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Effect of Organic Manure and Biofertilizers on Growth, Yield and Quality of Strawberry (*Fragaria* X *ananassa* Duch) CV. Sweet Charlie

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Abstract
Strawberry (*Fragaria* x *ananasa* Duch.) is an important fruit of the genus *Fragaria* and belongs of the family Rosaceae. Adoption of Strawberry even under subtropical condition is gaining momentum. However, standardization of agro-techniques for the cultivation of Strawberry still needs to be stimulated under sub- tropical conditions to enhance production and maintain the quality at the same time. The present investigation entitled "Effect of Organic Manure and Biofertilizers on Growth, Yield and Quality of Strawberry (*Fragaria* x *ananassa* Duch) cv Sweet Charlie" was conducted at Research field, Department of Horticulture, School of Agriculture, ITM University Gwalior (M.P.) during the winter season of 2015-16. The experiment comprised of seven treatments viz. T_1-control, T_2- 100% FYM, T_3- 100% Poultry Manure, T_4- 100% Vermicompost, T_5- 50% Vermicompost + 50% Poultry Manure, T_6- 50% Vermicompost + 50% FYM, T_7 - 50% Poultry Manure + 50% FYM, T_8- 50% Vermicompost + 50% Poultry Manure + Azotobacter, T_9- 50% Vermicompost + 50% FYM + Azotobacter, and T_{10}- 50% Poultry Manure + 50% FYM + Azotobacter, used as organic manure and biofertilizers. The experiment was laid out in Randomized Block Design replications. The results revealed that the treatment T_8 - 50% Vermicompost + 50% Poultry Manure + Azotobacter was found to be the best among the various treatment and recorded maximum plant height (19.61 cm), number of leaves (21.11), plant spread (24.54), number of flowers (30.41plant^{-1}), number of fruit (12.41 plant^{-1}), fruit length (3.70 cm), fruit width (3.20cm), fruit weight (11.83 g).The treatment also recorded the maximum fruit yield (144.77 g plant $^{-1}$, 2.32 kg plot^{-1}, and 7.72 t ha^{-1}) which was followed by T_9 - 50% Vermicompost + 50% FYM + Azotobacter.

Keywords: Organic Manure, Biofertilizers, Yield, Quality and Strawberry

Introduction
Strawberry is an herbaceous perennial plant and is adapted to different climates, and can even be grown from tropical and sub-tropical to temperate regions of high altitudes up to 3000 meter above mean sea level with assured irrigation facility. It is the most widely distributed fruit-crop due to its genotypic diversity, highly heterozygous nature and broad range of environmental adaptations (Larson, 1994, Childers *et al.*, 1995) [6, 5]. Due to the constant efforts of strawberry breeders, the world wide interest for strawberry cultivation has boosted its production tremendously, which has resulted in widespread popularity of strawberry in the last 50 years.

The modern cultivated strawberry is one of the most delicious, refreshing and soft fruits of the world. It is a most important soft fruit in the world after grape and is being preferred by the people around the world due to its attractive colors and pleasant flavour and aroma (Sharma and Yamdagni, 2000) [14]. The fresh- ripe fruits of strawberry are the rich source of vitamins and minerals (Singh *et al.* 2007) [18]. Among vitamins it is a fairly good source of vitamin A (60 IU/100g of edible portion) and vitamin C (30-120mg/100g of edible portion).

In India, during last decade; it has become favourite fruit among growers because of its remunerative prices and higher profitability (Pathak and Singh, 1971; Sharma, 1975) [11, 13] Strawberry can be grown on a wide range of soil ranging from heavy clay to light sand. The plant has fibrous root system and most of its roots are confined to the top 15-20 cm layer of the soil, and it grows best in the light porous soil that is rich in humus (Singh and Sharma, 1970; Sharma and Singh, 1999; Sharma, 2002) [16, 15, 17]. The plant is a surface feeder; therefore

fertility, moisture, drainage and microbial status of the upper layer of soil have great impact on growth, development, fruit, quality and production of runners.

