFECT OF ORGANIC MANURE LEVELS AND INTERCROPPING PATTERN IN DIFFERENT VEGETABLES AND BANANA CROP UNDER CERTIFIED ORGANIC FARM

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ABSTRACT
Plant height, girth of pseudostem, number of leaves and leaf area of banana reduced in intercropped banana compared to sole crop at initial stage of growth *i.e.* at 3rd and 5thMAP. But later on it comes to the level of sole crops as the difference become non- significant after 7th MAP and at flowering. The highest yield of 41.0 t ha^{-1} was obtained with banana + garlic @ 100 % RDN and the lowest 34.53 t ha^{-1} with banana + beet with 50 % RDN under sole crop yield was 37.80 t ha^{-1},dry matter production was highest (9.77 t ha^{-1}) when banana was intercropped with garlic with 100 % RDN through organic source. Among the micronutrients only Zn content and uptake of banana leaves was affected significantly and the effect on Ca, Mg, Fe, Mn and Cu was non significant. Theyield of *viz*. onion, garlic, radish and beet root were found more under the 100 % RDN.On the basis of investigation, it is conclude that yield attributing characters of vegetables with banana intercropping systems play a vital role in increasing the yield of the crop. Intercropping of garlic in banana with (100% RDN) through organic manures gave highest yield, dry matter yield and nutrient removal.

INTRODUCTION

Banana (*Musa spp*.) is the most important fruit crops of the world. It has nutritional, medicinal, industrial as well as aesthetic value in Hindu religion. Out of the large number of varieties grown in India, Grand Naine is the popular variety grown mostly in all export oriented countries of Asia, South America and Africa (Vanilarasu *et al.*, 2014). Initial growth of banana is slow which offers an opportunity to take short duration crop with banana crop. Intercropping, the simultaneous growth of more than one species in the same field (Willey, 1979) is the practical application of basic ecological principles such as diversity, competition and facilitation and it is becoming more and more important to improve soil fertility and increase the crop productivity. Some crops like onion, garlic, radish, cauliflower, cabbage, beet root *etc.* taken with banana also add extra income due to which there has been an increase in the growers' interest in using intercropping. The increase in productivity also increased use of chemical fertilizers and pesticides causing serious damage to the environment, soil and human health. Due to the escalating cost of fertilizers and their hazardous effects on environment, the awareness has been increased in the farming community for the alternate agriculture system known as biological farming or organic farming. This became a major concern where the consumers are aware of health hazards and started demanding the purely organically grown food by making organic farming successful (Mustaffa and Sathiamoorthy, 2001). The application of vermicompost is surely effective alternative nutrient for resource poor farming community to grow their crops without polluting the environment (Adhikary, 2014). Hence now days,organic fertilizers are necessary as a remedy to maneuver theill-effects from chemical farming, to provide the crop nutritionaldemand to produce higher yield as well as to improve quality, of produce by supplying various organic manures in balancedproportion (Shinde *et al.*, 2015). Keeping this in view, the present investigation was planned to study the comparative effect of organic manure levels and intercropping pattern in different vegetables and banana crop under certified organic farm.

MATERIALS AND METHODS

The field experiment was conducted during the period 2011-12 at the Organic farm, Navsari Agricultural University, Navsari, Gujarat. In Randomized Block Design with four replications and nine treatments T_1-Sole banana, T_2- (Banana + Onion @ 50% RDN), T_3- (Banana + Onion @ 100% RDN), T_4- (Banana + Garlic @ 50% RDN), T_5- (Banana + Garlic @ 100% RDN), T_6- (Banana + Radish @ 50% RDN), T_7- (Banana + Radish @ 100% RDN), T_8- (Banana + Beet @ 100% RDN), T_9- (Banana + Beet @ 100% RDN). There were nine treatments having two different doses of recommended dose of nitrogen (RDN) *viz.*, 50 % and 100 %. The RDN was applied through organic manure *viz.*, biocompost, vermicompost and castor cake (BC:VC:CC) on equivalent basis of nitrogen. Banana crop was fertilized with 300 g N/plant. Similarly intercrops like

