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Effect of organic inputs and growing conditions on quality parameters of strawberry (*Fragaria* × *ananassa*)

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ABSTRACT

The field experiment was conducted during 2020–2022 at Assam Agricultural University, Jorhat, Assam to evaluate the effect of organic inputs and growing conditions on quality parameters of strawberry (*Fragaria* × *ananassa* Duch.). The experiment was laid out in a factorial randomized block design (F-RBD) replicated thrice comprising of five treatments [FYM @180 g/plant (T_1), rock phosphate @4.50 g/plant + microbial consortium @0.063 g/plant (T_2), T_2 + vermicompost @45 g/plant (T_3), T_2 + enrich compost @45 g/plant (T_4) and T_2 + poultry manure @45 g/plant (T_5)] under four different growing conditions [rain shelter with insect proof net (S_1) (top covered with 200 micron UV film and side wall of 40 mesh net), rain shelter without insect proof net (S_2), net house (50% shade) i.e. S_3 and open condition (S_4)]. Quality parameters in terms of higher TSS (9.09 ºBrix), reducing sugar (4.78%), non reducing sugar (3.27%), TSS/Acid ratio (23.59%), total sugar (8.05%), ascorbic acid (54.72 mg/100 g), anthocyanin content (46.30 mg/100 g) and minimum titratable acidity (0.38%) were recorded in treatment combination of T_3S_1 (vermicompost @45 g/plant + rock phosphate @4.5 g/plant + microbial consortium @0.063 g/plant in growing condition of insect proof net covered with 200 micron UV film on top and 40 mesh net in side.

Keywords: Growing condition, Organic inputs, Quality parameters, Strawberry

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most attractive, fascinating, delicious, refreshing and nutritious soft fruit that belongs to the family Rosaceae. The cultivated species of strawberry has resulted from a cross between two American strawberries i.e. *Fragaria virginiana* (garden strawberry) and *Fragaria chileonsis* (wild strawberry) and having chromosome number 2n=2x=56. Strawberry is one of the most important temperate berry fruit, which can also be cultivated in subtropical and tropical regions. It is native to France. The edible portion of the fruit is about 98% and shows non-climacteric ripening behavior. The largest producer of strawberry in the world is the United States of America and its domestic demand is so high. In India, strawberry cultivation is mainly confined in Dehradun, Nainital (Uttarakhand), Solan and Kullu Valley (Himachal Pradesh), Srinagar (Jammu and Kashmir), Hills of Darjeeling (West Bengal), in Gurgaon (Haryana) and Muzaffarnagar (Uttar Pradesh). The fresh ripe fruits of strawberry are a fairly good source of vitamin A, B_1, B_2, B_6 and vitamin C and minerals like P, K, Ca and Fe and it regarded as one of the best natural sources of antioxidant, anticarcinogenic and antidiabetic.

Organic agriculture is a holistic production management system that is designed to optimize the productivity and fitness of diverse communities within the eco-system, including soil organisms, plant, livestock and people. Organic fertilizers are utilized globally to safeguard soil against deterioration and to eliminate food pollution. They also revamp the soil structure, chemical reactions, biophysical conditions, and availability of essential nutrients, thus enhanced soil fertility and sustain productivity. Organic manures, viz. FYM, vermicompost, rock phosphate, enriched compost, press mud in combination with microbial consortium like *Azotobacter, Azospirillum*, *Phosphate Solubilizing Bacteria*, *Rhizobium* improves the physical properties of soil (water holding capacity, soil aeration drainage and water retention capacity), also prevent soil degradation and increase important beneficial micro-organism population. Microbial consortium plays a very significant role in improving soil fertility by fixing atmospheric nitrogen both in association with plant roots and without it. It solubilizes insoluble soil phosphate and produces plant growth substances in the soil. Another important organic product is vermicompost, that contains both plant growth hormones and humic acids which can act as plant growth regulators (Kumar *et al.* 2018). It not only supplies essential nutrients to plant but

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also improves physico-chemical and biological properties of soil, with sustaining crop yield without deteriorating soil health. Rock phosphate is obtained from those rocks that contained high amount of phosphate minerals, mostly of the group containing apatite. It mainly produces phosphatic fertilizers for agricultural uses. In association with phosphate solubilizing microorganisms and organic manure, rock phosphate could be used as a phosphorus source in many crops (Datta *et al.* 1982).

Poultry manure is an excellent organic fertilizer, in contrast to chemical fertilizers; it adds organic matter to soil that improves soil physical, chemical and biological/ microbial properties of soil like soil structure, nutrient retention, aeration, soil moisture holding capacity, water infiltration and P availability to plants (Garg and Bahla 2008).