The application of synthetic fertilizers has improved yield per unit area manifold but these fertilizers are expensive and hamper the ecological balance of the soil. Imbalance and inadequate fertilizer application gradually reduces their response efficiency.

Organic manures like vermicompost, FYM, compost, bio fertilizers etc. have been utilized in agriculture as a significant source of organic manure. These manures helps not only in bridging the existing wide gap between the nutrient removal and supply but also in insuring balanced nutrient proportion, by enhancing response efficiency, and maximizing crop productivity of desired quality.

Method and materials

The present research work entitled "Studies on organic manures and biofertilizers on growth yield and quality of strawberry (*Fragaria* x *ananassa* Duch) cv Sweet Charlie" was conducted at Research Field, Department of Horticulture, School of Agricultural, ITM University Gwalior during the winter season of 2015-2016. The experiment was laid down in Randomized Block Design with three replication and 10 different organic manure and biofertilizers treatments viz.T_1(Control), T_2(100% FYM), T_3(100% Poultry manure), T_4(100% Vermicompost), T_5 (50%Vermicompost + 50% Poultry Manure), T_6(50%Vermicompost + 50% FYM), T_7(50% Poultry Manure + 50% FYM), T_8(50%Vermicompost + 50% Poultry Manure with),T_9 (50%Vermicompost + 50% FYM with Azotobacter) and T_{10} (50% Poultry Manure + 50% FYM with Azotobacter). In the cultural operation, three weeding followed by hoeing were done manually after 30 and 45 days of transplanting. A light irrigation was given immediately after planting and subsequent irrigation given according to the requirement of crop. To protect the crop from insects and diseases spray of Imidaclorprid (15.8%) and Dithane M-45 (0.25%) were done, respectively and application of Thimate @ 10kg/ha was also done at flowering stage. Picking was done on every five day in the morning hours. Yields obtained from the four central rows from each plot were used to record data on various parameters. Statistical analysis of data recorded in all observations was computed by method of analysis of variance and treatments were compared with the help of vertical difference as suggested by Panse and Sukhatme (1989) [10].

Results and discussion

Growth attributes

Plant Height (cm)

The data pertaining in table 1 revealed that the height of plant was significantly influenced by the different sources of nutrients and produce maximum plant height under treatment T_8 – 50% vermicompost+50% poultry manure with inoculation of Azotobacter (15.41cm) and (19.61cm) at 60 and 90 DAT respectively. It was at par with T_9 - 50% vermicompost +50% FYM with inoculation of Azotobacter (13.45 cm and 17.29 cm), T_{10} - 50% poultry manure+ 50% FYM with inculcation of Azotobacter (13.03 cm and 16.74cm) respectively.

Number of leaves

The data pertaining in table 1 revealed that the maximum number of leaves plant^{-1} was recorded under treatment $T_8$50%vermicompost+50% poultry manure with Azotobacter (20.39), which was at par with T_9- 50% vermicompost+50% FYM with Azotobacter (20.27), T_{10} - 50% poultry manure+ 50% FYM with Azotobacter (19.49), T_6 - 50%vermicompost+50% FYM (18.66) T_5 -50%vermicompost + 50% poultry manure (18.85) T_4 - 100% Vermicompost (18.17), T_3 - 100% Poultry manure. (18.58) and T_7 - 50% Poultry manure + 50% FYM (17.57). It was significantly superior over T_2- 100% FYM (15.93) and control (12.94).

Plant spread (cm)

The data revealed that the treatments significantly influenced the spread of plant. The maximum spread of strawberry plant was observed in treatment T_8 –50%Vermicompost+50% Poultry Manure with Azotobacter (24.54 cm), which was statistically at par with treatment T_9- 50%Vermicompost+50% FYM with Azoto bacter (23.05 cm), T_{10} - 50% Poultry Manure + 50% FYM with Azoto bacter (22.03cm), T_7- 50% Poultry Manure + 50% FYM (18.57 cm), T_6- 50%Vermicompost+50% FYM (18.60), T_5 – 50%Vermicompost+50% Poultry Manure (18.92cm) and T_4 – 100% Vermicom post (18.38 cm). The data revealed that Integration of FYM with Vermicom post and Poultry manure with bio-fertilizer was significantly superior in respect to plant spread over T_3– 100% Poultry manure (18.09 cm), T_2 - 100% FYM (15.39 cm) and T_1 – Control (13.07 cm).