onion, garlic, radish and beet were fertilized with 80, 25, 100 and 70 kg N/ha. The plot size of banana is gross & net: 3.0 m x7.2 m. The plot size of used for intercrops, gross plot: 1.8 m × 7.2 m and net plot 1.2 m × 6.8 m for onion and garlic and plot size of radish and Beet to gross plot: 1.8 m ×7.2 m and net plot: 0.9 m × 6.8 m were used. Banana is planted at a spacing of 1.5 m × 1.2 m × 3.3 m (Paired raw) and intercrops like both onion & garlic: 15 cm × 10 cm and radish &beet: 30 cm × 20 cm.Chemical composition ofthe used organic manure is shown in table 1.The height of the banana pseudostem was measured from ground level to the upper most point of contact of petioles of two youngest leaves (Lahav, 1972), girth was measured at 20 cm above ground level and the leaf area was worked out as the multiplication of the product of length and breadth of the leaf with leaf area factor (0.8) (Obiefuna and Ndubizu, 1979).The leaves were collected at maturity, sequentially washed with dilute HCL and deionized water dried in the air and then in an oven at 60º C to constant weight and worked out from the dry matter yield (AOAC, 1990).The leaves samples were digested in a mixture of HNO_3 + $HCLO_4$ (4:1) and analyzed for total Fe, Mn, Zn and Cu by atomic absorption spectrophotometer (Elwell and Gridley (1967) and determination of total Ca and Mg (Cheng and Bray, 1951) was performed on the titration using Versanate (EDTA) method, The dry matter yield, individual concentration of element in leaves was used to calculate the total uptake of banana.

$$\text{Uptake of Fe, Mn, Znand Cu (g ha}^{-1}) = \frac{\text{Nutrient content (mg kg}^{-1}) \text{ x DMY (kg ha}^{-1})}{1000}$$

$$\text{Uptake of Ca and Mg (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x DMY (kg ha}^{-1})}{100}$$

Collected data were analyzed statically using computer package MSTATC (Gomez and Gomez, 1993) and tested at 5 per cent level of significance for finding the effects.

RESULTS AND DISCUSSION

The plant height as expressed pseudostem height was found to be significantly influenced due to different treatments at initial growth stages *i.e.* upto 5 months(Table 2). Significantly higher plant height of 62.5 cm and 89.6 cm at 3rd MAP and 5th MAP, respectively were recorded under sole banana treatment (T_1), which was at par with treatments T_5 B + G (@ 100% RDN) and T_2 B + O (@ 50% RDN) in case of 3rd MAP, while in case of 5th MAP except treatment T_6 and T_8. The lowest values of pseudostem height of banana were observed 36.9 cm and 68.1 cm, respectively at 3rd MAP and 5th MAP under the treatment T_6 B + R (@ 50% RDN). The pseudostem height was not differed significantly at 7th MAP as well as at flowering. It might be due to intercrops, which compete with main crop for essential nutrients, space, light and water for growth and development at initial stage of growth but banana being a long duration crop the effect become non significant as the growth period of intercrop is over during initial stage of banana crop. Similarly, the girth of the banana pseudostem reduced significantly at 3rd and 5th MAP, but not at 7th MAP. Data of pseudostem girth showed significant differences due to intercrops at, 3rd and 5th MAP only, later on the effect was nullified at 7th MAP and at flowering. Highest pseudostem girth (20.5 cm and 38.8 cm) was reported under the treatment T_5 B + G (@ 100% RDN) at 3rd and 5th MAP, respectively. However, it was found statistically similar with the treatments T_1 (sole banana) at 3rdMAP and T_3 B + O (@ 100% RDN) at 5th MAP. The differences in pseudostem girth of banana at 7th MAP and at flowering stage were found non-significant(Table 2). A possible explanation of girth reduction up to five months under radish and beet root was that rapidly growing intercrop exerts a shedding effect on the banana during first 5 months association between banana and intercrops may have resulted in competition for water and nutrients. Rainfall after May, however, allowed the banana in various intercrop to make a recovery in girth. Similar result was also observed by Rao and Edmunds (1983).

