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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF STRAWBERRY (*FRAGARIA* × *ANANASSA* DUCH.)CV. SWEET CHARLIE

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ABSTRACT

The experiment conducted during the year 2013-14 and 2014-15 with 21 treatments included combinations of organic and microbial sources of nutrients (Compost, Poultry manure, Vermicompost, FYM, *Azotobacter* and PSB) replicated thrice with 18 plants per replication in Randomized Block Design. Observations were recorded for vegetative growth, fruit yield, and quality of fruit parameters. In different combinations organic manure and biofertilizers the treatment T_{15} (Vermicompost + Poultry manure +PSB +*Azotobacter*) was recorded highest plant height (16.19 cm), plant spread (24.68 cm), number of leaves plant^{-1} (15.79) and leaf area index (77.26 cm^2) and T_{17} (Vermicompost+ FYM + PSB+ *Azotobacter*) was recorded highest petiole length (8.81cm). Plant supplied with T_{15} (Vermicompost + Poultry manure+ PSB+ *Azotobacter*) registered earliest in flowering (40.68 days) and T_{17} (Vermicompost+ FYM + PSB+ *Azotobacter*) highest number of flowers per plant (13.42). The maximum fruit weight (12.86 g), number of fruits plant^{-1} (11.78), quality TSS (7.05 °B) and Ascorbic acid (53.42 mg/100 g fruit pulp) and yield (112.63 g plant^{-1}) were recorded with plants treated with a T_{15} (Vermicompost+ Poultry manure +PSB +*Azotobacter*) followed by T_{18} (Poultry manure+ compost+ PSB+ *Azotobacter*) and T_{17} (FYM+ Vermicompost + PSB+ *Azotobater)* treatment. the highest yield and best quality fruit were recorded in the combination of T_{15} (Vermicompost + Poultry manure+ PSB+ *Azotobacter*).

KEY WORDS: strawberry, organic manure, biofertilizers, vegetative growth, quality.

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INTRODUCTION

The strawberry (*Fragaria* × *ananassa* Duch.) an aggregate fruit, occupies a significant place in fruit growing. Since, it can be cultivated in plains as well as in hills. It has gained the status of being one of the most important soft fruit of the worlds after grapes, its popularity can be judged from the very fact that total area and production of the world had increased considerably over the past decade. It occupies on n area of 2, 43,907 ha with a total production 43,66,662 tones (FAO, 2010). It is cultivated to a limited extent is plains and sub mountainous areas of Himachal Pradesh, Uttarakhand, Uttar Pradesh, Maharashtra, Karnataka, Punjab, Haryana and Madhya Pradesh, wherever, irrigation facilities are available in India. Among the various factors which contribute to the growth and yield of strawberry, nutrition is an important aspect of crop production that accounts for about one third of the total cost of production Bhat, 1999 and Nazir, 2005. The excess use of chemical fertilizers has become essential part of production, a balanced form of fertilizer is a pre- requisite to higher yields. However, these chemical fertilizers are costlier and also pollute the environment through the process of de-nitrification, volatilization and leaching. The surest means to tide over the challenge is through environmentally sustainable farming methods. To sustain the fertility status of the soil, maintenance of appropriate status of microflora, to make safe the produce and for realizing the additional yields, Integrated Nutrient Management is a certain answer. To combat this problem, use of organic manures and bio fertilizers are probably the best way to maintain a sustained food production pattern.

MATERIALS AND METHODS

The present investigation was carried out at the research farm of the Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India during year 2013-14 and 2014-15. The experiment was laid out Randomized Block Design (RBD) with 21 treatments and 3 replications. The strawberry runners of uniform size were transplanted 2-5 cm depth at a spacing of 60×30 cm. in first week of November. Un-inoculated runners were transplanted first then the inoculated runners were planted. FYM, compost, vermicompost and poultry manure were applied in the concerned plots as per the treatment. NPK were applied in the control treatment. Slurry of 200 ml of the lignite based culture of PSB and *Azotobacter* were prepared in 15 L of water individually and combinations of both 100 ml *Azotobacter* and 100 ml PSB (phosphate solubilizing bacteria) culture were prepared in 15 L of water. Four months old strawberry runners were dipped in the slurry for 30 minutes and then transplanted. The various combinations of organic manures and biofertilizers were: T0- Recommended dose of nutrients through chemical fertilizers, T_1- compost, T_2- poultry manure, T_3- vermicompost, T_4- FYM, T_5- vermicompost + poultry manure, T_6- poultry manure + Compost, T_7- FYM + vermicompost, T_8- poultry manure + FYM, T_9- vermicompost + compost, T_{10}- Compost + FYM, T_{11}- compost + *Azotobacter* + PSB, T_{12}- poultry manure+ *Azotobacter* + PSB, T_{13}- vermicompost+ *Azotobacter* + PSB, T_{14}- FYM+ *Azotobacter* + PSB, T_{15}- vermicompost+ poultry manure+ PSB+ *Azotobacter*, T_{16}- poultry manure + compost+ *Azotobacter* + PSB, T_{17}- FYM + vermicompost+ *Azotobacter* + PSB, T_{18}- poultry manure + FYM+ *Azotobacter* + PSB, T_{19}- vermicompost + compost+ *Azotobacter* + PSB, T_{20}- compost + FYM+ *Azotobacter* + PSB. Paddy straw mulch was applied after 60 days of planting. Mulch usually applied on the surface of soil to protect the fruit in the direct contact of soil.