Table 1: Effect of different treatment on Plant Height (cm), no of leaves and spread of pant of Strawberry

S. No.	Treatment	Plant height (cm)			Number of leaves			Spread of plant (cm)		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	Control	3.91	6.75	8.54	8.41	12.94	13.53	5.10	11.24	13.07
T_2	100% FYM	5.77	9.94	12.55	10.43	15.93	16.93	6.00	13.23	15.39
T_3	100% Poultry manure.	6.40	11.03	13.97	12.08	18.58	19.48	7.48	15.97	18.09
T_4	100% Vermicompost.	6.30	10.91	13.76	11.73	18.17	18.91	7.17	15.80	18.38
T_5	50%Vermicompost+50% Poultry Manure	6.82	11.51	14.48	12.19	18.85	19.45	7.53	16.27	18.92
T_6	50%Vermicompost+50% FYM	6.73	11.25	14.19	12.13	18.66	19.52	7.25	15.99	18.60
T_7	50% Poultry Manure+ 50% FYM	6.44	11.05	13.06	11.35	17.57	18.26	7.06	15.56	18.57
T_8	50%Vermicompost+50% Poultry Manure with.	9.00	15.41	19.61	13.20	20.39	21.11	9.63	21.10	24.54
T_9	50%Vermicompost+50% FYM with Azotobacter	7.89	13.45	17.29	13.11	20.27	20.99	8.96	19.82	23.05
T_{10}	50% Poultry Manure+ 50% FYM with Azotobacter	7.56	13.03	16.74	12.67	19.49	20.44	8.66	18.95	22.03
	S. Em+	0.464	0.820	1.089	0.891	1.361	1.435	0.802	1.798	2.09
	CD at 5%	1.377	2.431	3.236	2.648	4.043	4.426	2.383	5.343	6.21

Table 2: Effect of different treatment on no of fruit, flower fruit length, weight, width and yield of Strawberry Plant

S. No.	Treatment	Number of fruits/ plant	No. of flowers/plant	Fruit			Yield		
				Length (cm)	Width (cm)	Weight (g)	/plant (g)	/plot (kg)	/ha (t)
T_1	Control	7.40	19.90	2.63	1.56	8.17	67.14	1.07	3.58
T_2	100% FYM	9.07	21.85	3.18	2.35	9.04	87.29	1.40	4.66
T_3	100% Poultry manure.	9.71	23.46	3.35	2.51	9.77	103.61	1.66	6.15
T_4	100% Vermicompost.	9.71	22.74	3.21	2.46	9.51	103.11	1.65	5.53
T_5	50%Vermicompost+50% Poultry Manure	10.50	24.54	3.57	2.74	10.33	107.59	1.72	6.64
T_6	50%Vermicompost+50% FYM	10.20	24.11	3.40	2.67	10.12	105.14	1.68	6.42
T_7	50% Poultry Manure+ 50% FYM	9.58	22.47	3.33	2.43	10.37	97.85	1.57	5.22
T_8	50%Vermicompost+50% Poultry Manure with.	12.41	30.41	3.70	3.20	11.83	144.77	2.32	7.72
T_9	50%Vermicompost+50% FYM with Azotobacter	11.89	25.73	3.65	3.10	10.59	126.74	2.03	7.57
T_{10}	50% Poultry Manure+ 50% FYM with Azotobacter	11.05	24.68	3.24	2.92	10.75	120.41	1.93	6.76
	S. Em+	0452	1.529	0.179	0.224	0.607	8.716	0.139	0.384
	CD at 5%	1.394	4.544	0.531	0.690	1.804	25.898	0.414	1.142

The growth parameters like plant height, plant spread, and number of leaves plant^{-1} were significantly influenced by the organic manure and bio-fertilizers. The production of auxin and gibberellin in plant growth regulators is known to help in higher plant height and plant spread, which were released more in treatment T_8 (Vermicompost + Poultry Manure + Azotobacter and further affected in vegetative growth of plant. Apart from the reasons mentioned earlier, enhanced growth parameters like plant height, plant spread and number of leaves plant^{-1} due to Azotobacter may also be attributed to the influence of nitrogen, the chief constituent of protein – essential for formation of protoplasm, which enhances cell division and cell enlargement.