Nowadays the risk is very much high in open field strawberry production as strawberries are very much susceptible to many insect, pests, diseases and weeds. All these quickly overrun the field of strawberry leading to choking off production. Moreover, severe winter temperature or late spring frosts can destroy crops. Due to excessive rainfall, the severity of diseases increase and that can interfere with pollination, fruit set, and harvest. Also lack of labour, marketing, and transportation facility represents risks in strawberry farming (Akinkunmi and Obigbesan 2006). Growing strawberries under polyhouse condition decreases the dependence of fruit quality on climate and soil conditions. Such cultivation system also enables better water, light and temperature control to a certain extent (Kumar and Ahad 2012). So, considering aforesaid facts, with increasing demand of sustainable agriculture and organic farming, the present investigation was undertaken to study the effect the organic inputs and growing condition on fruit quality parameters of strawberry.

MATERIALS AND METHODS

The field experiment was conducted during 2020–2022 at Assam Agricultural University, Jorhat (26°45'N and 94°12'E; at an elevation of 87 m amsl), Assam. The field experiment was laid out in factorial randomized block design (FRBD) with five treatments [T_1, FYM @180 g/plant; T_2, rock phosphate @4.50 g/plant + microbial consortium @0.063g/plant; T_3, T_2 + vermicompost @45 g/plant; T_4, T_2 + enrich compost @45 g/plant; and T_5, T_2 + poultry manure @45 g/plant] replicated three times under four different growing conditions [rain shelter with insect proof net (S_1) (top covered with 200 micron UV film and side wall of 40 mesh net); rain shelter without insect proof net (S_2); net house (50% shade) (S_3) and open condition (S_4)] with spacing of 30 cm × 60 cm. Each treatment comprised of beds having 10 number of plants in each beds depending on spacing. The variety used for experiment was Sweet Charlie.

The tissue cultured planting materials of strawberry variety Sweet Charlie were imported form a nursery. The plant was small, compact with medium to dark green, slightly cupped, semi-glossy leaves. The outer leaves were pinched off and coco-peats of the roots of the seedlings were washed properly. The experimental land inside poly-house, 50% shade net house and open field condition were first ploughed with small power tiller in last week of September to loosen the soil and left for few days exposed to bright sunshine. After one week, soil was harrowed twice to bring it to fine tilth followed by levelling. After preparatory tillage, for each treatment equal sized beds each measuring 3 m × 0.6 m were laid out accommodating plants depending on spacing in each bed. Each treatment contained three number of replication. Moreover, raised beds of 15–20 cm in height were prepared for planting the strawberry plants. Beds were mulched with paddy straw mulch and the recommended treatment was applied to the soil during the preparation of beds. Healthy, disease free tissue cultured planting material along with ball of earth were planted carefully with a *khurpi* at a row to row distance of 60 cm and 30 cm between plants at 5 cm depth. While planting, care was taken so that the crown portion of the plant do not come in contact with the soil and one third portion of plant was above the soil. After planting, the beds were irrigated with a watering can. Just after planting runners light irrigation was given for the better establishment of the plants. The treatment combinations were as follows:

T_1S_1, Control (FYM @180 g/plant) in growing condition S_1; T_1S_2, Control (FYM @180 g/plant) in growing condition S_2; T_1S_3, Control (FYM @180 g/plant) in growing condition S_3; T_1S_4, Control (FYM @180 g/plant) in growing condition S_4; T_2S_1, Rock Phosphate (4.50 g/plant) + Microbial consortium @0.063 g/plant in growing condition S_1; T_2S_2, Rock Phosphate (4.50 g/plant)+Microbial consortium @0.063 g/plant in growing condition S_2; T_2S_3, Rock Phosphate (4.50 g/plant)+Microbial consortium @0.063 g/plant in growing condition S_3; T_2S_4, Rock Phosphate (4.50 g/plant) + Microbial consortium @0.063 g/plant in growing condition S_4; T_3S_1, T_2 + vermicompost @45 g/plant in growing condition S_1; T_3S_2, T_2 + vermicompost @45 g/plant in growing condition S_2; T_3S_3, T_2 + vermicompost @45 g/plant in growing condition S_3; T_3S_4, T_2 + vermicompost @45 g/plant in growing condition S_4; T_4S_1, T_2 + enrich compost @45 g/plant in growing condition S_1; T_4S_2, T_2 + enrich compost @45 g/plant in growing condition S_2; T_4S_3, T_2 + enrich compost @45 g/plant in growing condition S_3; T_4S_4, T_2 + enrich compost @45 g/plant in growing condition S_4; T_5S_1, T_2 + poultry manure @45 g/plant in growing condition S_1; T_5S_2, T_2 + poultry manure @45 g/plant in growing condition S_2; T_5S_3, T_2 + poultry manure @45 g/plant in growing condition S_3; T_5S_4, T_2+ poultry manure @45 g/plant in growing condition S_4.