The data revealed that total leaf area per plant differed significantly due to various intercrops at 3rd and 5th MAP. At 3rd MAP significantly higher leaf area of 0.33 m^{-2} was recorded under treatment T_5 B + G (@ 100% RDN) which was remained at par with treatment T_3 B + O (@ 100% RDN)(Table 2). In case of at 5th MAP the treatment T_5 showed significantly higher value of 0.58 m^{-2} which was at par with the value obtained with treatment T_1. The minimum values of leaf area 0.17 m^{-2} and0.38 m^{-2} respectivelywere recorded with the treatment T_6 at both the stage of growth. They were at par with the some of the treatments. The differences in leaf area under variousinter cropping systems at 7th MAP and at flowering stage were found tobe non-significant presented in table 2. A perusal of data in table 2 revealed that the number of leaves per plant in banana at 3rd and 5th MAP. Statistically higher values of 9.6 and 15.0 cm were recorded under the treatment T_5 at 3rd and 5th MAP, respectively which was at par with treatment T_3 in case of 5th MAP. The lower values of 6.0 and 10.9 cm were observed with the treatment T_6 at both the stage of growth. The effect of treatments on number of leaves per plant of banana was non significant at 7th MAP and at flowering stage. The result was finding the short duration of intercrop Increase in growth may be attributed to the resources given to intercrop which also utilized by main crop (banana). This might be due to that, in early stage inter and intra-crop competition was very intense due to growth of component crop of the treatments

Table 1: Chemical composition of organic manures

Manures	N %	P	K	Fe (mg kg^{-1})	Mn	Zn	Cu
Biocompost	0.72	0.53	0.97	984	89	25	10
Vermicompost	0.86	0.60	1.09	1040	91	19	13
Castor cake	3.55	1.53	1.36	1036	43	55	31

Table 2: Comparative effect of organic manure levels and intercropping pattern on growth of banana crop

Treatments	Pseudostem height (cm)				Pseudostem girth (cm)			
	3rd MAP	5th MAP	7th MAP	At flowering	3rd MAP	5th MAP	7th MAP	At flowering
T_1	62.5	89.6	142.2	195.5	19.6	36.2	47.6	62
T_2	55.9	85.5	141.4	190.2	17	30.2	45.3	60.7
T_3	45.3	80.4	142.3	197.7	18.8	34.2	49	63.6
T_4	53.9	85.2	141.8	191	17.4	32.5	46.3	61.2
T_5	57.7	86.1	143.5	202.6	20.5	38.8	50.5	64.3
T_6	36.9	68.1	139.7	180.2	14.4	22.2	38.2	57.1
T_7	50.8	83.5	140.2	184.7	15.7	25.6	41.2	59.2
T_8	44.7	76.2	140.1	180.8	15	23.2	40	58.3
T_9	49.5	82.3	141.4	189.4	16.5	27.7	43.5	60.4
S. Em. (±)	2.82	3.94	5.92	7.02	0.82	1.34	2.88	2.12
CD(P = 0.05)	8.24	11.51	NS	NS	2.39	3.92	NS	NS
C.V.%	11.12	9.64	8.36	7.39	9.56	8.96	12.94	6.99

Table 2: Cont.....

