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CULTIVATION OF STRAWBERRY (*Fragaria* × *ananassa* Duch.) Cv. chandler AS AFFECTED BY BIO AND INORGANIC FERTILIZERS UNDER OPEN CONDITIONS

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ABSTRACT
Strawberry is one of the potent profitable crops. Due to very less information on standardization of use of various inorganic and biofertilizers in strawberry plants limiting the cultivation of marginal farmer under subtropical conditions of Punjab. In the present study revealed that plant treated with 2.80 t/ha vermicompost showed significant increase in plant height, leaf area, number of leaves per plants, number of flowers, number of fruits per plant and fruit set per cent in strawberry. Similarly plant treated with 2.80 t/ha vermicompost also showed significant effect on physico-chemical properties of fruits. Fruits showed maximum fruit weight, fruit size, TSS, TSS: acid, total sugars, reducing sugars, ascorbic acid content, organoleptic rating, and minimum acidity with application of 2.80 t/ha vermicompost. Hence it concluded that vermicompost has significant effect on the vegetative growth and quality of strawberry.

KEY WORDS: Strawberry, Vermicompost, Biofertilizers, Inorganic fertilizers.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is an ancient crop belonging to family Rosaceae. All the cultivated varieties are octaploid (2x=56). Cultivated strawberry is a hybrid between two species (*Fragaria chiloensis* × *Fragaria virginiana*). It is one of the delicious fruit of the world which has attained a premium position in the world fruit market as well as in the processing industries (Sharma and Sharma 2003). It is amongst the few crops, which gives quick and very high returns per unit area on the capital investment, as the crop is ready for harvest within six months of planting. U.S.A is the leading producer of strawberry in world. Strawberry is generally grown in hilly as well as cool climatic zones of India. It is grown in Maharashtra, Haryana, Punjab, Uttar Pradesh, lower hilly areas of Himachal Pradesh and also in the hills up to an elevation of 3000 m in humid and dry regions (Kumar *et al* 2012). Strawberry is known for its pleasant organoleptic qualities and its high content of Vit-C, polyphenols and elagic acid, the latter of which have cancer fighting properties (Xue *et al* 2001). One hundred gram edible portion contain 89g water, 0.07g protein, 0.5g fat, 8.4g carbohydrates and 59g ascorbic acid. Other benefits has been ascribed to strawberries, such as high levels of antioxidant properties that aids in slow ageing, prevent urinary tract infection and the ability to reduce blood sugar (Villagran 2001).

Strawberry plant is a surface feeder; therefore fertility, moisture, drainage and microbial status of upper layer of soil have great impact on growth, development, fruit yield, quality and production of runners. The application of inorganic fertilizers has improved the yield per unit area manifold but these fertilizers are expensive and hamper the ecological balance of the soil. The unbalanced application of organic manures, biofertilizers, inorganic fertilizers and synthetic fertilizers to get higher production of quality berries and runners leads to degradation of Physico-chemical properties and microbial status of soil. Therefore an alternate source of nutrition is needed to sustain the productivity of land. Biofertilizers exert indirect effect on soil microbiological activities which in turn help the plant to grow better, besides having direct effect on nitrogen fixation and phosphorus mobilization (Singh *et al* 2012). In this regard, biofertilizers are helpful in improving biological activity of desirable micro-organisms in the soil and also improving the crop yield and good quality of produce. The biofertilizers are economically viable and eco-friendly as well as increase the crop yield by 15-30%. A judicious combination of inorganic and organic fertilizers or biofertilizers may be helpful in increasing the fruit production in strawberry. Moreover they are cost effective and renewable. Biofertilizers are known to increase the yield of strawberry (Shiow and Shin, 2002).

Organic nutrients increase soil enzyme activity, available nitrates, carbon to total organic carbon ratio and metabolic quotients resulting in enhanced soil fertility (Okwuagwu *et al* 2003). Organic fertilizers improve soil fertility by modifying soil structure, pH, bio- physical conditions and availability of essential nutrients (Atiyeh *et al* 2002). Vermicompost is homogenous and has reduced level of contaminants which in turns tends to hold more nutrients over a longer period, without impacting the environment, it is considered as an excellent product (Edwards and Niederer, 1988). Very less information is available on standardization of use of various inorganic and biofertilizers in strawberry plants under sub tropical conditions of Punjab. Hence the present study was conducted to optimize and effect the use of inorganic and biofertilizers on the plant health and fruit quality of strawberry.

MATERIALS & METHODS

Field experiment were carried out at the Department of Horticulture, Khalsa College, Amritsar (latitude 31^0-38' and longitude 75^0-52') during the year 2014-2015 on sandy loam in texture. Available nitrogen, phosphorus and potassium status of the soil was studied by taking sample from the field before the start of experiment i.e. pH(8.4), Total nitrogen (0.28 %), Available phosphorus (kg/ha) 16.00, and Available potash (kg/ha), (175.00). 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 up to 48°C. The runners of strawberry were procured from the Neva Plantation Nursery, Himachal Pradesh and transplanted in well-prepared raised beds each measuring 2m × 1m in size. The transplanting was done during second fortnight of October at a planting distance of 45×30cm. Uniform dose of FYM @ 50 t/ha was applied to all plots before field bed preparations.

