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Impact of organic fertilizers on performance of strawberry cv. Sweet Charlie under sub-tropical conditions of Punjab

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Abstract
The present investigation Impact of organic fertilizers on performance of strawberry cv. Sweet Charlie under sub-tropical conditions of Punjab was carried out in the experimental plot of Department of Horticulture, Khalsa College, Amritsar during the year 2018. The investigation was laid out in RBD (Randomized Block Design) with eleven treatments replicated thrice. In the trial strawberry plants were fertilized with different organic (vermicompost and biofertilizers as azotobacter & PSB) and inorganic fertilizers to find out the optimum doses of these fertilizers to increase the growth and yield of the fruits. The results of the present study showed that vermicompost 2.80 t/ha + biofertilizers(T_1) was found to be the best in improving the vegetative growth of the plants resulting in maximum plant height (15.05 cm), number of leaves per plant (23.24), average leaf area (90.87 cm^2), number of flowers (26.03), fruits (19.05) per plant and fruit set (75.96 %) followed by treatment T_2 (vermicompost 2.80 t/ha). The fruits yielded from the plants fertilized with vermicompost 2.80 t/ha + biofertilizers registered maximum fruit length (3.52 cm), breadth (2.36 cm) and fruit weight (14.58 g). The application of vermicompost 2.80 t/ha + biofertilizers also resulted in maximum fruit yield (298.44 g) per plant and (477.50 q) per hectare respectively.

Keywords: Strawberry, PSB, Vermicompost, Azotobacter, Biofertilizers, Vegetative growth, Yield.

Introduction
The cultivated strawberry (*Fragaria* × *ananassa* Duch.) belonging to family Rosaceae is one of the most delicious and refreshing soft fruit of the world. It is the most widely distributed fruit crop due to its genotypic diversity, highly heterozygous nature and broad range of environmental adaptation (Kumar *et al.* 2012) [14]. All cultivated varieties are octaploid (2x=56). It is a glamorous red, delicious, refreshing, nutritious soft fruit with a distinct tantalizing aroma. The name "strawberry" may have derived from the practice of using straw mulch for cultivation or it may have come from the Anglo-Saxon word strew, meaning to spread (Kaur *et al.* 2018) [3]. It is cultivated worldwide for its fruits, characteristic aroma, bright red colour, juicy texture and sweetness. Cultivated strawberry is a hybrid between *Fragaria chiloensis and Fragaria virginiana*. Strawberries are the rich source of vitamins A, B, C and niacin, minerals like P, K, Ca and Fe (Karkara and Dwivedi 2002). Medicinally, strawberries have been known to kill certain viruses like polio and herpes which may block the formation of nitrosamines leading to the cause of cancer, furthermore it was recently observed that these contain relatively high quantities of ellagic acid, which has a wide range of biological activity only recently discovered (Rieger 2006) [19]. It contains high levels of antioxidant properties that aids in slow ageing, prevent urinary tract infection and the ability to reduce blood sugar (Villagran *et al.* 2001) [27]. Strawberry fruit is regarded as a valuable food in the diet of millions of people around the globe. At present, chemical fertilizers contribute a lot in fulfilling the nutrient requirement of plants but their regular, excessive and unbalanced use may lead to health and ecological hazards, depletion of physico-chemical properties of the soil, ultimately leading to poor yields. However, these chemical fertilizers are costlier and also pollute the environment through the process of denitrification, volatilization and leaching. Amongst various available organic options, biofertilizers are agriculturally important as

beneficial micro-organisms which have the ability to mobilize the nutritionally important elements (Singh *et al.* 2012). Biofertilizers are known to increase the yield of strawberry (Shiow and Shin 2002) [20]. Organic fertilizers improve soil fertility by modifying soil structure, pH, biophysical conditions and availability of essential nutrients (Atiyeh *et al.* 2002) [4]. Biofertilizers like *Azotobacter* fix atmospheric nitrogen and enhances the production of various field crops (Umar *et al.* 2009) [26]. Vermicompost is an environmentally acceptable means for converting waste to nutritious compost. It is homogenous and has reduced level of contaminants which in turns tends to hold more nutrients over a longer period, without impacting the environment, hence considered as an excellent product (Edwards *et al.* 1988) [7]. Hence the present study was conducted to optimize the use of organic and inorganic fertilizers.

Materials and Methods

The present study entitled Impact of organic fertilizers on performance of strawberry cv.