Treatments	Total leaf area (m^2)				Number of leaves per plant			
	3rd MAP	5th MAP	7th MAP	At flowering	3rd MAP	5th MAP	7th MAP	At flowering
T_1	19.6	0.28	0.51	2.67	7.2	13.9	20.1	21.3
T_2	17	0.24	0.46	2.3	7.7	13.1	19.9	21.2
T_3	18.8	0.31	0.53	2.57	8	14.1	19.5	20.8
T_4	17.4	0.26	0.47	2.6	7.9	12.6	19.7	20.9
T_5	20.5	0.33	0.58	2.71	9.6	15	21.5	22.8
T_6	14.4	0.17	0.38	2.18	6	10.9	17.3	18.6
T_7	15.7	0.2	0.42	2.12	6.7	11.2	19.4	20.7
T_8	15	0.19	0.4	2.09	6.3	11	18.8	20.1
T_9	16.5	0.22	0.44	2.18	8.6	11.9	20.4	21.7
S. Em. (±)	0.82	0.01	0.02	0.16	0.28	0.45	0.76	0.76
CD(P = 0.05)	2.39	0.04	0.07	NS	0.81	1.3	NS	NS
C.V.%	9.56	13.54	11.32	13.89	7.43	7.11	7.83	7.36

Note: T_1: Sole Banana, T_2: Banana + Onion (50 % RDN), T_3: Banana + Onion (100 % RDN), T_4: Banana + Garlic (50 % RDN), T_5: Banana + Garlic (100 % RDN), T_6: Banana + Radish (50 % RDN), T_7: Banana + Radish (100 % RDN), T_8: Banana + Beet (50 % RDN), T_9: Banana + Beet (100 % RDN)

which induce demand pressure on resources *vis-à-vis* competition. The periodical increment in banana, number of leaves $plant^{-1}$ and leaf area $plant^{-1}$ indicated that minimum increment over period was observed between 0-5 MAP growth intervals. But at later stage of growth after 7th MAP and at flowering, there was no significance difference. Chundawat *et al*. (1982) reported that none of the intercrops reduced the vegetative growth of banana.

Significantly higher bunch yield (41.00 t ha^{-1}) and dry matter yield (9.77 t ha^{-1}) was recorded in treatment T_5 (Banana + garlic @ 100% RDN) which was statistically at par with treatments T_3 and T_1 and significantly lower bunch yield (34.36 t ha^{-1}) and dry matter yield (8.78 t ha^{-1}) was recorded under treatment T_6 B + R (@ 50% RDN). Similar result was also observed by Das and Maharana (1995). They had reported that yield of banana was higher when was intercropped with onion and chilli because nutrient removed by this crops were less. Mahant (2011) inferred that intercropping in banana is more productive and profitable than their sole cultivation without loss in yield. Similarly Singh (2010) also reported higher yield and yield attributing characters of banana fruit in intercropped banana as compared to sole banana(Table 3).

The Non significant differences were observed among different treatments of intercrops with two N levels with regards to calcium and magnesium content and uptake in banana leaves (Table 3). Higher calcium (0.79 %) and magnesium (0.32 %) content were observed under treatment T_1 (sole banana) and T_3 B + O (@ 100% RDN), respectively while, the lowest values 0.63 % of Ca and 0.25% of Mg, respectively were noted under treatment T_6 B + R (@ 50% RDN), However, numerically higher value of calcium and magnesium uptake (72.6 and 30.6 kg ha^{-1}, respectively) were recorded with the treatment T_5 B + G (@ 100% RDN) whereas lower uptake of both of nutrients were observed with T_6 B + R (@ 50% RDN) treatment. The data presented in table 3 indicated that iron, manganese and copper content and uptake were not influenced due to different treatments of intercropping systems except zinc. The highest Zn content and uptake (33.9 mg kg^{-1} and 319.6 g kg^{-1}) in leaves was observed in treatment T_1 sole banana, which differenced significantly from all other treatments except with T_5 treatment and that of lower in treatment T_2 B + O (@ 50% RDN). Numerically higher Fe content (132 mg kg^{-1}) and uptake (1268.9 g kg^{-1}) was found under treatment T_1 and T_5, respectively. However higher Mn and Cu content (84.4 and 13.0 mg kg^{-1}) and (815.9 and 125.5 g kg^{-1}) was obtained with treatment T_5(Table 3). The content and uptake of Zn as well as Fe, Mn and Cu though it did not differ significantly was higher in the intercrop treatments receiving 100 % RDN as application of organic manures out rightly proved their supremacy on the content and uptake of these micronutrient cations. The increase in Ca, Mg, Fe, Mn, Zn and Cu nutrients content in leaves of banana might be due to better mineralization of nutrients,