Experiment Details:

Number of Treatments : 11
Number of replications : 3
Total number of plots : 11× 3= 33
Statistical analysis :RBD (Randomised Block Design)
Number of runners per plot :14
Total number of runners :14 × 11 × 3= 462

TREATMENTS

T_1	Vermicompost 2.80 tonn/ha
T_2	Vermicompost 2.80 tonn/ha + Biofertilizers
T_3	Vermicompost 2.10 tonn/ha
T_4	Vermicompost 2.10 tonn/ha + Biofertilizers
T_5	Vermicompost 1.40 tonn/ha
T_6	Vermicompost 1.40 tonn/ha + Biofertilizers
T_7	Vermicompost 0.70 tonn/ha
T_8	Vermicompost 0.70 tonn/ha + Biofertilizers
T_9	Biofertilizers
T_{10}	80:40:40 kg/ha N:P:K
T_{11}	Control (No fertilizers)

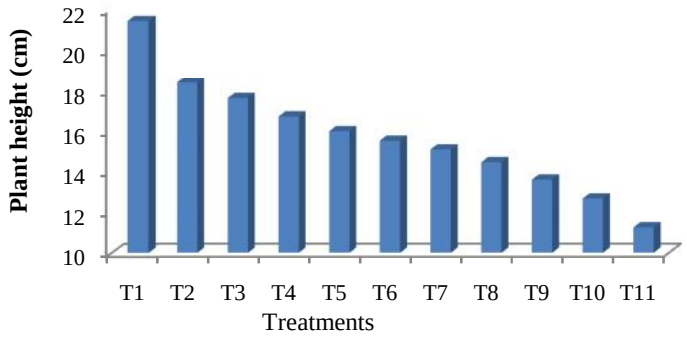
RESULTS & DISCUSSION

The data with regard to plant height as influenced by bio and inorganic fertilizers treatments are presented in Table 1.1 and Figure 1.1. Maximum plant height (21.43 cm) was recorded under T_1 treatment which was proved to be significantly higher than all other treatments. The height of plants under control was recorded to be minimum with 11.24 cm. Plants under T_{10} treatment registered plant height (12.66 cm) which was at par with control. Maximum growth in plant height was supported by the fact that increased level of Nitrogen increased the height of the plant. Addition of biofertilizer (*Azotobacter*) might have helpful in Nitrogen fixation and quicker source for plant absorption. These results have been reported by Choi *et al* (2000). Singh *et al* (2015) also concluded that application of biofertlizers and vermicompost increased the plant height (20.26 cm). They concluded that application of vermicompost enhanced the soil properties as cation exchange capacity and soil microbial activity. Similar findings have also been reported by Tripathi *et al* (2014), Ahmad *et al* (2013). Khalid *et al* (2013) also reported positive effect of vermicompost on the plant height of strawberry.

The perusal of data in Table 1.1 and Figure 1.2 revealed maximum number of leaves (27.18) was counted in plants treated with T_1 treatment which was found to be statistically significant than all other treatments. The lowest numbers of leaves (13.28) were found in control. The application vermicompost proved beneficial in increasing the number of leaves in strawberry. Increase in the dose of vermicompost increased the number of leaves per plant in strawberry. Similar findings have been reported by Singh *et al* (2015) with maximum number of leaves (54.30) with the application of vermicompost as compared to other treatments. This is due to high uptake of nutrients like nitrogen which has major role in increasing cell division and improving the growth of plants proved by Khalid *et al* (2013). The results are also in collaboration with the work of Gupta *et al* (2012) and Umar *et al* (2013).

Table 1.1: Effect of bio and inorganic fertilizers on the plant characters flowering, fruiting and physical characters of strawberry cv. Chandler

Treatments	Plant height (cm)	Number of leaves per plant	Leaf area (cm^2)	Number of flowers	Number of fruits	Fruit set (%)	Fruit Length (cm)
T_1	21.43	27.18	119.10	27.60	23.11	83.76	5.13
T_2	18.36	24.16	113.90	26.87	21.54	80.36	4.93
T_3	17.59	22.33	111.13	26.52	21.01	79.24	4.80
T_4	16.68	21.10	109.80	26.21	19.87	75.85	4.66
T_5	15.96	20.08	101.31	25.81	18.91	73.29	4.53
T_6	15.50	19.56	95.39	24.40	17.40	71.34	4.45
T_7	15.07	19.02	92.77	23.13	16.03	69.34	4.41
T_8	14.44	18.27	88.63	22.64	14.53	64.20	4.38
T_9	13.59	17.75	81.93	20.90	13.40	63.39	4.20
T_{10}	12.66	16.37	78.61	19.36	11.40	61.65	4.01
T_{11}	11.24	13.28	70.12	15.26	8.42	55.16	3.84
CD (5%)	**1.77**	**2.64**	**4.43**	**1.74**	**2.37**	**2.14**	**0.50**



FIGUREI.1: Effect of bio and inorganic fertilizers on the plant height (cm) of strawberry cv. Chandler

