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Use of kitchen waste based bio-organics for strawberry (*Fragaria x ananassa* Duch) production

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Utilization of waste materials is now getting popularity in agriculture production as a part of organic management. In the present experiment liquid manure from kitchen waste along with animal and plant parts was prepared and utilized them for strawberry (*Fragaria x ananassa* Duch) cv. Sweet Charlie production. The aim of the study was to see the effect of liquid manure on improvement of vegetative growth, yield and quality of strawberry fruits grown in high pH soil (8.2) at Lucknow subtropical condition of Uttar Pradesh, India. Runners of strawberry was planted at the spacing of 30 x 30 cm accommodating 9 plants per plot following randomized block design comprising 10 treatments replicated thrice. The results showed that use of treatment T_7 increased the plant height recorded at different dates after transplanting as compared to other treatments. The treatment T_7 was found to be better for improvement of vegetative growth, recording maximum number of branches per plant, number of leaves per plant, length and breadth of leaves and also caused early flowering (75.33 days after transplanting), maximum number of flowers per plant and maximum yield (fruits/plant and kg/ha). Similarly, good quality fruits having maximum TSS (9.3°B) and ascorbic acid (54.75 mg/100 g) were obtained under treatment T_7, though acidity was increased (0.91%) in this treatment. Thus, it can clearly be concluded that, liquid manure is effective for crop growth, better yield and good quality fruits.

Key words: Liquid manuring, quality, strawberry, yield.

INTRODUCTION

Strawberry *(Fragaria x ananassa* Duch) is one of the most aroma containing, nutritive and delicious fruits. Strawberry plants are spread all over the country for their attractive colour and growing adaptability to wide range of soil and environmental conditions. The genus *Fragaria* belongs to family Rosaceae containing 17 spp., among them strawberry is one of the most popular edible manmade octaploid (2n = 56) hybrid. India has 0.20 m ha area with production of 1.89 mt strawberry fruits and the leading states are Himachal Pradesh (0.50 mt) and Meghalaya (1.00 mt) (NHB Database, 2013-14). Although, it prefers temperate climate for its luxurious population, it also had a good performance under subtropical Lucknow condition. Fructose and glucose are the major sugars found in the strawberry and small proportion of sucrose is also found in strawberry (Giampieri et al., 2012). The red colour of fruits is mainly due to the presence of anthocyanin, pelarogonidin3-monoglucoside and traces

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of cyaniding and it is rich in antioxidants (Meyers et al., 2003). Considering the environmental safety and safe gourd from health hazards caused by synthetic chemical fertilizers and pesticides, people are approaching for organic farming (Maji and Das, 2008; Maji, 2013). Utilization of waste materials is an important part for modeling of sustainable agricultural system (Speelman et al., 2014). Magdoff and Weil (2004) reported that organic matter is the most important substrate for sustainable production as well as management of soil borne diseases while experimenting with chemical fertilizers, biofertilizers and organic manures (Aldahmani et al., 2010; Mir et al., 2013; Muoneke et al., 2014). Strawberry is a nutrient loving crop. Nutrients are very effective component in yield and quality improvement of strawberry fruits (May and Pritts, 1990). The present experiment is objected to supply the organic nutrients directly (foliar spray) to strawberry crop for easy and quick availability of nutrients. Liquid manure was made from common kitchen wastes and easily available local resources. Liquid manures are cost effective and renewable. Bio-fertilizers including liquid manure are known to increase the yield of strawberry (Shiow and Shin, 2002). Habashy and Laila (2005) studied that the plant growth and yield of wheat crop were increased by fertilization with humic acid at a rate of 100 ppm. Foliar application of humic acid up to 6 l/fed linearly increased total yield of watermelon (Salman et al., 2005). Liquid manure and some biodynamic preparations like Panchagavya, Jeevamruth and Beejamruth contain macro nutrients, essential micro nutrients, many vitamins, essential amino acids, growth promoting factors like IAA, GA and also beneficial microorganisms (Palekar, 2006; Sreenivasa et al., 2010). Utilization of agri-food waste was also studied by Serrano et al. (2014) and they found that fish waste along with glycerol increased the treatment capacity of strawberry. Preparation of liquid or solid manures from kitchen waste is not new but it is not popular so much. But, technical and compositional details have not been found so far. It is very useful and effective way for management of kitchen and domestic wastes. Nutritional details or other components present in kitchen waste are not found so far. Keeping the view, the present investigation has been planned to observe the influence of liquid manure on vegetative growth, yield and quality of strawberry fruits.