Sweet Charlie under sub-tropical conditions of Punjab was conducted in the nursery of Horticulture Department, Khalsa College, Amritsar during 2018. Amritsar represents the climatic conditions prevailing in the sub tropical humid zone of Punjab state. It receives an annual rainfall of 735 mm, the major portion of which falls from July to September. During winter, frost is of common occurrence while in summer, the atmospheric temperature occasionally reaches upto 480 C. The soil of experimental field was sandy loam in texture. The runners of strawberry were procured from the Neva Plantation Nursery, village Gopalpur, Tehsil Palampur, Distt Kangra Himachal Pradesh. The runners were transplanted in well prepared raised beds each measuring 2 m × 1 m in size. The transplanting was done during second fortnight of October at a planting distance of 45 × 30 cm. Uniform dose of FYM @ 50 t/ha was applied to all plots including control before field bed preparations. Vermicompost was applied at the time of planting. Organic fertilizers as *Azotobactor* @ 4 kg/ha and *PSB* @ 1 litre/ha were used. Organic fertilizers were mixed with soil and broadcasted at the planting time. The plants were protected against frost during second fortnight of December and first fortnight of January with the help of white polythene sheet (Polythene of 100 gauge thickness).The experiment was laid in eleven treatments(T_{1-} Vermicompost 2.80 t/ha + Biofertilizers; T_{2-}Vermicompost 2.80 t/ha ; T_{3-} Vermicompost 2.10 t/ha + Biofertilizers; T_{4-} Vermicompost 2.10 t/ha ; T_{5-} Vermicompost 1.40 t/ha + Biofertilizers; T_{6-} Vermicompost 1.40 t/ha ; T_{7-} Vermicompost 0.70 t/ha + Biofertilizers; T_{8-} Vermicompost 0.70 t/ha ; T_{9-} Biofertilizers ; T_{10-} N:P:K 80:40:40 kg/ha; T_{11-} Control (No fertilizers) replicated thrice.The Observations were statistically analysed by Randomized Block Design.

Results and Discussion

Maximum plant height (15.05 cm) was observed under treatment T_1 which was found to be significantly higher than all the other treatments. Minimum plant height (9.61 cm) was recorded under control. Improvement in plant height with the application of vermicompost along with biofertilizers might be due to the production of more chlorophyll content with inoculation of nitrogen fixers. It might be due to the production of plant growth regulator by bacteria in rhizosphere, which are absorbed by the roots. The better development of root system and the possibly synthesis of plant growth hormones like IAA, GA and cytokinins and direct influence of biofertilizers might have caused an increase in plant height of strawberry Tripathi *et al.* (2010) [25]. Similar results were observed by Hammam (2003) [10], Marathe and Bharambe (2005) [15] and Nazir *et al.* (2006) [17] in strawberry.

The data pertaining to the effect on leaf number depicted that maximum number of leaves per plant (23.24) were observed in the treatment T_1. It might be possible due to the reason that vermicompost along with biofertilizers provided all essential plant nutrients in readily available form like nitrogen, which supply 30 per cent of the entire crop requirement as a potential source for plant growth thus resulting in higher number of leaver per plant Curry and Byrne (1992) [5]. Similar findings have been reported by Tripathi *et al.* (2010) [25], Arancon *et al.* (2003) [1], Gajbhiye *et al.* (2003) [8] and Odongo *et al.* (2008) [18] in strawberry fruits. The lowest numbers of leaves (16.06) were found under control.

The perusal of data on leaf area under protected conditions showed that the maximum average leaf area (90.87cm^2) was observed in the plants under treatment. The present study demonstrated that the application of vermicompost along with biofertilizers increased the average leaf area per plant which might be due to the enhanced soil properties such as cation exchange capacity and soil microbial activity. The present results are in accordance with the findings of Tripathi *et al.* (2010) [25] and Arancon *et al.* (2003) [1] in strawberry. Minimum average leaf area (44.85cm^2) was observed under control.

Maximum number of flowers per plant (26.03) were observed with the treatment T_1 and were found to be significantly higher over all the treatments. The combined application of vermicompost and biofertilizers accelerated the development of inflorescence, leaf number in autumn, which are positively correlated with the number of flowers and fruits in the following spring Tripathi *et al.* (2010) [25] in strawberry. This was also due to the reason that vermicompost played a significant role in increasing gibberellic acid in roots thus increasing flowering buds and fruiting sites (Tagliavini *et al.* 2005) [24] or the increase in number of flowers with the application of vermicompost might be possible due to the reason that vermicompost increased the availability of plant growth influencing substances such as hormones and humic acid produced by microorganisms which probably contributed to increase flowering in strawberry Arancon *et al.* (2005) [2]. Similar findings were observed by Arancon *et al.* (2003) [1], Singh *et al.* (2008) [22], Atefe *et al.* (2012) [3], Arancon *et al.* (2006) and Tagliavini *et al.* (2005) [24] in strawberry fruits. Minimum numbers of flowers per plant (17.36) were recorded under control.