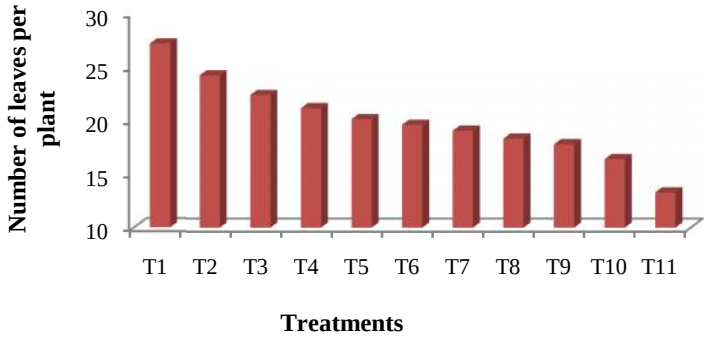


FIGURE 1.2: Effect of bio and inorganic fertilizers on the number of leaves per plant in strawberry cv. Chandler

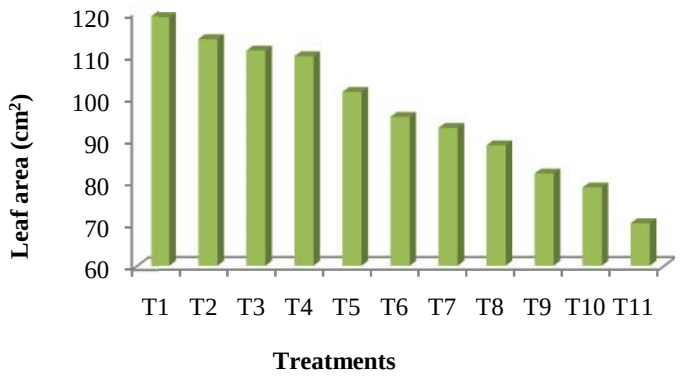


FIGURE 1.3: Effect of bio and inorganic fertilizers on the leaf area (cm^2) of strawberry cv. Chandler

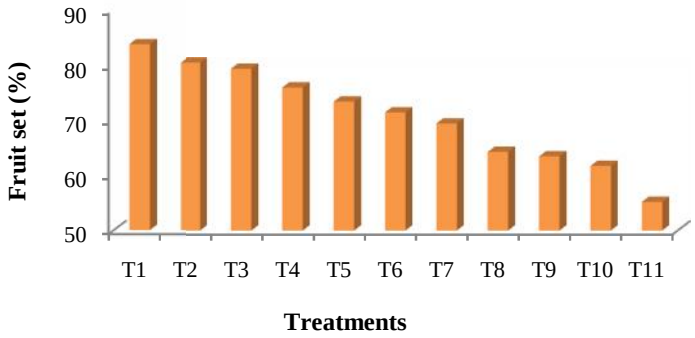


FIGURE 1.4: Effect of bio and inorganic fertilizers on the fruit set per cent in strawberry cv. Chandler

Average leaf area of strawberry plants i.e. 119.10 cm^2 showed rapid increase with strawberry plants under treatment T_1 presented in Table 1.1 and Figure 1.3. Minimum average leaf area 70.12 cm^2 was recorded in plants under control treatment. It was observed that 2.80 t/ha vermicompost produced leaf area of 119.10 cm^2 and this was proved to be the best to all over treatments. These results confirmed the findings of Singh *et al* (2008), Verma *et al* (2013) and Gupta *et al* (2012) in strawberry in which they also reported the positive role of vermicompost in enhancing the leaf area. This may be due to the enhanced soil properties like cation exchange capacity and soil microbial activity. Ogendo *et al* (2008) reported that organic manures contained proportionate amount of potassium which promotes the leaf growth and enhanced sugars accumulation thus increasing leaf area. Singh *et al* (2008) in their experiment observed that increasing level of vermicompost increases the leaf area of strawberry plants which was 23.1% more than the control.

Results of the present study presented in Table 1.1 showed that maximum number of flowers per plant (27.6) was observed in plants treated with 2.80t/ha vermicompost (T_1) which was followed by plants under T_2, T_3 and T_4 treatment were found with 26.87, 26.52 and 26.21 numbers of flowers per plant respectively. Lowest numbers of flowers (12.26) were observed in control treatment (T_{11}). Similar results have been favoured by Singh *et al* (2015) and Gupta *et al*. (2012). They observed that application of vermicompost in strawberry produced maximum number of flowers per plants as compared to other treatments. Arancon *et al* (2004) also favoured that application of vermicompost increases the number of flowers per plant in strawberry. Increasing level of phosphorous increased the number of flowers per plant which was also supported by Albregts *et al* (1996). The optimum level of nutrients as NPK and hormones provided by vermicomposts played a significant role in increasing the Gibberellic acid in roots thus breaking bud dormancy and increasing flowering buds and fruiting sites (Tagliviani *et al*, 2005).