MATERIALS AND METHODS

Experimental site

The present experiment was held at Horticultural Research Farm (Pragya Vatika), Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India 226025 during 2013- 2014. The soil pH was estimated before the experiment and it was determined as very high pH soil having pH 8.2. The soil type was sandy loam having EC (1:1) 0.26 and available N -110.50 kg ha^{-1}, P_2O_5- 40.5 kg ha^{-1} and K_2O -190.4 kg ha^{-1}.

Agro-climatic conditions

Lucknow is situated in the central part of Uttar Pradesh and comes under sub-tropical drier climate. Maximum temperature is ranging from 29.3 to 47°C in summer and minimum ranging from 3.5 to15°C in winter with relative humidity of 60 to 80% in different season of the year. Nearly 85% of the total annual rainfall (750 mm/annum) is received during the monsoon (only up to the September) with some scattered showers in winter brought by North-East monsoon. During the experimental period, the maximum and minimum temperature was 39.8 and 7.8°C and RH 98 and 25%, respectively. The average temperature and relative humidity was presented in Figure 1.

Planting materials and transplanting

The planting materials of strawberry cv. Sweet Charlie were obtained from Scientific Seedlings India Pvt. Ltd., Pune, Solapur Road, Dist. Pune (Maharashtra)-412202. Runners of strawberry plants were planted at spacing of 30 cm x 30 cm accommodating 9 plants per plot with making a small hole as it is a shallow rotted crop and a light irrigation was given immediate after transplanting just to moisten the soil moisture and maintain physiology of runners.

Preparation and application of liquid manure

The liquid manure was prepared by the fermenting the mixture of cow dung, potato (*Solanum tuberosum*) peels, carrot (*Daucus carota*) peels, legume (*Medicago* sp.) peels, neem (*Azadirachta indica*) leaves, tulsi (*Ocimum sanctum*) leaves in water. These household and kitchen waste materials were mixed into a big container following combination as stated in Table 1. After mixing, these materials were kept for 45 days for fermentation. In these 45 days it was stirred in every three days interval. Prepared liquid manure was filtered and taken few amount as sampling for nutrient status analysis. Nutrient analysis was done for macro and micro nutrients at Soil Testing Lab, Central Soil Salinity Research Institute (CSSRI), Alambagh, Lucknow following a standard procedure after centrifugation and nutrient status was presented in Table 2. The liquid manure was applied in three dilutions that is, 1: 5 (M_1), 1:10 (M_2) and 1:20 (M_3). The treatment combination was prepared as T_1 for control (C_0M_0), T_1 (C_1M_1), T_2 (C_1M_2), T_3 (C_1M_3), T_4 (C_2M_1), T_5 (C_2M_2), T_6 (C_2M_3), T_7 (C_3M_1), T_8 (C_3M_2) and T_9 (C_3M_3).

Statistical analysis

The field experiment was statistically designed with 10 treatments which were replicated three times and laid out under Randomized Block Design. The recorded data were statistically analyzed using analysis of variance at 5% level of significance (Panse and Sukhatme, 1985). Vegetative observations were recorded at 45, 90 and 135 days after transplanting at regular intervals for obtaining the proper results. All fruit morphological characters and quality parameters were studied in the laboratory of Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India following the standard method of AOAC (2000).