The total soluble solids estimated using a digital hand refractometer and expressed as °Brix (Ranganna 1986). Titratable acidity, was estimated as per method of AOAC (1980). Also, reducing sugar was estimated by following the method of Lane and Eynon as described by Ranganna (1986). Non-reducing sugar were calculated out from the differences in total sugar and reducing sugars:

Non Reducing sugars (%) = (Total sugars % – Reducing sugars %).

Moreover, sugar-acid ratio was determined by dividing

the percentage of the total sugar by that for titratable acidity. Ascorbic acid content of pulp was determined by visual titration method using 2, 6-dichlorophenol indophenols dye of Washko *et al.* (1992). Amount of ascorbic acid was calculated using the following formula:

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{volume made up}}{\text{Aliquot of extract taken for estimation} \times \text{Weight of sample}} \times 100$$

Also, the amount of anthocyanin was calculated by the following formula given by Srivastava and Kumar (2007) and expressed in mg/100 g.

$$\text{Total OD/100 g} = \frac{\text{OD} \times \text{Volume made up}}{\text{Wt. of the sample}} \times 100$$

$$\text{Total anthocyanin (mg/100 g)} = \frac{\text{Total OD/100 g}}{98.2} \times 100$$

RESULTS AND DISCUSSION

Total soluble solids (TSS): Different growing conditions had significant effect on the total soluble solid content of strawberry in the first year, second year as well as in pooled analysis (Table 1). The pooled data showed that the maximum total soluble solids (8.33ºBrix) content were recorded in growing condition S_1 followed by S_2 i.e. 8.04ºBrix and S_3 i.e.7.75 ºBrix . The minimum total soluble solids (7.48 ºBrix) were recorded in growing condition S_4. Treatments had significant effect on the total soluble solid content of strawberry in the first year, second year as well as in pooled analysis (Table 1, Fig. 1).

The data from combined analysis of both the years revealed that the maximum TSS was found in treatment T_3 (8.59 ºBrix) followed by treatment T_4 (8.24 ºBrix) and treatment T_5 (7.90 ºBrix) while the lowest was found in treatment T_1 (7.20 ºBrix). The interaction involving treatment and growing condition showed non-significant differences on total soluble solids for both the years as well as in pooled data.

The significantly higher total soluble solid (TSS ºBrix) might be due to the addition of organic manure like vermicompost that supplements nutrients, moisture and growth promoting substances which enhances metabolic hormonal activity of the plant and that promoted production of more photosynthates which was stored in fruit in the form of starch and carbohydrates. It is an established fact that the transformation of mature fruit into ripe form i.e. during the process of ripening the fruit undergoes physical, physiological and biochemical changes. The increase in TSS content of strawberry fruits could be attributed to the conversion of reserved starch and other insoluble carbohydrates into soluble sugars. These results elucidate the findings of Iqbal *et al.* (2009), Jain *et al.* (2018) and Soni *et al.* (2018) in strawberry. Rise in CO_2 concentration inside the plants grown in growing condition S_1 or rain shelter with insect proof net reduces transpiration by 20–40% and thus, water consumption is significantly reduced by CO_2 enrichment at the same time as photosynthesis increased (Morison 1985). Also due to presence of enough warm climate inside the growing condition S_1, favoured the constant growth of plant inside the polyhouse causing more photosynthesis and vegetative and reproductive growth of strawberry plants (Rashid *et al.* 2020).

Acidity (%): The data pertaining to titratable acidity of fruits as influenced by growing condition, nutrient treatment and combination of treatment and growing conditions are presented in (Table 1). Different growing conditions had significant effect on titratable acidity (%) content of strawberry fruit in the first year, second year as well as in pooled analysis. From pooled data it was seen that the minimum titratable acidity (0.44%) was recorded in growing condition S_1 followed by S_2 i.e. 0.47% while the maximum value of titratable acidity (0.54%) was recorded in growing condition S_4. Different nutrient treatments had significantly affected the titratable acidity content of strawberry fruits. From pooled analysis, it was observed that the minimum titratable acidity (0.44%) was found in treatment T_3 followed by treatment T_4 (0.46%) and the maximum value was found in treatment T_1 (0.53%).The interaction involving treatment