The data on the number of fruits per plant in strawberry as affected by various treatments are presented in Table 1.1. Results of the present study showed that maximum number of fruits per plant (23.11) was observed in plants treated with T_1 treatment which was followed by plants treated with T_2 and T_3 treatments with 21.59 and 21.01 numbers of flowers per plants respectively. All of these treatments were found to be at par with each other. Plants under T_4, T_5 and T_6 treatments were produced 19.87, 18.91 and 17.40 number of fruits per plant respectively which did not differ significantly. It was also found that plants under T_9 and T_{10} treatments were with 13.40 and 11.40 numbers of fruits per plant respectively which were found to be at par with each other. Lowest numbers of fruits (8.42) were observed in control treatment (T_{11}). Hence results of the present study demonstrated that 2.80 t/ha vermicompost increases the number of fruits per plant. These findings are in line with Arancon *et al* (2004) who favoured that application of vermicompost increases the number of fruits per plant in strawberry because application of vermicompost increases the nutrient availability in the soil. Nitrogen is mainly effects the fruiting because it resulted in more flowering sites and reduced the abortion of female flowers which enhanced the number of fruits (Tagliavini *et al*, 2005). Ali *et al* (2003) and Herencia *et al* (2011) are in their experiment also reported the positive effects of vermicompost on the fruiting of strawberry.

The data pertaining to fruit set per cent as influenced by Bio and Inorganic fertilizers are given in Table 1.1 and Figure 1.4 depicted that vermicompost treatments in alone proved its effectiveness in enhancing the fruit set than combination with biofertilizers in other treatments. Maximum fruit set (83.76 %) was recorded in plants of T_1 treatment which was found to be statistically significant than all other treatments. It was followed by plants under T_2 and T_3 treatments with fruit set 80.36 % and 79.24 % respectively. Both these treatments were found to be at par with each other. Minimum fruit set (55.16 %) was observed under control. So it was found that plants with treatment T_1 provided better fruit set per cent in strawberry. Increasing dose of vermicompost increased the N level and improved the fruit set per cent in strawberry. Similar findings have been reported by Gupta *et al* (2012) with better fruit set per cent in treatments receiving vermicompost application. Herencia *et al* (2011) also investigated the positive effect of vermicompost on fruit set per cent. Arnacon *et al* (2004) in their research trail concluded that application of vermicompost increased the fruiting in strawberry. Increased level of vemicompost enhanced the soil nutrients status and improves the microbial activity in soil which increases the flowering sites and reduced the abortion of female flowers and increases the fruit set percent.

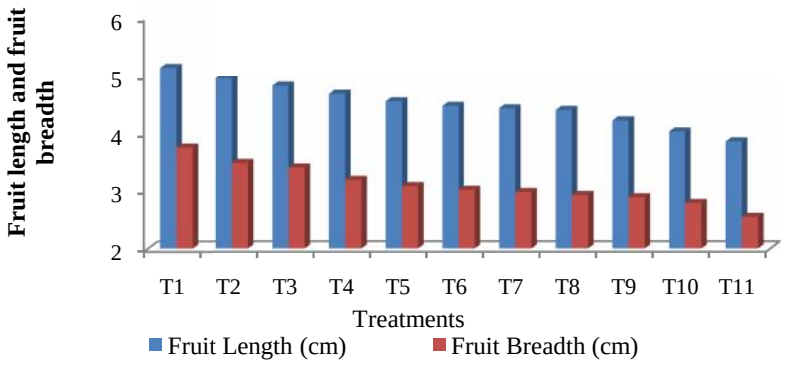


FIGURE 1.5: Effect of bio and inorganic fertilizers on the fruit size of strawberry cv. Chandler

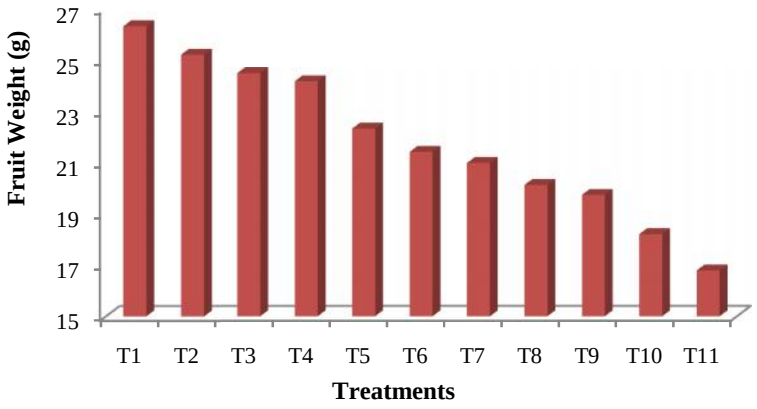


FIGURE 1.6: Effect of bio and inorganic fertilizers on the fruit weight of strawberry cv. Chandler

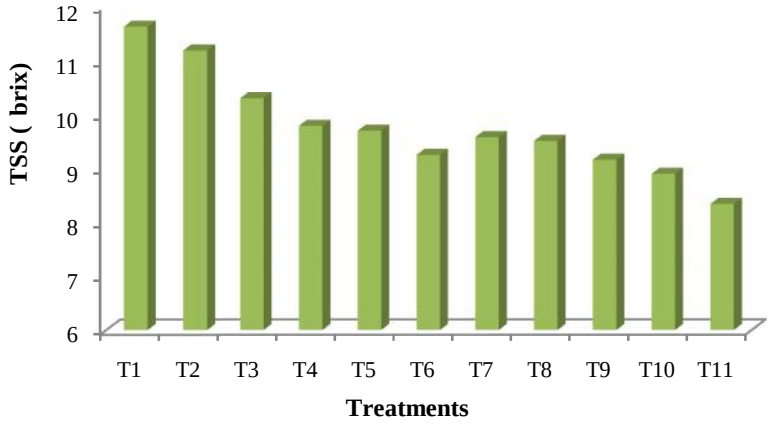


FIGURE 1.7: Effect of bio and inorganic fertilizers on the TSS of fruits of strawberry cv. Chandler