RESULTS AND DISCUSSION

Effect of liquid manures on vegetative growth parameters

The experimental findings (Table 3) clearly showed that

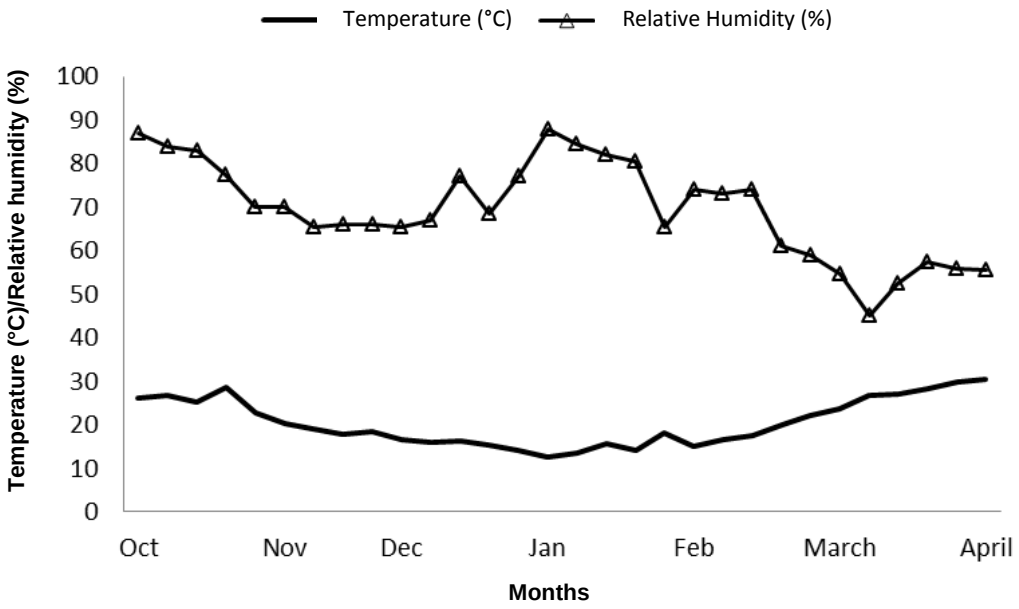

Figure 1. Average temperature and relative humidity status during the experiment.

Table 1. Composition of the different materials of liquid manures.

C_1	Cow dung = 1.0 kg + Potato peels = 750 g + Carrot peels = 400 g + Legume leaves = 400 g + Neem leaves = 200 g + Tulsi leaves = 100 g+ Water = 7 L.
C_2	Cow dung = 1.5 kg + Potato peels = 500 g + Carrot peels = 200 g + Legume leaves = 300 g + Neem leaves = 200 g + Tulsi leaves = 100 g + Water = 7 L.
C_3	Cow dung = 2.0 kg + Potato peels = 200 g + Carrot peels = 200 g + Legume leaves = 300 g + Neem leaves = 100 g + Tulsi leaves = 100 g + Water = 7 L.

Table 2. Nutrient status of various liquid manure compositions.

Treatments	N (%)	P (%)	K (%)	S (mg kg^{-1})	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Ca (mg kg^{-1})
T_1	0.13	0.052	0.038	4.1	0.043	0.083	0.018	2.3
T_2	0.081	0.018	0.034	1.38	0.018	0.039	0.01	1.04
T_3	0.046	0.01	0.019	0.16	0.012	0.023	0.006	0.58
T_4	0.154	0.073	0.041	2.1	0.024	0.061	0.050	1.58
T_5	0.096	0.028	0.023	1.06	0.006	0.037	0.023	0.86
T_6	0.051	0.011	0.013	0.58	0.002	0.61	0.013	0.43
T_7	0.188	0.084	0.069	2.18	0.031	0.068	0.071	1.43
T_8	0.102	0.031	0.020	1.17	0.008	0.03	0.025	0.88
T_9	0.067	0.014	0.008	0.71	0.005	0.01	0.017	0.47

application of liquid manures had positive effect on vegetative growth of strawberry. It was noted that the average plant height was significantly improved by application of liquid manure over control. The maximum plant height of 11.8 cm, 12.5 cm, 13.8 cm at 45 DAT, 90 DAT, 135 DAT, respectively was noted with the application of liquid manure (C_3M_1) T_7 closely followed by liquid manure (C_2M_1) T_4 and liquid manure (C_1M_1) T_1. This increase in plant height might be attributed to the fact that presence of higher amount of nitrogen in T_7

Table 3. Effect of liquid manuring on vegetative growth of strawberry.