The increase in plant height, number of leaves and plant spread might be due to the production of more chlorophyll with inoculation of nitrogen fixers. It may also be due to the production of plant growth regulators by bacteria in rhizosphere, which are absorbed by the roots. Therefore, increased vegetative growth may be attributed to the increased biological nitrogen fixation (Mohandas, 1987) [8]. The increase in height of plants and number of leaves plant^{-1} with the application of Azotobacter and Vermicompost has also been reported by Nazir *et al.* (2006) [9] and Tripathi *et al.* (2010) [21] in strawberry.

Vermicompost is a rich source of micro and macro nutrients, Fe and Zn might have enhance the microflora and enzymatic activity which might have augmented the vegetative growth and Poultry manure also supplies both macronutrients and micronutrients sufficiently for growth, yield and quality of horticultural crops production. Positive effect of Vermicompost and Poultry manure on plant growth has also been reported earlier Aroncon *et al.*, (2003) [1], Aroncon *et al.*, (2004) [2], Singh *et al.*, (2008) [25], Nazir *et al.*, (2006) [9] and Yadav *et al.*, (2010) [24]. The results obtained are in confirmation with the findings of Yadav *et al.*, (2010) [24] and Verma and Rao, (2013) [22] who reported that a combined application of biofertilizers, vermicompost with inorganic fertilizers significantly increased the number of leaves and leaf area of strawberry.

Yield attributes

Number of fruits plant^{-1}

Data revealed that maximum number of fruit were recorded from treatment T_8 – 50%Vermicompost+50% Poultry Manure with Azotobacter (12.41) which is statistically at par with T_9 – 50%Vermicompost+50% FYM with Azotobacter (11.89) and significantly superior over all other treatment T_{10}- 50% Poultry Manure+ 50% FYM with Azotobacter (11.05). The minimum number of fruit plant^{-1} (7.40) was recorded under the treatment T_1 – Control. The data revealed that integration of bio-fertilizer with Vermicompost, Poultry manure and FYM gave significant increase in concern of fruit plant^{-1} at harvest stage in strawberry crop.

4.2.1 Number of flowers plant^{-1}

The data presented in table 2 revealed that maximum number of flowers were recorded in treatment T_8 – 50%Vermicompost +50% Poultry Manure with Azotobacter (30.41) which is statistically at par with T_9–50% Vermicompost +50% FYM with Azotobacter.(25.73) and significantly superior over all other treatment T_{10}- 50% Poultry Manure + 50% FYM with Azotobacter. (24.68).The minimum number of fruit plant^{-1} (19.90) recorded under treatment T_1 – Control.

Fruit length (cm)

Data presented in table showed that minimum fruit length (2.63 cm) was observed in control under T_1 while maximum fruit length was recorded in T_8 –50%Vermicompost+50% Poultry Manure with Azotobacter(3.70). It was significantly at par with other all treatments except Control (2.63cm).

Fruit Width (cm)

The perusal of observation presented in table shown that, the maximum width of fruits was recorded under the treatment T_8 –50% Vermicompost+50% Poultry Manure with Azotobacter (3.20 cm), which was statistically at par with all other organic manure and bio-fertilizers treatment tested under experiment except T_2 – 100% FYM (2.35cm) and control (1.56 cm). The minimum fruit width was observed in treatment T_1 – Control.

Fruit weight (g)

The analyzed data were presented in table 4.2. The data were recorded from ten randomly selected fruit from each plot and the mean were analyzed statistically.