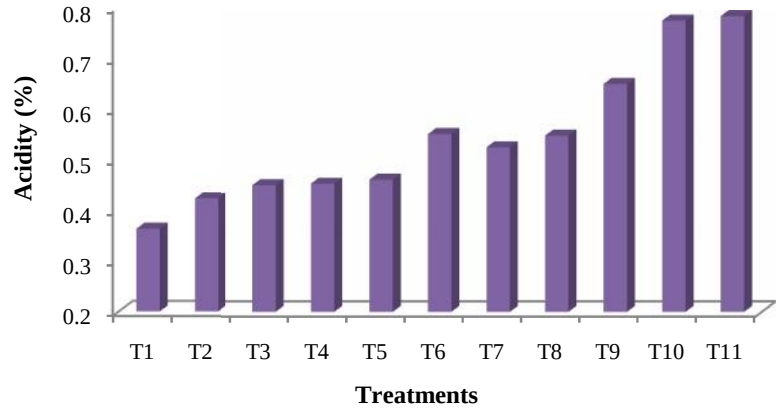


FIGURE 1.8: Effect of bio and inorganic fertilizers on the acidity of fruits of strawberry cv. Chandler

The data in Table 1.1 pertaining to the fruit length influenced by bio and inorganic fertilizers showed that the maximum fruit length (5.13 cm) was found in the plants under T_1 which was followed by treatments T_2, T_3 and T_4 with 4.93 cm, 4.80 cm and 4.66 cm fruit lengths respectively. Results of these findings showed that application of vermicompost increased the fruit length in strawberry. These results are in accordance with the findings of Gupta *et al* (2012), Ali *et al* (2003) and Dadashpour *et al* (2012) also reported the increase in berry size with organic manures. Organic manures contains favorable amount of macro and micro nutrients which had pronounced effect of fruit size.

TABLE 1.2: Effect of bio and inorganic fertilizers on the physical characters and the colour of fruits of strawberry cv. Chandler

Treatments	Fruit Breadth (cm)	Fruit Weight (g)	Organo-leptic Rating	Colour		
				L	A	B
T_1	3.75	26.32	9.50	31.47	18.98	11.30
T_2	3.47	25.21	9.10	32.68	25.82	12.41
T_3	3.39	24.50	9.00	25.21	22.31	9.56
T_4	3.18	24.18	8.90	30.66	19.63	9.90
T_5	3.07	22.33	8.30	29.61	21.64	10.57
T_6	3.01	21.42	8.00	27.50	20.12	10.44
T_7	2.97	20.99	7.30	31.42	20.18	10.81
T_8	2.92	20.13	7.20	33.37	26.42	12.95
T_9	2.88	19.74	7.80	29.17	22.94	11.99
T_{10}	2.78	18.21	8.20	31.94	25.23	11.92
T_{11}	2.54	16.79	6.80	34.36	26.04	14.20
CD (5%)	0.20	1.54	0.59	2.62	2.49	0.69

Presentation of the data regarding fruit breadth influenced by bio and inorganic fertilizers are presented in Table 1.2. Results of these findings showed that application of vermicompost increased the fruit breadth in strawberry. It has favoured by Gupta *et al* (2012), they reported positive effect of vermicompost on fruit breadth. These results are also in collaboration with the findings of Ali *et al* (2003) and Dadashpour *et al* (2012). The data regarding the fruit weight of strawberry fruits in Table 1.2 and Figure 1.6 showed that the maximum fruit weight (26.32 g) was observed in the treatment T_1 respectively, which was found to be significant all over the treatments. Lowest fruit weight (16.79 g) was found in the control treatment. Results of these findings were confirmed by Verma *et al* (2013) and Dadashpour *et al* (2012) observed that enhanced level of vermicompost increased the NPK level in soil helped in production of heavy strawberry fruits.

Manures contained favorable amounts of macro and micro nutrients and enhanced the fruit weight by the formation of carbohydrates. These findings are in accordance with Odongo *et al* (2008). Gupta *et al* (2012) also showed positive effect of vermicompost on the fruit weight of strawberry fruits. Data regarding the organoleptic rating is presented in Table 1.3. Maximum organoleptic scores 9.50, 9.10 and 9.00 were awarded to the strawberry fruits from the plant under T_1, T_2 and T_3 respectively. All of these treatments were found to be at par with each other. It was also observed that fruits from treatments T_4, T_5 and T_6 scored 8.90, 8.30 and 8.00 organoleptic ratings respectively, which did not differ significantly. Fruits yielded from control treatment got minimum 6.80 organoleptic scores.