Table 3: Comparative effect of organic manure levels and intercropping pattern on yield, dry matter yield and nutrient content and uptake of banana leaves

Treatments	Bunch Yield	Dry matter yield of leaves	Calcium Content (%)	Uptake (kg ha^{-1})	Magnesium Content (%)	Iron Uptake (kg ha^{-1})	Content (ppm)	Manganese Uptake (g ha^{-1})	Zinc Content (ppm)	Uptake (g ha^{-1})	Copper Content (ppm)	Uptake (g ha^{-1})	Content (ppm)	Uptake (g ha^{-1})
T_1	37.80	9.42	0.79	68.3	0.31	28.9	132.0	1240.1	83.3	795.2	33.9	297.7	12.8	122.6
T_2	35.29	9.16	0.67	61.3	0.29	26.4	116.3	1172.7	78.0	714.6	25.8	235.7	12.4	113.2
T_3	38.82	9.61	0.75	71.2	0.32	27.7	128.0	1115.5	82.3	790.5	27.3	261.1	12.6	120.4
T_4	35.42	9.31	0.68	63.2	0.30	27.9	119.7	1112.9	78.1	728.4	27.1	251.4	12.5	117.0
T_5	41.00	9.77	0.74	72.6	0.28	30.3	130.0	1268.9	84.4	815.9	30.5	319.6	13.0	125.5
T_6	34.36	8.78	0.63	56.5	0.25	22.4	123.8	1086.4	69.7	616.9	22.0	193.0	11.0	96.3
T_7	34.85	8.89	0.66	59.2	0.28	24.9	130.3	1159.1	76.7	683.2	23.7	210.5	11.9	106.2
T_8	34.53	8.83	0.65	57.5	0.27	23.7	127.6	1125.8	71.4	631.0	22.9	202.1	11.6	103.0
T_9	35.09	8.96	0.73	65.4	0.27	24.3	129.7	1156.3	74.9	669.9	24.4	217.9	12.6	112.4
S. Em. (±)	1.12	0.33	0.03	3.82	0.01	1.71	3.60	41.13	3.86	47.58	1.35	11.78	0.68	7.69
CD (P = 0.05)	3.28	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.9	34.3	NS	NS
C.V. %	6.34	7.17	10.25	11.98	10.10	13.05	5.7	7.1	9.9	13.2	10.2	9.6	11.2	13.6

Note: T_1: Sole Banana, T_2: Banana + Onion (50 % RDN), T_3: Banana + Onion (100 % RDN), T_4: Banana + Garlic (50 % RDN), T_5: Banana + Garlic (100 % RDN), T_6: Banana + Radish (50 % RDN), T_7: Banana + Radish (100 % RDN), T_8: Banana + Beet (50 % RDN), T_9: Banana + Beet (100 % RDN)

enhanced activities of microbes and well developed net work of root and soil aggregate formation due to the combined application of different organic manures. Similar results were also reported by Gubbuk*et al.,*and Doran *et al.* (2003). Vanilarasu *et al.* (2014) reported that FYM, vermicompost, neem cake, green manuresand biofertilizers along with optimum soil moisture retentionfacilitated by them might have favored the microbial populationto solubilise the available nutrients in soil and uptake of byplants.Selvi and Perumal, (1997) noticed that the supremacy could be due to many reasons, firstly due to the release of more micronutrients due to faster mineralization, micronutrients change in soil pH resulting in better nutrient availability, alteration in soil condition and better root netting. Sole banana recorded the highest nutrient content and uptake of all nutrient followed by banana with garlic and onion intercrop treatment which had comparable content and uptake with sole banana. It might be due to additive effect of nutrient supplied to onion and garlic as they withdrawn less amount of nutrient compared to radish and beet root which is supported by uptake data of respective crop. Hence the remaining was utilized by the banana crop resulting in higher content of nutrients. Solaimalai and Mathusankaranarayan (2000) reported that nutrient uptake by sorghum was significantly higher under sole sorghum over sorghum under intercropping systems.