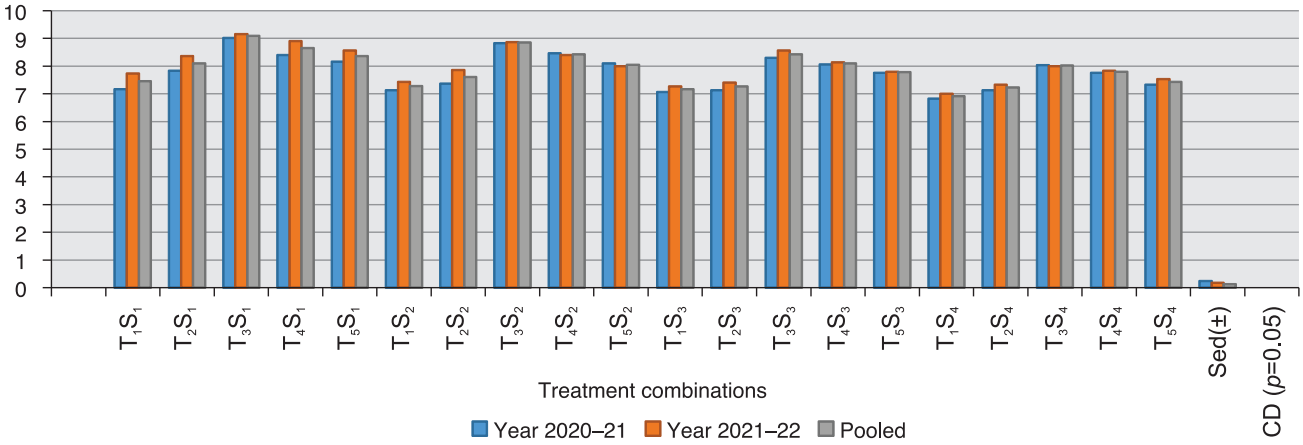

Fig. 1 Graphical representation of influence of organic inputs and growing conditions on TSS (ºBrix) content of strawberry.

Table 1 Effect of organic inputs and growing conditions on TSS and titratable acidity content of strawberry fruit

Growing condition	TSS (ºBrix)			Acidity (%)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
S_1	8.11	8.54	8.33	0.44	0.44	0.44
S_2	7.98	8.11	8.04	0.47	0.46	0.47
S_3	7.66	7.83	7.75	0.49	0.50	0.50
S_4	7.42	7.54	7.48	0.51	0.56	0.54
Sed(±)	0.11	0.07	0.06	0.006	0.007	0.005
CD (p=0.05)	0.22	0.15	0.12	0.012	0.013	0.010
Treatment	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1	7.05	7.35	7.20	0.53	0.54	0.53
T_2	7.36	7.74	7.55	0.50	0.51	0.51
T_3	8.54	8.65	8.59	0.42	0.45	0.44
T_4	8.17	8.31	8.24	0.45	0.47	0.46
T_5	7.84	7.97	7.90	0.49	0.49	0.49
Sed(±)	0.12	0.08	0.06	0.007	0.007	0.006
CD (p=0.05)	0.25	0.17	0.14	0.014	0.015	0.011
Treatment combination	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1S_1	7.16	7.73	7.45	0.50	0.50	0.50
T_2S_1	7.83	8.36	8.10	0.47	0.47	0.47
T_3S_1	9.01	9.16	9.09	0.38	0.39	0.38
T_4S_1	8.40	8.90	8.65	0.41	0.41	0.41
T_5S_1	8.16	8.56	8.36	0.45	0.44	0.45
T_1S_2	7.13	7.43	7.28	0.52	0.52	0.52
T_2S_2	7.37	7.86	7.61	0.50	0.49	0.50
T_3S_2	8.83	8.86	8.85	0.40	0.41	0.41
T_4S_2	8.46	8.40	8.43	0.46	0.44	0.45
T_5S_2	8.10	8.00	8.05	0.48	0.46	0.47
T_1S_3	7.06	7.26	7.16	0.54	0.54	0.54
T_2S_3	7.13	7.40	7.26	0.52	0.52	0.52
T_3S_3	8.30	8.56	8.43	0.44	0.47	0.46
T_4S_3	8.06	8.13	8.10	0.47	0.49	0.48
T_5S_3	7.76	7.80	7.78	0.50	0.50	0.50
T_1S_4	6.83	7.00	6.91	0.56	0.60	0.58
T_2S_4	7.13	7.33	7.23	0.52	0.58	0.55
T_3S_4	8.03	8.00	8.02	0.47	0.52	0.49
T_4S_4	7.76	7.83	7.80	0.49	0.55	0.52
T_5S_4	7.33	7.53	7.43	0.51	0.57	0.54
Sed(±)	0.24	0.17	0.13	0.01	0.01	0.01
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Treatment details are given under Materials and Methods.

and growing condition showed non-significant differences on titratable acidity content of strawberry fruit for both the years as well as in pooled analysis.