Treatments	Plant height (cm)			Branch plant $^{-1}$	Number of leaves plant $^{-1}$			Leaf length (cm)			Leaf breadth (cm)		
	45 DAT	90 DAT	135 DAT		45 DAT	90 DAT	135 DAT	45 DAT	90 DAT	135 DAT	45 DAT	90 DAT	135 DAT
T_0	8.1	10.0	10.8	5.75	15	16.67	22	3.4	3.4	3.6	3.4	3.41	3.61
T_1	10.9	11.6	13.3	7.74	18.33	22.7	28.33	4.4	4.9	5.3	3.6	4.9	5
T_2	10.6	11.1	12.6	7.00	17.67	21	29.67	4.1	4.5	4.9	4.1	4.3	4.9
T_3	9.8	10.5	11.5	6.5	17	21.67	27	3.5	4.4	4.5	3.9	4.1	4.3
T_4	10.9	11.8	13.5	8.18	18.33	24.67	27.67	4.5	5.1	5.5	4.5	4.9	5.2
T_5	10.9	11.1	12.7	6.66	13.67	18.33	27.67	4.3	4.4	5	4	4	4.5
T_6	10.3	11.2	12.5	6.55	15.67	19	28.33	3.5	4.5	4.6	3.7	3.8	4.1
T_7	11.8	12.5	13.8	8.21	19.33	24.67	29.33	4.5	5.2	5.8	4.5	4.8	5.5
T_8	10.4	11.6	12.4	7.62	16.33	21	25.67	4.2	4.6	5	4	4.1	4.2
T_9	9.9	10.7	13.1	7.10	17	20	24.33	3.8	4.5	4.7	4.2	4.3	4.7
SEm (±)	**0.576**	**0.565**	**0.742**	**0.721**	**0.984**	**1.217**	**1.480**	**0.209**	**0.208**	**0.255**	**0.222**	**0.201**	**0.273**
CD (P = 0.05)	**1.21**	**1.18**	**1.56**	**1.51**	**2.06**	**2.55**	**3.11**	**0.44**	**0.43**	**0.53**	**0.46**	**0.42**	**0.57**

(nutrient composition of various liquid manure had been presented in Table 2). It is established that nitrogen is the builder of protein and is the main constituent of proto-plasm in plants. Thus, the increase in nitrogen supply accelerated synthesis of amino acids which might have indirectly exhibited increase the vegetative growth in terms of plant height of strawberry plants (Maji and Ghosh, 2006).

Data recorded on number of branches per plant as compared with control showed that the maximum number of branches per plant (8.21) was recorded with the application of liquid manure (C_3M_1) T_7 followed by application of liquid manure (C_2M_1) T_4 and (C_1M_1) T_1. This significant and positive increment in number of branches might be due to the application of liquid manure (C_3M_1) T_7 which resulted more photo synthetic efficiency and growth substances like auxins which favoured the initiation of cell division, cell elongation for growth. The results are similar to the finding of Shwetha (2008) who conducted an experiment to know the effect of nutrient management through organics in soybean wheat cropping system and they reported that significantly higher plant height, number of branches per plant were recorded with the application of organic manures in combination with fermented organics *viz.,* Beejamrut, Jeevamrut, Panchagavya over organics application alone.

The maximum number of leaves per plant (8.21) was recorded with the application of liquid manure (C_3M_1) T_7, followed by application of liquid manure (C_2M_1) T_4. This significant and positive increment in number of leaves under application of liquid manure (C_3M_1) T_7 might be due to the fact that T_7 resulted to more photo-synthetic efficiency favouring the initiation and extension of leaves. Similarly, Sabarad et al., (2004) also stated that the application of organic manures (vermicompost) on banana cv. Rajapuri (Musa AAB) recorded increased plant height, plant girth, number of leaves and number of suckers per plant.