The influence of organic and inorganic fertilizers on number of fruits per plant depicted that the maximum number of fruits per plant (19.05) was observed in the plants treated with treatment T_1 while least number of fruits (11.12) was observed under control. The combined application of vermicompost and biofertilizers increased the number of fruits per plant due to the fact that it contains populations of bacteria, fungi and actinomycetes with outstanding physico-chemical and biological properties which helped in increasing the number of fruits Nair *et al.* (1997) [16]. Nitrogen mainly increased fruiting as it reduced the abortion of female flowers. The increase in fruit set is due to commutative effect of vermicompost along with biofertilizers that results the more number of fruits per plant Tripathi *et al.* (2010) [25]. These

findings are in accordance with those of Herencia *et al*. (2011) [11] and Atefe *et al.* (2012) [3] in strawberry.

The perusal of data showed that the maximum fruit set (75.96 %) was recorded in the plants treated with treatment T_1. Minimum fruit set (63.88 %) was observed under control. Hence it is clear from the data that with an increase in dose of vermicompost along with biofertilizers fruit set per cent was also increased. Biofertilizers are best known to improve plant development hence the improvement in fruit set. This might be due to the commutative effect of vermicompost along with biofertilizers that resulted in the more number of fruits per plant Tripathi *et al.* (2010) [25]. These results conforms the findings of Arancon *et al.* (2003) [1] who stated that the increased doses of vermicompost enhanced the soil nutrient status and improved the microbial activity in soil which increased flowering and reduced the abortion of female flowers thus increasing the fruit set per cent.

The data related to fruit yield per plant demonstrated that the fruit yield per plant increased rapidly with the increasing dose of vermicompost along with biofertilizers. Maximum fruit yield (298.44 g/plant) and (477.50 q/ ha) was noted in the plants under treatment T_1 which proved to be significantly higher than all other treatments. Minimum fruit yield 111.57 g/plant and 178.52 q/ha was observed in control. Significantly increase in fruit yield might be attributed to the increased fruit set per plant, berry length and width as well as berry weight. Moreover, it might also be due to the fact that vermicompost and biofertilizers not only increased the availability of nitrogen to the plants but also increased their translocation from root to flower through plant foliage Singh and Singh (2009) [21]. The present results are in accordance with the findings of Tripathi *et al.* (2010) [25], Wange *et al.* (1998), Dadashpour *et al.* (2012) [6], Grappelli *et al.* (1987) [9] and Singh *et al.* (2008) [22].

Conclusion

From the present investigation, it has been concluded that the strawberry plants treated with 2.80 t/ha vermicompost + biofertilizers showed significant increase in plant characteristics in terms of plant height, number of leaves per plant, leaf area, number of flowers per plant, number of fruits per plant, fruit set per cent in strawberry and fruit yield respectively. Hence it is concluded that vermicompost and biofertilizers combination are quite beneficial for the vegetative growth and quality of strawberry.

Table 1: Effect of various fertilizers on plant height (cm) in strawberry cv. Sweet Charlie

Treatments		Plant height (cm)
T_1	Vermicompost 2.8 t/ha + Biofertilizers	15.05
T_2	Vermicompost 2.8 t/ha	14.07
T_3	Vermicompost 2.10 t/ha + Biofertilizers	13.66
T_4	Vermicompost 2.10 t/ha	13.09
T_5	Vermicompost 1.40 t/ha + Biofertilizers	12.54
T_6	Vermicompost 1.40 t/ha	12.22
T_7	Vermicompost 0.70 t/ha + Biofertilizers	11.58
T_8	Vermicompost 0.70 t/ha	11.08
T_9	Biofertilizers	10.04
T_{10}	N:P:K 80:40:40 kg/ha	13.90
T_{11}	Control (No fertilizers)	9.61
CD (p=0.05)		0.90

Table 2: Effect of various fertilizers on leaf number (cm) in strawberry cv. Sweet Charlie

Treatments		Number of leaves Per plant
T_1	Vermicompost 2.8 t/ha + Biofertilizers	23.24
T_2	Vermicompost 2.8 t/ha	22.59
T_3	Vermicompost 2.10 t/ha + Biofertilizers	22.25
T_4	Vermicompost 2.10 t/ha	21.87
T_5	Vermicompost 1.40 t/ha + Biofertilizers	21.40
T_6	Vermicompost 1.40 t/ha	20.94
T_7	Vermicompost 0.70 t/ha + Biofertilizers	20.22
T_8	Vermicompost 0.70 t/ha	19.66
T_9	Biofertilizers	18.65
T_{10}	N:P:K 80:40:40 kg/ha	22.40
T_{11}	Control (No fertilizers)	16.06
CD (p=0.05)		0.71