Results of the study revealed that the increased dose of vermicompost application enhanced the fruit quality of strawberry. Plants treated with 2.80 t/ha vermicompost produced fruit of better quality with high fruit weight, fruit size, fruit colour, TSS, Sugars and ascorbic acid content of strawberry fruits. On the basis of all these factors fruits treated with 2.80 t/ha vermicompost got highest 9.50 organoleptic scores. Results of these findings are confirmed by Verma *et al* (2013), Gupta *et al* (2012) and Singh *et al* (2012). They observed positive effect of vermicompost on qualityof strawberry fruits. The data regarding the fruit colour of strawberry fruits presented in Table 1.2. 'L' denotes the degree of darkness (0-50) and degree of lightness (50-100). Positive (+) values of 'a' denotes redness and negative (-) values indicates greenness. Positive (+) value of 'b' depicts yellowness and negative (-) value depicts degree of blueness. Maximum values of 'L' (34.36) were found in treatment T_{11} which was followed by T_8, T_2 with 33.37, and 32.68degree of darkness respectively. Minimum value of darkness (27.50) was found in treatment T_3. The treatments have the values ranges between 27.50 to 34.36. It indicates that strawberry fruits were of dark colour. Values of 'a' is positive in all treatments this indicates redness with maximum value of 26.42 in treatment T_8 which was followed by treatments T_{11} with 26.04 values of redness respectively.

The value of 'b' also positive that indicates that strawberry has yellowness along with red colour. Minimum value (9.56) of yellowness was found in treatment T_3 which was followed by treatment T_4 with 9.90 degree of yellowness and both of these treatments were found to be at par with each other. Maximum value of yellowness was found in T_{11}. In the case of strawberries, anthocyanins that is, natural colour pigments such as pelargonidin 3-glucoside (PG) and cyanidin 3-glucoside (CG) are predominant pigment responsible for the color development. Results of above experiment are in agreement with the reporting of Reganold *et al* (2010) in his study different strawberry cultivars were grown under organic cultivation system.

Bio-chemical Characters: It is clear from the data that are presented in Table 1.3 and Figure 1.7, TSS increased significantly with the increased dose of vermicompost. Maximum TSS of 11.62 per cent were found in the fruits treated with T_1 and it was followed by T_2 and T_3 with TSS 11.18 and 10.30 per cent respectively and these treatments were found to be at par with each other and proved to be significantly higher than all other treatments. Hence it was observed that maximum TSS was found in plants treated with 2.80 kg/ha vermicompost application. Results of these findings were confirmed by Verma *et al* (2013), Gupta *et al* (2012) and Singh *et al* (2012). They observed positive effect of vermicompost on TSS of strawberry fruits. This might be due to gradual supply of nutrients by inoculation of vermicompost throughout the growth period

which increased the metabolites in berry (Haynes and Goh 1987). Singh *et al* (2008) also confirmed that TSS of fruits were increased with increasing doze of vermicompost from 2.5 to 10 t/ha respectively.

Acidity level (0.363%) of fruits decreased significantly with increased dose of vermicompost showed in Table 1.3 and Figure 1.8 under treatment T_1 which was significantly followed by T_2 with acidity 0.423%. Results of these findings are in conformation with the results of Gupta *et al* (2012) and Singh *et al* (2012). Singh *et al* (2008) applied four doses of vermicompost (2.5, 5.0, 7.5 and 10.0 t/ha) and results of the study revealed that increasing dose of

TABLE 1.3: Effect of bio and inorganic fertilizers on the bio-chemical characters of fruits of strawberry cv. Chandler

TREATMENTS		TSS (^{0}brix)	Acidity (%)	TSS/Acid Ratio (%)	Reducing sugars (%)	Total Sugars (%)	Ascorbic Acid (mg/100g pulp)
T_1	Vermicompost 2.80 tonn/ha	11.62	0.363	31.99	4.81	6.54	62.90
T_2	Vermicompost 2.80 tonn/ha + Biofertilizers	11.18	0.423	26.39	4.16	6.29	51.25
T_3	Vermicompost 2.10 tonn/ha	10.30	0.450	22.96	4.13	6.15	48.30
T_4	Vermicompost 2.10 tonn/ha + Biofertilizers	9.79	0.453	21.60	3.96	6.13	42.40
T_5	Vermicompost 1.40 tonn/ha	9.70	0.461	21.05	3.86	5.97	39.12
T_6	Vermicompost 1.40 tonn/ha + Biofertilizers	9.25	0.551	16.77	3.66	5.88	29.58
T_7	Vermicompost 0.70 tonn/ha	9.58	0.525	18.25	3.85	5.94	35.76
T_8	Vermicompost 0.70 tonn/ha + Biofertilizers	9.51	0.548	17.35	3.81	5.90	31.75
T_9	Biofertilizers	9.16	0.650	14.11	3.57	5.86	25.73
T_{10}	80:40:40 kg/ha N:P:K	8.90	0.775	11.61	3.19	5.67	23.21
T_{11}	Control (No fertilizers)	8.34	0.784	10.62	3.06	5.48	21.3
CD (5%)		0.85	0.02	1.87	0.33	0.38	7.49