The experimental finding advocated that the average length and width of leaves were also significantly improved by application of liquid manure. The maximum length and width of leaf (4.5, 5.2 and 5.8 cm) and (4.5, 5.2 and 5.8 cm) at 45 DAT, 90 DAT and 135 DAT respectively, were noted with use of liquid manure T_7 closely followed by liquid manure T_4 and T_1. This increase in average length and width of leaves might be attributed to the fact that presence of higher amount of nitrogen in T_7 (as presented in Table 2) which improved and enhanced vegetative growth of crop.

Effect of liquid manuring on flowering and fruiting

Among liquid manures, the application of liquid manure (C_3M_1) T_7 recorded higher number of flowers per plant (24.33) significantly, followed by the application of liquid manure (C_1M_1) T_1 (22.67) (Table 4). The result also found the similarity with the findings of Naidu et al., (2001) who tested that

Table 4. Effect of liquid manuring on flowering, fruiting, yield and fruit quality of strawberry.

Treatments	No. of flowers plant $^{-1}$	Days taken to first flowering	Days taken for first fruiting	Number of fruit plant $^{-1}$	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (ml)	Fruit weight (g)	Fruit yield plant $^{-1}$ (g)	Fruit yield hectare $^{-1}$ (kg)	Ascorbic acid (mg 100g $^{-1}$)	TSS (^{o}Brix)	Acidity (%)
T_0	17.33	96.3	108.5	12.31	3.56	2.09	7.5	10.34	127.3	425.33	53.03	7.33	0.82
T_1	22.67	77.6	91.26	13.5	4.49	3.79	12.5	16.45	222.9	742.93	53.75	8.67	0.83
T_2	18.67	84.5	94.67	12.65	4	3.45	16	14.22	179.9	599.9	53.53	8.33	0.85
T_3	15.67	92.16	106.33	11.16	3.5	3.2	7.5	13.55	150.7	502.63	53.06	7.67	0.89
T_4	20.33	76.01	93.36	13.20	4.75	3.9	15.5	20.21	266.8	889.33	53.96	8.79	0.84
T_5	18.00	86.67	99.66	11.98	4.12	3.41	12.16	15.89	190.5	635.2	53.26	8.31	0.86
T_6	16.67	94.66	105.13	9.99	3.30	3.10	12.5	13.65	136.4	454.9	53.16	7.43	0.90
T_7	24.33	75.33	88.63	13.43	4.9	4.35	17.16	21	282.2	940.67	54.75	9.3	0.91
T_8	18.33	88.57	96.13	13.66	4.3	3.44	12.50	14.45	197.5	658.30	53.62	8.63	0.85
T_9	17.67	95.66	102.80	12.32	3.5	3.1	12.16	14.31	176.4	588.00	53.24	7.57	0.88
SEm (±)	**1.144**	**1.702**	**1.991**	**1.091**	**0.263**	**0.239**	**1.116**	**1.073**	**17.157**	**36.767**	**0.369**	**0.523**	**0.026**
CD (P = 0.05)	**2.40**	**3.57**	**4.18**	**2.29**	**0.55**	**0.50**	**2.34**	**2.25**	**36.05**	**77.24**	**0.77**	**1.09**	**0.05**

application of (100 kg) N + (50 kg) P_2O_5 + (20 t) FYM per ha was significantly superior than the other combinations and gave maximum plant height number of leaves, number of branches as well as number of flower cluster, number of fruits and fruit yield per plant.

It was also observed that the treatments caused early flowering by reducing the requirement of days for first flowering. The minimum number of days (75.33) taken for first flowering was recorded with the application of liquid manure (C_3M_1) T_7 followed by T_4 (C_2M_1), T_1 (C_1M_1), and T_2 (C_1M_2). It was also seen that the treatments were significantly showed earlier fruiting in comparison to control. The minimum number of days (88.63 days) was taken for first fruiting under the application of liquid manure (C_3M_1) T_7 which was closely followed by application of treatment T_4 (91.26 days). The result corroborated with the finding of Arancon et al., (2003) who reported that application of vermicompost in strawberry (*Fragaria* sp.) increased leaf area, number of suckers, number of flowers and shoots per plant. Similar result on flowering and fruiting due to more use of nitrogen was also found by Maji and Ghosh (2007) on pummelo while experimenting on the effect of nitrogen levels on flowering and fruiting.