RESULTS AND DISCUSSION

The data regarding the different growth parameters have been presented in Table 1 clearly indicate that the application of integrated sources of nutrients significantly affect the vegetative growth of the plant. The plant height (16.19 cm), plant spread (24.68 cm), number of leaves plant^{-1} (15.79) and leaf area index (77.26 cm2) were found maximum with the application of T_{15} (vermicompost + poultry manure + *Azotobacter* + PSB) which was statistically significant to other treatments. The application T_0 (recommended dose of nutrients through chemical fertilizers) recommended NPK registered minimum values of these characters. The most obvious effect of nutrition is to bring changes in the vegetative growth attributes of any crop. The growth parameters like plant height, plant spread, number of leaves plant^{-1} and leaf area index were significantly influenced by the integrated nutrient management. 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_{15} (vermicompost + poultry manure + *Azotobacter* + PSB) and further affected in vegetative growth of plant. Apart from the reasons mentioned earlier, enhanced growth parameters like plant height, plant spread, number of leaves and leaf area per plant 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 mechanisms by which PSB augmented plant growth are through phosphate dissolution Nowsheen *et al.,* 2006 and in the biosynthesis of auxin Sattar and Gaur, 1987 and IAA Bareae *et al*., 1976. Also by providing protection against the non-parasitic root pathogens and transforming unavailable mineral and organic compounds into available forms in plants. This mechanism leads to increase in vegetative growth of the plant. 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 micro-nutrients 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, Aroncon *et al*., 2004, Singh *et al*., 2008, Nazir *et al*., 2006 and Yadav *et al.,* 2010. The results obtained are in confirmation with the findings of Yadav *et al.*, 2010 and Verma and Rao, 2013 who reported that a combined application of biofertilizers, vermicompost with inorganic fertilizers significantly increased the number of leaves and leaf area of strawberry. Earliest flowering (40.67 day) was recorded in T_{15} (vermicompost+ poultry manure + *Azotobacter*+ PSB) followed by (41.00 days) T_{17} (FYM + vermicompost +