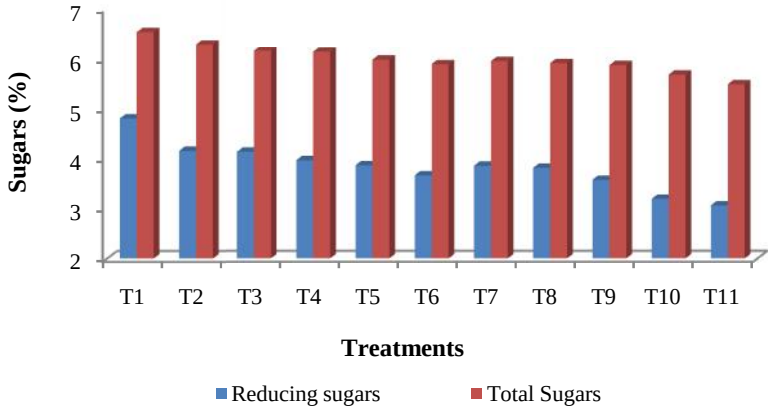


FIGURE 1.9: Effect of bio and inorganic fertilizers on the sugars of fruits of strawberry cv. Chandler

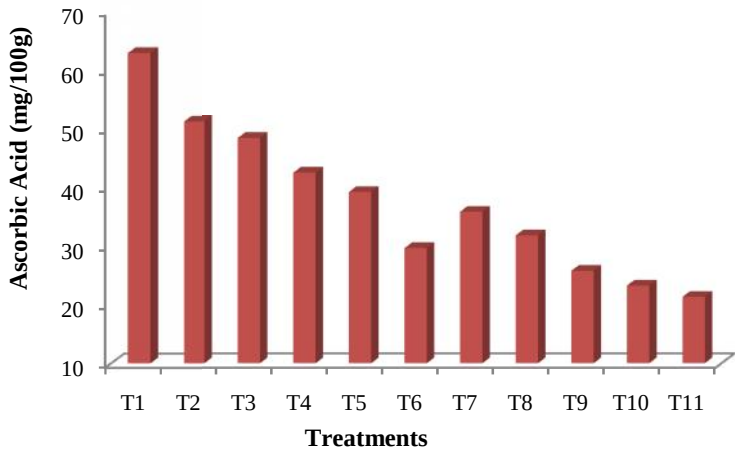


FIGURE 1.10: Effect of bio and inorganic fertilizers on the ascorbic acid content of fruits of strawberry cv. Chandler

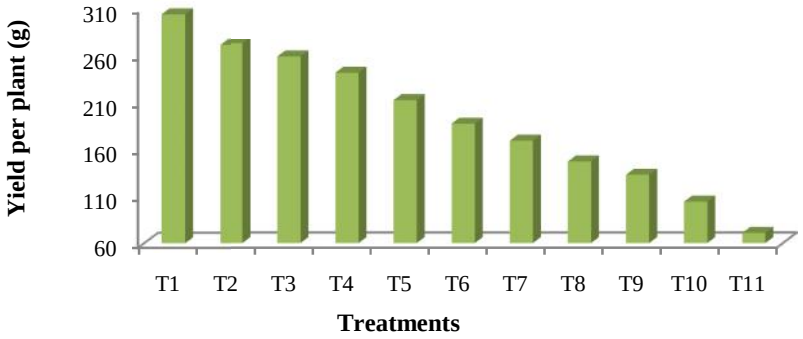


FIGURE 1.11: Effect of bio and inorganic fertilizers on the fruit per plant of strawberry cv. Chandler

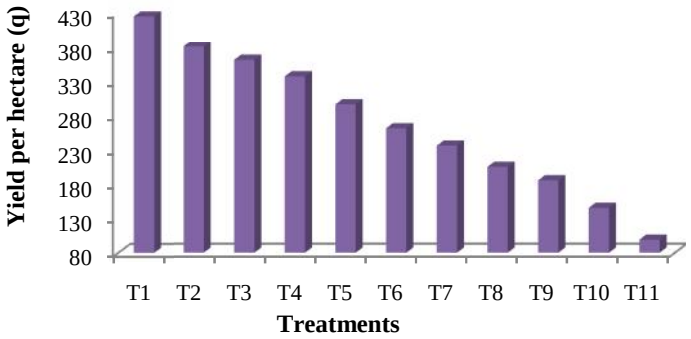


FIGURE 1.12: Effect of bio and inorganic fertilizers on the yield per hectare of strawberry fruits of strawberry cv. Chandler

vermicompost decreased the acid content in strawberry fruit. Increase in acidity might be due to synthesis of more organic acids in the treatment without application of vermicompost. The data regarding TSS: acid ratio is presented in Table 1.3 and Figure 1.8 which showed that maximum TSS: acid ratio (31.99) was observed in the plants of T_1 followed by 26.39 TSS: acid ratio which was found to be significantly higher than all other treatments. The results were in accordance with the finding of Gupta *et al* (2012) and Singh *et al* (2008) vermicompost increase the metabolites in berry which enhanced the TSS: acid ratio.