Effect of liquid manuring on the yield and yield attributing characters

The maximum fruit yield (282.2 g plant^{-1}, 940.64 kg ha $^{-1}$) was recorded with the application of liquid manure (C_3M_1) T_7 and the lowest yield (127.3 g plant $^{-1}$, 425.33 kg ha^{-1}) per plant was recorded in control (Table 4). However, the highest number of fruits per plant (13.66) was found in T_8 but, maximum yield was recorded in T_7. The similar trend was also observed by Veerabhadraiah and Badrinath (2006). They showed that application of Angara and Amrithpani to soil and Panchagavya as foliar spray was found to increase sorghum grain and dry fodder yields. Increase in yield by FYM in strawberry cv. Douglas was also reported by Ilgn et al*.,* (2006).

Effect of liquid manuring on morphology of fruits

The data (Table 4) also revealed that application of liquid manures influenced the fruit length and diameter of strawberry significantly. The highest fruit length and diameter (4.9 and 4.35 cm, respectively) was recorded with liquid manure (C_3M_1) T_7 followed by liquid manure composition (C_2M_1) T_4 (4.75 and 4.35 cm, respectively). The highest fruit volume (17.16 ml) was also recorded with liquid manure (C_3M_2) T_7 followed by T_4 (15.5 ml) and the lowest fruit volume was recorded with liquid manure (C_1M_2) T_2 (16 ml). The treatment T_7 also recorded the highest fruit weight (21 g) was

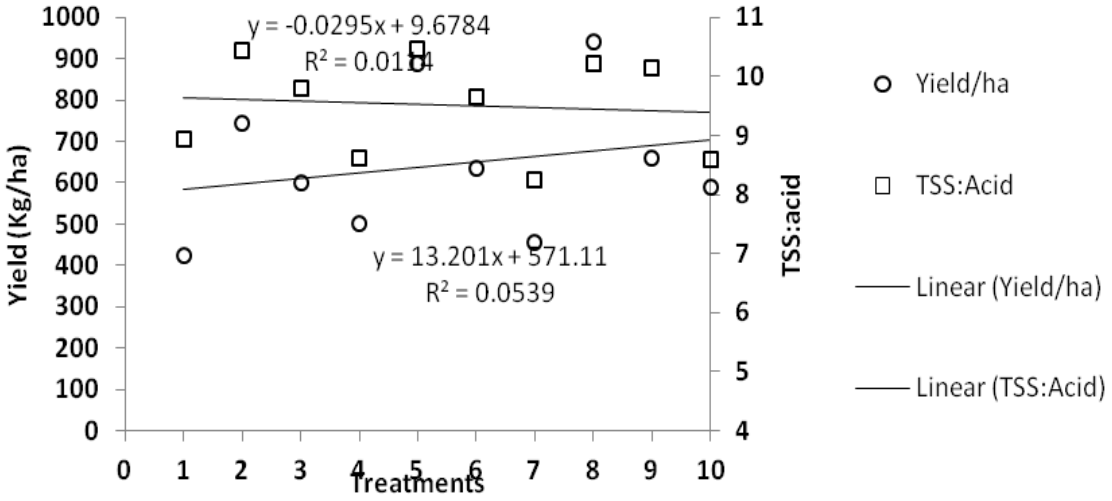

Figure 2. A positive correlation between fruit yield and TSS:acid ratio due to application of liquid manures.