The significantly lower titratable acidity might be due to the addition of organic manure like vermicompost that supplements nutrients, moisture and growth promoting substances which enhances metabolic hormonal activity of the plant and that promotes production of more photosynthates which are stored in fruit in the form of starch and carbohydrates. During the process of ripening the fruit undergoes physical, physiological and biochemical changes. The reduction of titratable acidity of strawberry fruit through application of different organic manure with microbial consortium is because of positive influence of

zinc and boron in conversion of acids into sugar and their derivatives by the reaction involving glycolytic pathway or be used in respiration or both (Singh *et al.* 2010).

TSS/acidity ratio (%): Different growing conditions had significant effect on TSS/acidity ratio of strawberry fruit in the first year, second year as well as in pooled analysis (Table 2). Maximum TSS/acidity ratio (19.03%) was found in S_1 followed by S_2 i.e. 17.28% while the minimum TSS/acidity ratio (13.97%) were recorded in growing condition S_4 (Table 2). Various nutrient treatments had significant effect on the TSS/acidity ratio of strawberry in the first year, second year as well as in pooled analysis. Maximum TSS/Acidity ratio was found in treatment T_3 (19.86%) followed by treatment T_4 (17.87%) and treatment T_5 (16.22%) while the lowest was found in treatment T_1(13.45%). The interaction involving treatment and growing condition showed significant

Table 2 Effect of organic inputs and growing conditions on TSS/acidity ratio and reducing sugar content of strawberry fruit

Growing condition	TSS/acidity ratio (%)			Reducing sugar (%)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
S_1	18.51	19.54	19.03	4.49	4.31	4.40
S_2	17.02	17.53	17.28	4.26	4.04	4.15
S_3	15.52	15.57	15.54	4.14	3.83	3.99
S_4	14.56	13.38	13.97	3.77	3.64	3.71
Sed(±)	0.29	0.28	0.22	0.08	0.07	0.07
CD (p=0.05)	0.59	0.58	0.44	0.16	0.15	0.14
Treatment	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1	13.23	13.67	13.45	3.83	3.53	3.68
T_2	14.59	15.14	14.86	4.01	3.76	3.89
T_3	20.18	19.54	19.86	4.52	4.37	4.45
T_4	17.93	17.80	17.87	4.30	4.15	4.23
T_5	16.08	16.35	16.22	4.15	3.97	4.06
Sed(±)	0.32	0.32	0.24	0.09	0.08	0.07
CD (p=0.05)	0.66	0.65	0.49	0.18	0.17	0.15
Treatment combination	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1S_1	14.32	15.46	14.89	4.26	3.91	4.08
T_2S_1	16.65	17.78	17.21	4.34	4.09	4.21
T_3S_1	23.71	23.48	23.59	4.83	4.74	4.78
T_4S_1	20.48	21.70	21.09	4.60	4.49	4.54
T_5S_1	18.13	19.45	18.57	4.43	4.31	4.37
T_1S_2	13.71	14.28	14.00	4.01	3.72	3.86
T_2S_2	14.74	16.04	15.22	4.10	3.87	3.99
T_3S_2	22.07	21.60	21.58	4.64	4.38	4.51
T_4S_2	18.39	19.09	18.73	4.34	4.18	4.26
T_5S_2	16.87	17.39	17.12	4.21	4.07	4.14
T_1S_3	13.07	13.44	13.25	3.87	3.32	3.60
T_2S_3	13.71	14.23	13.96	4.03	3.67	3.85
T_3S_3	18.86	18.21	18.32	4.41	4.26	4.34
T_4S_3	17.14	16.59	16.87	4.26	4.08	4.17
T_5S_3	15.52	15.60	15.56	4.12	3.84	3.98
T_1S_4	12.19	11.66	11.91	3.17	3.19	3.18
T_2S_4	13.71	12.63	13.14	3.59	3.41	3.50
T_3S_4	17.08	15.38	16.36	4.21	4.10	4.15
T_4S_4	15.83	14.23	15.00	4.02	3.87	3.95
T_5S_4	14.37	13.21	13.75	3.87	3.66	3.76
Sed(±)	0.65	0.64	0.49	0.18	0.17	0.15
CD (p=0.05)	1.32	1.30	0.99	NS	NS	NS

Treatment details are given under Materials and Methods.

differences on TSS/Acidity ratio for both the years as well as in pooled data. The maximum TSS/acidity ratio (23.59%) was observed in treatment combination of T_3S_1 whereas; the minimum ratio (11.91%) was recorded under treatment combinations of T_1S_4.