Results of the study showed that showed that reducing sugars increased rapidly with increasing dose of vermicompost (Table 1.3 and Figure 1.9). It was noted that plants with T_1 yielded fruits with maximum reducing sugars 4.81 per cent which proved to be significantly higher than all other treatments, it was followed by T_2 with 4.16% reducing sugars respectively. These findings are confirmed by Gupta *et al* (2012), Singh *et al* (2012) and Dadashpour *et al* (2012). Increasing dose of vermicompost increased the nitrogen, phosphorous and postassium levels which promotes sugars accumulation in berries and balanced of N, P and K is essential for proper availability of those nutrients to strawberry plants. Wang and Lin (2002) also found increase in reducing sugars content with the application of organic fertilizers. Total sugars showed that they increased rapidly with increasing dose of vermicompost (Table 1.3 and Figure 1.9). It was noted that plants of T_1 treatment yielded fruits with maximum total sugars as 4.81 per cent which was followed by T_2 with 4.16 percent total sugars. Both of these treatments were found at par with each other. These results are in line with the findings of Gupta *et al* (2012) in their research trails by showing positive effect of vermicompost on sugars content of strawberry fruits. Singh *et al* (2012) and Dadashpour *et al* (2012) also favoured the application of vermicompost and organic amendments on in increasing the total sugars of strawberry fruit. Wang and Lin (2002) also found increase in total sugars content with the application of organic fertilizers. Vermicompost application increased the level of potassium which promotes the sugars content in strawberry. Singh *et al* (2008) also favoured that application of vermicompost enhanced the sugars content of strawberry fruits.

Ascorbic acid influenced by various concentrations of bio and inorganic fertilizers presented in Table 1.3 and Figure 1.10 showed that ascorbic acid percentage trends to increase with the increasing dose of vermicompost. Maximum ascorbic acid content 62.9 mg/100 g pulp was found in fruits produced by plants of T_1 treatment which proved to be significantly higher than all other treatments. Hence it is observed that plants treated with 2.80 t/ha vermicompost were produced fruits with maximum ascorbic acid content. Singh *et al* (2008), Gupta *et al* (2012) and Khalid *et al* (2013) reported similar results in strawberry fruits. Organic fertilizers are hydrophilic in nature and absorb moisture and nutrients which persist longer thus improving the soil structure and indirectly enhancing fruit quality and ascorbic acid contents these findings are in accordance with those of Arancon *et al* (2004) and Ayesha *et al* (2011).

Yield character: Significantly highest yield per plant (304.12 g) and yield per hectare (425.70 qt) were recorded

in T_1, followed by plants with T_2 over remaining treatments presented in Table 1.4 and Figure 1.12. The results of present study are in close conformity with findings of Singh *et al* (2015), Tagliavini *et al* (2005) and Cabilovski *et al* (2014) in strawberry.

TABLE 1.4: Effect of bio and inorganic fertilizers on yield parameters and leaf nutrients status of the strawberry cv. Chandler

Treatments	Yield per plant	Yield per hectare (q)	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)
T_1	304.12	425.70	518	39.00	302.00
T_2	271.51	380.01	480	31.20	275.00
T_3	257.37	360.38	432	30.00	245.00
T_4	240.22	336.30	410	28.00	210.00
T_5	211.13	295.58	390	25.00	178.00
T_6	186.35	260.89	360	21.00	129.80
T_7	168.23	235.52	375	17.30	145.00
T_8	146.24	204.73	340	17.00	133.90
T_9	132.25	185.15	310	18.00	128.00
T_{10}	103.75	145.20	295	15.00	110.00
T_{11}	70.68	98.95	280	12.50	98.00
CD (5%)	27.20	46.45	6.77	4.63	5.23

Vermicompost being the source of macro and micro nutrient like Fe and Zn, enzymes, growth hormones and presence of micro flora might have played secondary role in increasing the fruit yield. The result of investigation revealed that effect of T_1 alone recorded the maximum nitrogen, P_2O_5 and K_2O with 518, 39 and 302 kg/ha out of all the treatments while increased in the dose of vermicompost and bio fertilizers leads to the amount of NPK presented in Table 1.6. Biofertilizers alone (T_9) also leads to lesser amount of NPK with 320 kg, 18 kg and 128 kg/ha as compared to the treatment followed by a decrease in (T_{10}) and minimum in the control. The results of the study clearly depicted that vermicompost had a very good effect on the contents of NPK in the strawberry plants. Biofertilizers proved more beneficial then inorganic fertilizers. These results are in accordance with the findings of Singh *et al* (2012) who also stated that biofertilizers helped the plant to grow better and had direct effect on the nitrogen fixation and phosphorous mobilization in the strawberry plants.

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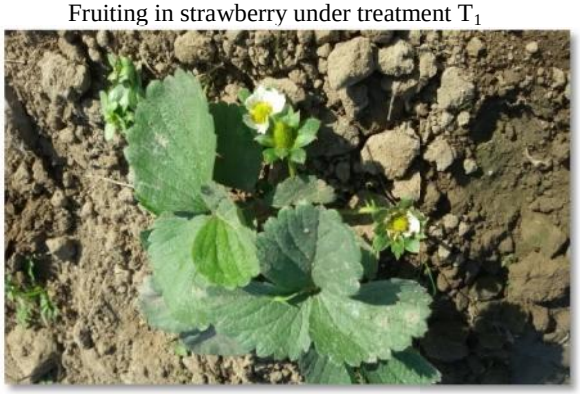
Strawberry plots after transplanting of runner.

Initial stage of growth in strawberry plant

Flowering in strawberry

Fruiting in strawberry under treatment T_1

Flowering and fruiting under treatment T_2



Flowering under treatment T_{10}

Fruiting under treatment T_9

Fruiting under treatment T_{10}

Strawberry plant under control.

Fruiting under control

Fruits under treatment T_1

Fruits under treatment T_2

Fruits under treatment T_9

Fruits under treatment T_{10}

Fruits under control