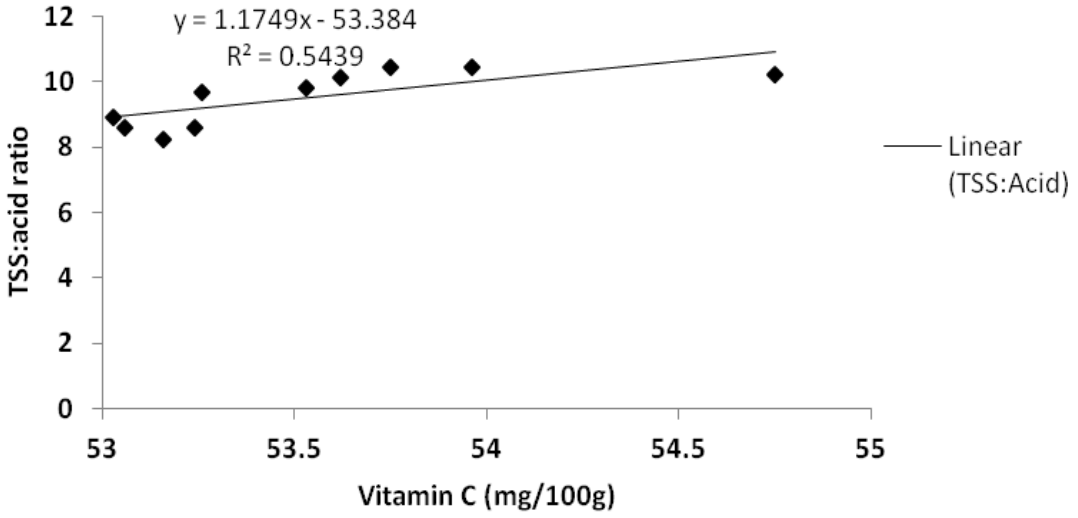

Figure 3. Positive relation between Vitamin C and TSS: acid ratio of strawberry as influenced by liquid manure application.

followed by liquid manure (C_2M_1) T_4 (20.21 g). The fruit weight differed significantly by the application of liquid manures and the lowest fruit weight (10.34 g) was recorded with control (T_0). No literature was found regarding effect of liquid manure on fruit morphological characters, however, Arancon et al*.,* (2004) reported that application of vermicompost on strawberry cv. Chandler exhibited the highest yield, fruit weight and width. Improvement of fruit physical characters with application of liquid manures might be due to the presence of both macro and micro nutrients in liquid manures under study. Positive role of nitrogen on improvement of fruit size and weight was also reported by Maji and Ghosh (2007) in pummelo and Maji and Das (2008) in guava.

Effect of liquid manuring on fruit chemical characters

It is evident from the data that all the treatments significantly increased vitamin C content and thus, maximum (54.75 mg 100 g^{-1}) was recorded under treatment T_7 followed by liquid manure (C_2M_1) T_4 (53.96 mg 100 g^{-1}) and minimum value (53.03 mg 100g^{-1}) was observed in control (T_o). Total soluble solids (TSS) was recorded maximum (9.3°B) in strawberry under treatment T_7 whereas, minimum TSS (7.33°B) of strawberry was observed in control (T_0) (Table 4).

Similarly, quality improvement by use of Panchagavya was also reported by Hannah et al., (2005) and Sharma (2004) who observed the improvement of fruit quality of

banana with spraying of panchagavya solution at 3%. Likewise, TSS and vitamin C application of liquid manures increased titratable acidity also which might affect the TSS: acid ratio. Figure 2 also showed that there was a positive correlation between the liquid manures and fruit yield. Yield was improved from control (T_o) to T_7 and decreased thereafter at T_8. While, negative correlation was observed in case of TSS: acid ratio, though T_7 recorded maximum amount of TSS: acid ratio. A positive correlation was found between vitamin C and TSS: acid ratio (Figure 3). It might be due to the fact that as T_7 counted higher amount of nitrogen (Table 2) and nitrogen has position correlation with acidity of fruits (Maji and Ghosh, 2007) after a certain level. In general, liquid manures had good amount of N, P, K along with S, Zn, Fe, Mn, Ca (Table 2) which might improve the fruit quality in the present investigation.

Conclusion

The present experiment showed that vegetative growth, yield and physico-chemical characteristics of fruits were improved by liquid manure application. Among the treatments T_7 (C_3M_1) showed its potentiality to overall improvement of strawberry production. Therefore, it may be concluded that liquid manure composition (C_3M_1) T_7 is beneficial for strawberry production for its growth, yield and fruit quality.

Conflict of Interests

The authors have not declared any conflict of interests.

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