Significantly higher TSS/acidity ratio might be due to the addition of organic manure like vermicompost that supplements nutrients, moisture and growth promoting substances which enhances metabolic hormonal activity of the plant and that promotes production of more photosynthates which are stored in fruit in the form of starch and carbohydrates. During the process of ripening the fruit undergoes physical, physiological and biochemical changes. These results elucidate the findings of Iqbal *et al.* (2009) and Jain *et al.* (2018) in strawberry.

Reducing sugar (%): The data pertaining to reducing sugar (%) of fruits as influenced by growing condition, various nutrient treatment and combination of treatment and growing conditions are presented in (Table 2). Different growing conditions had significant effect on reducing sugar (%) content of strawberry in the first year, second year as well as in pooled analysis. From combined analysis of both the years it was observed that the maximum reducing sugar (4.40%) was found in growing condition S_1 followed by S_2 i.e. 4.15% while the minimum reducing sugar (3.71%) was recorded in growing condition S_4. Different treatments had significant effect on the reducing sugar content of strawberry fruit in the first year, second year as well as in pooled analysis. The data from combined analysis of both the years revealed that the maximum value of reducing sugar was found in treatment T_3 (4.45%) followed by treatment T_4 (4.23%) and treatment T_5 (4.06%) while the lowest was found in treatment T_1 (3.68%).The interaction involving treatment and growing condition showed non-significant differences on reducing sugar for both the years as well as in pooled data.

Non-reducing sugar (%): The data pertaining to non-reducing sugar (%) content of strawberry fruits as influenced by growing condition, treatment and combination of treatment and growing conditions are presented below (Table 3). Growing conditions had significantly affected the non-reducing sugar (%) content of strawberry fruit in all the years. The maximum value (2.94%) was recorded in growing condition S_1 followed by S_2 i.e. 2.88% while the minimum non-reducing sugar (2.49%) content were recorded in S_4. Treatments had significant effect on non-reducing sugar content of strawberry fruit. The maximum non-reducing sugar was found in treatment T_3 (3.09%) followed by treatment T_4 (2.91%) while the minimum value was recorded in treatment T_1 (2.48%).The interaction involving treatment and growing condition showed non-significant differences on non-reducing sugar content for both the years as well as in pooled data.

Total sugar (%): Growing conditions had significantly affected the total sugar (%) content of strawberry fruit during both the years as well as in pooled analysis (Table 3). Maximum value of total sugar content (7.34%) was found in growing condition S_1 followed by S_2 i.e. 7.03%, while the minimum (6.20%) were recorded in growing condition S_4. Treatments had significant effect on the total sugar content of strawberry fruit in the first year, second year as well as in pooled analysis. From pooled data it was observed that the maximum total sugar content was found in treatment T_3 (7.54%) followed by treatment T_4 (7.15%) and treatment T_5 (6.79%), while the lowest was found in treatment T_1 (6.17%). The interaction involving treatment and growing condition showed non-significant differences on total sugar content of strawberry for both the years as well as in pooled data.

Higher reducing, non-reducing and total sugar content of strawberry fruit was found in growing condition S_1 was also due to the better utilization of nutrients and light within the plant as well as translocation of maximum nitrogen to the top and because of the favourable climatic condition build up inside the growing condition which results in higher number of flowers and fruit. Also due to continuous availability of nutrients in the soil might have hastened the vegetative growth as well as reproductive growth of the plant. Addition of organic manures supplements ample of nutrients, moisture and growth promoting substances which enhances metabolic and hormonal activity of the plant and that promotes production of more photosynthates which were stored in fruits in the form of starch and carbohydrates. The fruit changes physically, physiologically, and biochemically as it ripens. The transformation of conserved starch and other insoluble carbohydrates into soluble sugars may be the cause of the rise in reducing, non-reducing, and total sugar content of strawberry fruit. The findings Bhavidoddi (2003) in banana and of Patil *et al.* (2004) in tomato are clarified by these findings.