Table 3: Effect of various fertilizers on leaf area (cm^2) in strawberry cv. Sweet Charlie

Treatments		Leaf area (cm^2)
T_1	Vermicompost 2.8 t/ha + Biofertilizers	90.87
T_2	Vermicompost 2.8 t/ha	87.89
T_3	Vermicompost 2.10 t/ha + Biofertilizers	85.92
T_4	Vermicompost 2.10 t/ha	82.98
T_5	Vermicompost 1.40 t/ha + Biofertilizers	75.74
T_6	Vermicompost 1.40 t/ha	69.48
T_7	Vermicompost 0.70 t/ha + Biofertilizers	66.13
T_8	Vermicompost 0.70 t/ha	63.20
T_9	Biofertilizers	57.12
T_{10}	N:P:K 80:40:40 kg/ha	86.46
T_{11}	Control (No fertilizers)	44.85
CD (p=0.05)		3.06

Table 4: Effect of various fertilizers on number of flowers in strawberry cv. Sweet Charlie

Treatments		Number of flowers
T_1	Vermicompost 2.8 t/ha + Biofertilizers	26.03
T_2	Vermicompost 2.8 t/ha	24.20
T_3	Vermicompost 2.10 t/ha + Biofertilizers	23.26
T_4	Vermicompost 2.10 t/ha	22.83
T_5	Vermicompost 1.40 t/ha + Biofertilizers	20.89
T_6	Vermicompost 1.40 t/ha	19.98
T_7	Vermicompost 0.70 t/ha + Biofertilizers	19.27
T_8	Vermicompost 0.70 t/ha	17.93
T_9	Biofertilizers	17.76
T_{10}	N:P:K 80:40:40 kg/ha	23.49
T_{11}	Control (No fertilizers)	17.36
CD (p=0.05)		0.75

Table 5: Effect of various fertilizers on number of fruits in strawberry cv. Sweet Charlie

Treatments		Number of fruits
T_1	Vermicompost 2.8 t/ha + Biofertilizers	19.05
T_2	Vermicompost 2.8 t/ha	17.89
T_3	Vermicompost 2.10 t/ha + Biofertilizers	16.71
T_4	Vermicompost 2.10 t/ha	16.35
T_5	Vermicompost 1.40 t/ha + Biofertilizers	14.95
T_6	Vermicompost 1.40 t/ha	14.05
T_7	Vermicompost 0.70 t/ha + Biofertilizers	13.26
T_8	Vermicompost 0.70 t/ha	12.16
T_9	Biofertilizers	11.62
T_{10}	N:P:K 80:40:40 kg/ha	15.72
T_{11}	Control (No fertilizers)	11.12
CD (p=0.05)		1.20

Table 6: Effect of various fertilizers on fruit set (%) in strawberry cv. Sweet Charlie

Treatments		Fruit set (%)
T_1	Vermicompost 2.8 t/ha + Biofertilizers	75.96
T_2	Vermicompost 2.8 t/ha	73.84
T_3	Vermicompost 2.10 t/ha + Biofertilizers	71.89
T_4	Vermicompost 2.10 t/ha	71.67
T_5	Vermicompost 1.40 t/ha + Biofertilizers	71.53
T_6	Vermicompost 1.40 t/ha	70.27
T_7	Vermicompost 0.70 t/ha + Biofertilizers	68.77
T_8	Vermicompost 0.70 t/ha	67.90
T_9	Biofertilizers	65.68
T_{10}	N:P:K 80:40:40 kg/ha	67.52
T_{11}	Control (No fertilizers)	63.88
CD (p=0.05)		2.35

Table 7: Effect of various fertilizers on fruit yield in strawberry cv. Sweet Charlie.

Treatments		Yield per plant (g)	Yield per hectare (q)
T_1	Vermicompost 2.8 t/ha + Biofertilizers	298.44	477.50
T_2	Vermicompost 2.8 t/ha	247.02	395.23
T_3	Vermicompost 2.10 t/ha + Biofertilizers	211.48	338.34
T_4	Vermicompost 2.10 t/ha	203.31	325.31
T_5	Vermicompost 1.40 t/ha + Biofertilizers	167.24	267.59
T_6	Vermicompost 1.40 t/ha	155.0	248.12
T_7	Vermicompost 0.70 t/ha + Biofertilizers	142.28	227.65
T_8	Vermicompost 0.70 t/ha	127.86	204.57
T_9	Biofertilizers	121.01	193.62
T_{10}	N:P:K 80:40:40 kg/ha	161.00	257.61
T_{11}	Control (No fertilizers)	111.57	178.52
CD (p=0.05)		32.50	52.01

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