The data of yield and yield related characters of various intercrops studied are presented in table 4. It is seen that total dry matter yield, bulb diameter (cm^3), bulb volume (cm), bulb weight (g) and bulb yield (t/ha) of onion under intercrop of onion T_3 (100 % RDN) recorded highest values (6.17, 80.19, 6.45, 71.80 30.87, respectively) for almost all yield and yield attribute characters compared to 50 % RDN treatment (T_2). This might bedue to high nutrient availability which was applied to intercrop onion. Similarly in case of garlic also the treatment receiving 100 % RDN (T_5) showed better performance like number of clove per bulb (17.25), clove length (2.32 cm) and breadth (1.47 cm), total dry matter yield (4.10 t/ha) and bulb yield (5.45 t/ha) compared to treatment T_4 which was received 50 % RDN. Singh *et al.*, (2001) reported that onion as intercrop produced maximum yield which was superior to rest of the treatments. Increased total productivity by intercropping of onion in sugarcane has been reported by Venkataraman (1977). The better yield of radish with respect of marketable root yield and dry matter production as well as yield attributes *viz.*, girth, length of shoot and root (radish), fresh weight of radish and dry matter yield were more under T_7*i.e.* treatment receiving 100 % RDN compared to T_6 50 % RDN (Table-4). Similar trend of yield of beet root (28.87 t/ha) and yield attributes characters like equatorial diameter (28.48 cm), polar diameter (24.78 cm), volume of beet (107.76 cm^3) and total dry matter yield (t ha^{-1}) was observed in beet root crop also being the higher value under treatment receiving 100 % RDN *i.e.* T_9 compared to T_8 receiving 50 % RDN (Table-4). Rao and Edmunds (1983) noticed that different intercropping patterns did not affect the yield of intercrops significantly.

Table 4: Comparative effect of organic manure levels and intercropping pattern on yield attributes, dry matter yield and yield of different vegetables

Treatments/Crop Onion	Yield attributes			Dry matter yield (t ha^{-1})			Yield
	Volume of bulb (cm^3)	Bulb diameter(cm)	Bulb weight (g)	Bulb	Leaves	Total	Bulb yield (t ha^{-1})
T_2	79.19	6.18	58.90	3.85	1.21	5.06	26.13
T_3	80.19	6.45	71.80	4.45	1.72	6.17	30.87
Garlic							
	No. of cloves/bulb	Clove length (cm)	Clove breadth (cm)	Bulb	Leaves	Total	Bulb yield (t ha^{-1})
T_4	15.50	2.06	1.44	2.75	0.70	3.45	3.98
T_5	17.25	2.32	1.47	3.15	0.95	4.10	5.45
Radish							
	Girth of radish (cm)	Length of shoot (cm)	Length (cm)	Bulb	Leaves	Total	Root yield (t ha^{-1})
T_6	10.05	5.23	24.66	5.10	2.53	7.63	20.48
T_7	10.39	5.69	28.03	6.12	3.12	9.24	26.68
Beet root							
	Equatorial diameter (cm)	Polar diameter (cm)	Volume of beet cm^3)	Bulb	Leaves	Total	Beet root yield (t ha^{-1})
T_8	25.73	23.70	91.48	4.78	2.36	7.14	25.51
T_9	28.48	24.78	107.76	5.40	3.24	8.64	28.87

Note: T_2: Banana + Onion (50 % RDN), T_3: Banana + Onion (100 % RDN), T_4: Banana + Garlic (50 % RDN), T_5: Banana + Garlic (100 % RDN), T_6: Banana + Radish (50 % RDN), T_7: Banana + Radish (100 % RDN), T_8: Banana + Beet (50 % RDN), T_9: Banana + Beet (100 % RDN).

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