Anthocyanin content (mg/100 g): The data pertaining to anthocyanin content (mg/100 g) of fruits as influenced by growing condition, treatment and combination of treatment and growing conditions are presented below (Table 4) Growing conditions significantly affected anthocyanin content of strawberry in the first year, second year as well as in pooled analysis. Maximum anthocyanin content (42.44 mg/100 g) was found in growing condition S_1 followed by S_2 i.e. 39.52 mg/100 g while the minimum (32.39 mg/100 g) were recorded in growing condition S_4. Anthocyanin content was significantly affected by different treatments. The maximum was found in treatment T_3 (41.55 mg/100 g) while minimum was observed in treatment T_1 (32.91 mg/100 g). The interaction involving treatment and growing condition had non-significant differences on anthocyanin content for both the years as well as in pooled data.

Growing condition and organic treatment individually influenced significantly the anthocyanin content in strawberry. Growing condition S_1 was better for anthocyanin production as it provided optimum light intensity. Growing strawberry in agro shade net is not good for coloured fruits of strawberry i.e. least synthesis of anthocyanin (Pandey *et al.* 2015).The respective increase in anthocyanin content and ascorbic acid content in strawberry under treatment T_3 might be due to the increased efficiency of microbial inoculants to

Table 3 Effect of organic inputs and growing conditions on non-reducing sugar and total sugar content of strawberry fruit

Growing condition	Non reducing sugar (%)			Total sugar (%)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
S_1	2.96	2.92	2.94	7.45	7.23	7.34
S_2	2.90	2.86	2.88	7.16	6.90	7.03
S_3	2.75	2.72	2.73	6.89	6.56	6.72
S_4	2.50	2.48	2.49	6.27	6.13	6.20
Sed (±)	0.04	0.06	0.04	0.09	0.09	0.08
CD (p=0.05)	0.09	0.13	0.08	0.19	0.19	0.16
Treatment	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1	2.53	2.43	2.48	6.36	5.97	6.17
T_2	2.64	2.54	2.59	6.66	6.30	6.48
T_3	3.09	3.09	3.09	7.62	7.47	7.54
T_4	2.90	2.92	2.91	7.21	7.08	7.15
T_5	2.71	2.73	2.72	6.87	6.71	6.79
Sed (±)	0.05	0.07	0.04	0.11	0.10	0.09
CD (p=0.05)	0.10	0.14	0.09	0.22	0.22	0.18
Treatment combinations	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1S_1	2.77	2.63	2.70	7.03	6.54	6.78
T_2S_1	2.81	2.75	2.78	7.15	6.84	6.99
T_3S_1	3.27	3.26	3.27	8.10	8.00	8.05
T_4S_1	3.06	3.13	3.09	7.66	7.62	7.64
T_5S_1	2.89	2.84	2.87	7.32	7.16	7.24
T_1S_2	2.67	2.51	2.59	6.68	6.23	6.46
T_2S_2	2.76	2.62	2.69	6.87	6.5	6.68
T_3S_2	3.18	3.18	3.18	7.82	7.56	7.69
T_4S_2	3.08	3.08	3.08	7.43	7.26	7.34
T_5S_2	2.80	2.90	2.85	7.01	6.97	6.99
T_1S_3	2.47	2.41	2.44	6.35	5.73	6.04
T_2S_3	2.62	2.50	2.56	6.65	6.17	6.41
T_3S_3	3.05	3.08	3.07	7.47	7.35	7.41
T_4S_3	2.86	2.86	2.86	7.13	6.94	7.03
T_5S_3	2.73	2.78	2.75	6.85	6.62	6.73
T_1S_4	2.21	2.20	2.20	5.39	5.39	5.39
T_2S_4	2.38	2.31	2.34	5.97	5.72	5.85
T_3S_4	2.87	2.86	2.87	7.09	6.96	7.02
T_4S_4	2.61	2.62	2.62	6.64	6.50	6.57
T_5S_4	2.42	2.42	2.42	6.29	6.08	6.18
Sed (±)	0.10	0.14	0.09	0.21	0.21	0.18
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Treatment details are given under Materials and Methods.

fix atmospheric nitrogen and excretion of growth promoting substances, which accelerated the physiological process like carbohydrates synthesis (Pirlak and Kose 2009). Lingua *et al.* (2013) also observed that increase in fruit quality parameters such as TSS, ascorbic acid, sugars and colour, when plants are inoculated with microbial consortium such as PSB along with vermicompost, might be due to the solubilization of phosphate and zinc, which further increased the nutrients availability and uptake in strawberry plants.