Azotobacter + PSB) and (41.33 days) and T_{18} (poultry manure + FYM +*Azotobacter* + PSB) respectively. However, plants grown in T_1 (compost) took maximum days to flowering (50.20 days). The maximum number of flowers per plant (13.42) were obtained in case of plants grown in combination of T_{17} (vermicompost + FYM + *Azotobacter* + PSB) treatment which was statistically at par with (13.00) T_{15} (vermicompost + poultry manure +*Azotobacter* + PSB), whereas, the least number of flowers per plant (8.73) was observed in T_1 (compost). The treatment combination had significant effect on the days taken to flowering and number of flowers plant^{-1}. Plants receiving T_{15} (vermicompost + FYM + *Azotobacter* + PSB) in combination had taken significantly less number of days for flowering and number of flowers plant^{-1} in comparison to other treatment combinations. The earliness of flowering may be attributed to the presence of biofertilizers especially inoculation with *Azotobacter* and PSB 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, Yadav *et al.,* 2010 and Verma and Rao, 2013 in strawberry. The Vermicompost might have an indirect role for early flowering and more flower duration through better uptake of nutrients. Plants receiving T_{15} (vermicompost + poultry manure + *Azotobacter* + PSB) recorded highest average fruit weight of (12.26 g) which was found at par with T_{17} (FYM + vermicompost + *Azotobacter* + PSB) (12.23 g). However, plants treated with T_0 (Recommended dose of nutrients through chemical fertilizers) exhibited least fruit weight (7.94 g). Maximum fruit diameter (2.99 cm) was recorded in T_{15} (vermicompost + poultry manure+ *Azotobacter* + PSB) which was significantly higher to other treatments but it was at par with T_{17} (FYM + vermicompost+ *Azotobacter* + PSB) (2.98 cm) and T_{18} (poultry manure + FYM +*Azotobacter* + PSB) (2.94 cm). Least fruit diameter (2.42 cm) was obtained in T_0 (recommended dose of nutrients through chemical fertilizers). T_{15} (vermicompost + poultry manure + *Azotobacter* + PSB) was recorded highest average fruit length of (5.25 cm) followed by T_{17} (FYM + vermicompost + *Azotobacter* + PSB) (4.61 cm). However, plants treated with T_0 (recommended dose of nutrients through chemical fertilizers) exhibited least fruit length (3.06 cm). Maximum number of fruits per plant (11.78) was found in T_{15} (vermicompost + poultry manure + *Azotobacter* + PSB) which was significantly higher to other treatments but it was at par with T_{17} (vermicompost+ FYM + *Azotobacter* +PSB) (11.71) and T_{18} *(*poltry manure + FYM +*Azotobacter* + PSB) (11.70). Least number of fruits per plant (8.34) was obtained in T_0 (recommended dose of nutrients through chemical fertilizers). Application of T_{15} (vermicompost + poultry manure +*Azotobacter* + PSB) gave significantly maximum total yield of fruit per plant (112.63 g) followed by T_{17} (FYM + vermicompost +*Azotobacoer* + PSB) (109.5 g) and T_{18} (FYM + poultry manure +*Azotobacter* + PSB) (105.4 g). However, the minimum yield of fruits per plant (51.61 g) was observed in plant receiving T_0 (recommended dose of nutrients through chemical fertilizers). The increase yield may be due to balanced availability of macro and micro nutrients and growth promoting hormones produced by different bio-fertilizers applied in different treatment combinations. This may be attributed to better fillings of fruits due to more balanced uptake of nutrients which may have lead to better metabolic activities in the plant ultimately lead to high protein and carbohydrate synthesis (Singh *et al.,* 1970). 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. 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. Brown *et al.,* 1993 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. The total soluble solids, acidity, ascorbic acid and pH were significantly influenced by the organic manure application. The maximum total soluble solids (7.05 °B) and ascorbic acid (53.42 mg/100g of pulp) were recorded with treatment T_{15} (vermicompost + poultry manure + *Azotobacter* + PSB) followed by total soluble solids (6.51°B) and ascorbic acid (52.86 mg/100g of pulp) with T_{17} (vermicompost + FYM +*Azotobacter* +PSB) respectively and while the minimum total soluble solids (5.31°B) and ascorbic acid (49.38 mg/100g of pulp) were observed in T_0 (recommended dose of nutrients through chemical fertilizers) and minimum acidity (0.64 %) and pH (2.63) was found in T_{15} (vermicompost + poultry manure + *Azotobacter* + PSB) followed by acidity (0.66%) and (0.66%) and pH (2.69) and (2.78) T_{17} (vermicompost+ FYM + *Azotobacter* + PSB) and T_5 (vermicompost + poultry manure) respectively and maximum acidity (0.72%) and pH (3.90) in T_0 (Recommended dose of nutrients through chemical fertilizers). Increased TSS and ascorbic acid at higher levels of nitrogen might have resulted due to the fact that absorption of nitrogen may be exerted regulatory role as an important and during ripening of fruits the carbohydrate reserves of the roots and stem are drawn upon heavily by fruits which might have resulted into higher TSS and ascorbic acid in fruits. Increased TSS, ascorbic acid in fruits and decreased acidity and pH are in agreement with the findings of El-Hamid *et al.,* 2006 who reported that that application of PSB on strawberry resulted increase in TSS, total sugar, ascorbic acid and juice percentage and Singh *et al.,* 2008 who reported that the fruit harvested from plant receiving vermicompost were TSS and ascorbic acid increases, acidity decreased and color more attractive. Poultry manure contains essential plant nutrients that play significant role in improving quality as reported by Prabakaran and Pichal, 2003.

Table 1

Effect of Integrated Nutrient Management on growth, yield and quality of strawberry cv. Sweet Charlie