The data revealed that the maximum fruit weight was recorded in treatment T_8 – 50%Vermicompost+50% Poultry Manure with Azotobacter (11.83 g), which was followed by T_9– 50%Vermicompost+50% FYM with Azotobacter, (10.59 g), T_{10}- 50% Poultry Manure + 50% FYM with Azotobacter,

(9.71 g), T_7 – 50% Poultry Manure+ 50% FYM (10.37 g), T_6– 50%Vermicompost+50% FYM (10.12 g), and T_5 – 50%Vermicompost+50% Poultry Manure (10.33 g). The minimum fruit width was observed in treatment T_1 – Control 8.17 g

The data presented in table revealed that there was significant influence of organic manure and biofertilizers treatment on the yield of strawberry crop. The maximum yield 144.77, g/plant, 2.32 kg/plot and 7.72 t/ha were recorded under the application of 50%Vermicompost+50% Poultry Manure with Azotobacter in treatment T_8. It is followed by T_9 and T_{10}.

The minimum yield per plant, per plot and per hectare was recorded under T_1-control 67.14 g.plant^{-1}, 1.07 kg.ha^{-1} and 3.58 t/ha respectively. The application of 50% Vermicompost+50% FYM with Azotobacter was produced significantly higher crop yield over 100% alone application of FYM, Vermicompost and Poultry Manures as well as, 50–50 combination of FYM, Vermicompost and Poultry manure. However, except application of 100% FYM other nutrient sources produced significantly higher yield over control.

The increase in number of fruit per plant, fruit breadth (cm), fruit length (cm) and fruit weight (g) may be attributed to the presence of biofertilizers especially inoculation with Azotobacter which consequently lead to flower initiation and the number of flowers per plant. This may be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinins to the axillary buds resulting in breakage of apical dominance, ultimately; they resulted in better sink for faster mobilization of photosynthesis and early transformation of plant parts from vegetative to reproductive phase. These results are in the line with the findings of Zargar *et al*., 2008 [25], Yadav *et al.*, (2010) [24] and Verma and Rao, (2013) [22] in strawberry.

The Vermicompost might have an indirect role for increase in number of fruit per plant, fruit breadth (cm), fruit length (cm) and Fruit weight (g) through better uptake of nutrients. Plants receiving T_8 (vermicompost + poultry manure + Azotobacter recorded highest average fruit weight and other yield attributing characters. However, plants treated with T_1 (Recommended dose of nutrients through chemical fertilizers control) exhibited least fruit weight and yield plant^{-1}, per plot and per hectare.

The increase yield may be due to balanced availability of macro and micro nutrients and growth promoting hormones produced by different biofertilizers applied in different treatment combinations. This may be attributed to better fillings of fruits due to more balanced uptake of nutrients which may have led to better metabolic activities in the plant ultimately lead to high protein and carbohydrate synthesis (Singh and Sharma 1970) [16]. Beside nitrogen fixing abilities of the microbial inoculants, the capacity to releasing phyto-hormones especially gibberellins should be regarded which increases the fruit size. Also the different partitioning of photosynthesis towards the sink by Azotobacter inoculation increased the fruit size and weight Rana and Chandel, (2003) [12]. The increased in yield enhanced uptake of nutrients and water caused to higher photosynthesis leading to an increase of the assimilation rates. The generation of Co_2 during compost decomposition has also been found responsible for increasing yield Lieten, (1996) [7]. Brown *et al.*, (1993) [4] showed that among various organic sources, Poultry manure had the most important role followed by FYM that is in agreement with the result of this study. A similar finding was found in Ahmad and Mohammad (2012) [3]. The total soluble solids, acidity, ascorbic acid and pH were significantly influenced by the organic manure application.

Application of organic sources might have increased the activities of beneficial microorganisms due to increased organic pool in soil, which resulted in production of growth promoting substances and improved nutrient availability for longer period throughout the crop growth. The beneficial effect of organic sources of nutrient and fertilizers on yield was also reported by Wange *et al.* (1998) [23] and Tripathi *et al.* (2010) [21] in strawberry.

Conclusion

It was concluded from present experiment that the application of treatment T_8 – 50%Vermicompost +50% Poultry Manure with Azotobacter was the most appropriate combination for enhances the growth and yield of strawberry under Gwalior conditions. Which was closely followed by the application of 50%Vermicompost +50% FYM with Azotobacter (T_9).

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