Ascorbic acid content (mg/100 g): The data regarding ascorbic acid content (mg/100 g) of fruits as influenced by growing condition, treatment and combination of treatment and growing conditions are presented in Table 4. Maximum anthocyanin content (51.20 mg/100 g) was found in growing

Table 4 Effect of organic inputs and growing conditions on anthocyanin and ascorbic acid content of strawberry fruit

Growing condition	Anthocyanin content (mg/100 g)			Ascorbic acid content (mg/100 g)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
S_1	42.53	42.35	42.44	52.26	50.14	51.20
S_2	39.40	39.65	39.52	49.48	47.17	48.33
S_3	36.35	33.25	34.80	47.11	46.36	46.73
S_4	34.35	30.42	32.39	43.98	44.41	44.20
Sed (±)	0.26	0.23	0.16	0.37	0.30	0.24
CD (p=0.05)	0.53	0.48	0.34	0.75	0.61	0.48
Treatment	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1	33.75	32.07	32.91	45.18	43.64	44.41
T_2	35.93	34.39	35.16	46.45	44.47	45.46
T_3	42.47	40.62	41.55	51.43	50.88	51.15
T_4	40.38	38.57	39.47	49.67	48.93	49.30
T_5	38.26	36.45	37.35	48.31	47.18	47.75
Sed (±)	0.29	0.26	0.18	0.41	0.34	0.26
CD (p=0.05)	0.59	0.53	0.38	0.84	0.69	0.54
Treatment combination	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
T_1S_1	38.72	37.73	38.23	48.94	46.59	47.77
T_2S_1	40.54	40.65	40.59	50.58	47.63	49.10
T_3S_1	46.46	46.15	46.30	55.28	54.17	54.72
T_4S_1	44.20	44.39	44.29	53.66	52.06	52.86
T_5S_1	42.76	42.86	42.81	52.84	50.24	51.54
T_1S_2	34.74	35.80	35.27	46.80	43.81	45.30
T_2S_2	36.87	37.52	37.19	47.57	44.43	46.00
T_3S_2	43.76	43.91	43.83	52.93	51.21	52.07
T_4S_2	41.84	41.88	41.86	50.61	49.51	50.06
T_5S_2	39.79	39.14	39.47	49.52	46.87	48.20
T_1S_3	31.87	28.55	30.21	44.21	42.6	43.40
T_2S_3	33.87	30.99	32.43	45.38	43.68	44.53
T_3S_3	41.12	37.53	39.32	50.40	50.29	50.34
T_4S_3	38.94	35.47	37.20	48.58	48.37	48.47
T_5S_3	35.94	33.71	34.83	46.97	46.88	46.92
T_1S_4	29.67	26.19	27.93	40.78	41.56	41.17
T_2S_4	32.46	28.39	30.43	42.27	42.14	42.21
T_3S_4	38.57	34.90	36.73	47.12	47.85	47.49
T_4S_4	36.53	32.54	34.54	45.85	45.77	45.81
T_5S_4	34.55	30.09	32.32	43.90	44.75	44.33
Sed (±)	0.58	0.52	0.37	0.83	0.68	0.53
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Treatment details are given under Materials and Methods.

condition S_1 followed by S_2 i.e. 48.33 mg/100 g while minimum (44.20 mg/100 g) were recorded in growing condition S_4. Ascorbic acid content was significantly affected by different treatments. Maximum value (51.15 mg/100 g) was recorded in treatment T_3 while the minimum was observed in treatment T_1 (44.41 mg/100 g). The interaction involving treatment and growing condition showed non-significant differences on ascorbic acid content for both the years as well as in pooled data.

Significantly higher ascorbic acid (mg/100 g pulp) in treatment consisting of vermicompost and microbial consortium might be due to the addition of organic manure that supplements ample of nutrients, moisture and growth promoting substances which enhanced metabolic and

hormonal activity of the plant that promoted production of more photosynthates which was stored in fruits in the form of starch and carbohydrates. During the process of ripening, the fruit undergoes physical, physiological and biochemical changes. These might be due to the presence of active enzymes, the conversion of starch to dextrose, glucose and sucrose. The increase in acidity may also be due to an increase in sugar content at the ripening stage. Similar results were obtained by Bhalerao *et al.* (2009) and Shekhar *et al.* (2009) in banana.

From this investigation, it is clear that the organic farming is very healthy and remunerative practice in strawberry fruit production. It not only improves the quality of fruits but also provide sustainability in production for long term. Based on results of two years investigation, treatment combination T_3S_1 i.e. strawberry runners receiving treatment of rock phosphate @4.50 g/plant + microbial consortium @0.063 g/plant (T_2) + vermicompost @45 g/plant (T_3), grown in insect proof net covered with 200 micron UV film on top and 40 mesh net in side may be considered as the best for fruit quality parameters of strawberry.

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