Treatments	Plant height (cm)	Plant spread (cm)	Petiole length (cm)	Number of leaves plant^{-1}	Leaf area index (cm^2)	Days to first flowering	Number of flowers plant^{-1}	Number of fruit plant^{-1}	Fruit yield plant^{-1} (g)	Fruit weight (g)	Fruit diameter (cm)	Fruit length (cm)	Specific gravity	TSS (° B)	Acidity (%)	pH	Ascorbic Acid (mg/100 g pulp)
T0	12.34	20.56	5.87	11.58	69.72	50.00	9.11	8.34	51.61	7.94	2.42	3.08	1.13	5.31	0.72	3.90	49.38
T1	13.54	22.96	6.89	13.01	69.68	50.20	8.73	8.91	67.70	8.97	2.54	3.58	1.23	5.56	0.71	3.79	49.79
T2	13.85	21.02	7.02	13.78	71.26	49.78	9.38	9.08	70.33	9.18	2.47	3.37	1.48	5.51	0.71	3.69	51.66
T3	12.70	22.52	6.23	13.09	72.21	48.11	8.92	9.17	80.88	10.63	2.75	3.84	1.43	6.08	0.68	3.12	51.28
T4	12.82	22.59	6.20	13.41	71.75	48.00	9.35	9.27	66.25	9.89	2.54	3.57	1.38	5.74	0.69	3.10	51.42
T5	15.44	24.14	7.71	15.76	74.38	43.89	11.95	10.36	100.7	11.71	2.89	4.55	1.81	6.59	0.66	2.78	52.78
T6	15.03	22.74	6.29	15.27	72.90	48.89	9.54	10.70	97.87	11.59	2.76	3.92	1.60	6.06	0.67	3.29	52.16
T7	15.32	23.00	6.97	15.53	72.81	45.89	10.03	11.50	105.3	11.94	2.89	3.89	1.70	6.08	0.70	3.60	52.26
T8	14.56	23.19	7.55	14.44	72.22	50.17	9.97	9.78	92.45	11.28	2.83	4.27	1.66	5.98	0.68	3.41	52.12
T9	14.25	22.33	6.67	13.78	71.17	43.67	9.59	9.69	86.11	11.28	2.73	3.67	1.67	5.58	0.69	3.23	51.95
T10	14.36	21.37	6.46	13.66	71.48	45.11	9.90	9.18	77.52	10.84	2.77	3.35	1.45	5.50	0.69	3.21	52.16
T11	14.39	21.99	6.39	13.60	72.38	49.78	9.40	9.57	77.03	10.38	2.53	3.62	1.54	5.38	0.71	3.49	50.31
T12	14.14	22.76	7.64	13.59	71.27	45.61	9.63	9.22	79.36	10.40	2.76	3.66	1.76	5.35	0.70	3.32	50.22
T13	14.65	22.54	6.15	13.41	71.49	45.78	9.68	9.61	81.24	10.51	2.80	3.73	1.59	5.38	0.70	3.30	51.98
T14	14.57	21.24	6.98	13.86	71.56	46.33	9.61	9.72	81.40	10.50	2.75	3.71	1.59	5.57	0.69	3.21	51.76
T15	16.19	24.68	8.23	15.79	77.26	40.67	13.00	11.78	112.6	12.26	2.99	5.25	1.84	7.05	0.64	2.63	53.42
T16	14.77	21.85	8.13	15.15	72.89	42.45	11.99	11.07	98.65	11.89	2.77	3.72	1.53	6.30	0.69	3.13	52.35
T17	15.95	23.87	8.81	15.56	75.34	41.00	13.42	11.71	109.5	12.23	2.98	4.61	1.86	6.51	0.66	2.69	52.86
T18	15.86	23.57	8.51	14.13	75.02	41.33	12.86	11.70	105.4	12.11	2.94	4.14	1.80	6.84	0.68	2.98	52.58
T19	13.95	23.66	7.89	14.57	74.89	41.78	11.05	10.77	88.29	11.37	2.85	3.83	1.74	6.10	0.69	3.28	52.49
T20	14.67	22.32	6.38	13.91	70.31	48.78	10.33	9.71	87.81	11.67	2.83	3.50	1.75	5.66	0.70	3.37	50.91
F-test	**S**	S	S	**S**	**S**	**S**	S	S	**S**	**S**	**S**	**S**	**S**	**S**	**S**	S	**S**
SE.d (±)	0.295	0.632	0.238	0.307	0.496	2.228	0.566	0.437	1.817	0.076	0.053	0.285	0.220	0.237	0.009	0.107	0.222
CD t 0.5%	0.596	1.278	0.482	0.620	1.002	4.503	1.144	0.883	3.673	0.153	0.107	0.576	0.445	0.479	0.019	0.217	0.449

CONCLUSION

On the basis of present investigation during 2013-14 and 2014-15, it is concluded that the treatment T_{15} (poultry manure + vermicompost + PSB+ *Azotobacter*) was found the best in terms of plant height (16.19 cm), plant spread (24.68 cm), number of leaves (15.79) and leaf area per plant (77.26 cm^2), yield (112.63 g $plant^{-1}$) and fruit quality TSS (7.05 °B) and ascorbic acid (53.42mg/ 100 g of pulp) parameters of strawberry.

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