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Effects of Variety and Organic Manures on Growth, Yield and Quality of Cherry Tomato under Vertical Farming

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ABSTRACT

Cherry tomatoes are taste-bud delight, delicious and nutritious food that becomes more nourishing, healthy and appealing to consumers when produced under organic farming. The experiment was conducted at the Horticulture Farm and Postgraduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from September 2019 to March 2020 to assess the effects of variety and organic manures on growth, yield and quality of cherry tomato. It was plotted in Randomized Complete Block Design with three replications. The treatments were in a factorial arrangement of 2 × 8, with 2 varieties of cherry tomato viz. V_1: Binatomato-10 and V_2: BARI Tomato-11 (Jhumka) and 8 different organic manures viz. T_0: Control, T_1: Cow dung @ 3 kg/m^2, T_2: Mustard oil cake (MOC) @ 0.6 kg/m^2, T_3: Poultry manure@ 3 kg/m^2, T_4: Cow dung + MOC @ (3+0.6) kg/m^2, T_5: Cow dung + Poultry manure @ (3+3) kg/m^2, T_6: MOC + Poultry manure @ (0.6+3) kg/m^2, T_7: Cow dung + MOC + Poultry Manure @ (3+0.6+3) kg/m^2. All the parameters under study showed significant variation between cherry tomato varieties and organic manures. Binatomato-10 revealed the highest growth, yield and quality characters except plant height and number of leaves per plant compared to BARI Tomato-11 (Jhumka). Combined application of cowdung + MOC + poultry manure ensued the greatest growth, yield and quality characters in comparison with the other treatments. BARI Tomato-11 (Jhumka) accompanying the combined application of cowdung + MOC + poultry manure (V_2T_7) gave the highest plant height (127.75 cm) and number of leaves per plant (51.25). Binatomato-10 together with combined application of cowdung + MOC + poultry manure (V_1T_7) produced the highest number of fruits per plant (502.33), individual fruit weight (12.50 g), fruit length (4.23 cm) and breadth (3.22 cm), yield (89.07 t/ha), and total soluble solids (TSS) content (10.40%) while the lowest number of fruits per plant (43.55) and individual fruit weight (6.23 g), fruit length (2.10 cm) and breadth (1.79 cm), yield (8.23 t/ha) and TSS content (4.80%) was found in BARI Tomato 11 (Jhumka) with control treatment (V_2T_0). Therefore, Binatomato-10 together with combined application of cowdung + MOC + poultry manure was found to be better in respect of growth, yield and quality of cherry tomato.

Introduction

Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) belonging to the Solanaceae family is a popular type of table tomato that is considered as an additional genetic intermediate between wild-type tomatoes and home garden tomatoes (Nesbitt and Tanksley, 2002). Cherry tomatoes are smaller in size (1.5-3.5 cm in diameter), spherical to slightly oblong in shape, and usually red in colour (BBC, 2014). Cherry tomatoes are grown usually for their edible fruits of superior quality and sweet taste compared to large table tomatoes (Kobryn and Hallmann, 2005). Cherry tomato is beneficial to human health due to its high content of antioxidant and anti-carcinogenic property, vitamin A and vitamin C, ascorbic acid, and phytochemical compounds, including lycopene, beta-carotene, flavonoids and many essential nutrients (Rosales *et al.,* 2011). Cherry tomatoes can be used directly as raw vegetable and as well for preparing convenience foods such as sauce, soup, ketchup, curries, paste, rasam and sandwitch (Anonymous, 2009) but they are preferred as salad tomato to vegetable (Ramaya *et al*., 2016). It is commonly referred to as garden tomato and becoming very popular to many small farmers, special gardeners and green house managers around the world (Abdel-Razzak *et al.,* 2013) due to its higher commercial value compared to regular tomatoes (Menezes *et al*., 2012; Mantur *et al*., 2014; Venkadeswaran *et al*., 2018). Cherry tomato is a novel vegetable crop in Bangladesh. Consumers always have a great fascination to new vegetables, whereas cherry tomatoes are also very colorful and their unique size

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makes them more attractive. So, considering all above mentioned, growing cherry tomato could be a profitable activity for Bangladeshi farmers.

Worldwide there is a growing demand for organic products that are beneficial to human health and environment. Consumers often pay attention to the taste of organic foods, which should be healthier than the conventional foods (Ekelund and Tjärnemo, 2004). In addition, the use of synthetic fertilizer in the long term will have an adverse impact on the nutritional value of the crops (Shimbo *et al.,* 2001) and will also increase the cost of crop production. In contrast to inorganic fertilizers, organic manures provide plants with nutrients, organic matter (Grandy *et al*., 2002) and have impact on structural, hydro-physical and chemical properties of the soil for a longer time and consequently affect the yield of grown crops, even several years after application (Gutser *et al*., 2005). Aside from the slow release of nutrients, organic fertilizers made from animal excreta or other agricultural wastes is usually used to improve the structure and stability of the soil as well as enhancing the yield and quality of the crop plants (Chang *et al.*, 2010; Tejada and Gonzalez, 2003; Marzouka and Kassem, 2011). Various organic manures such as cow dung, compost, mustard oilcake (MOC), green manure and poultry manure are excellent source of organic matters commonly used for crop production (Hasan, 2013; Rahman *et al.,* 2018). At present, in Bangladesh, due to the increasing number of dairy and poultry farms organic manures such as cow dung and poultry manure have become very available at a reasonable price as well as mustard oil cake is also available in the market**.** These three organic manures are very effective in more economic and quality production of cherry tomato, which needs further investigation.

On the other hand, growth, yield and quality of different cherry tomato varieties are incompatible and to improve the cherry tomato production in Bangladesh, it is essential to promote better varieties to the growers. However, still a limited work has been done on the single and combined application of organic manures under different cherry tomato cultivars. Therefore, the present study was, undertaken to study the optimization of growth, yield and quality of cherry tomato cultivars through organic farming.

Materials and Methods

Experimental site and materials

The experiment was executed at the Horticulture Farm and Postgraduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh to evaluate the effects of variety and organic manures on growth, yield and quality of cherry tomato during the period from September 2019 to March 2020. The experimental site was medium high land belonging to the Old Brahmaputra Floodplain under the Agro-Ecological Zone 9 having non-calcareous dark gray floodplain soil (UNDP and FAO 1988). The soil of the experimental plot was silty loam in texture and neutral (pH 7.0) in reaction, which is suitable for cherry tomato production.

Plant materials

Binatomato-10 and BARI Tomato-11 (Jhumka) were used in this study. These two varieties are recommended as cherry tomato in Bangladesh. Seeds of these varieties were collected form Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, and Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

Experimental design and treatments

The experiment was laid out in randomised complete block design (RCBD) with three replications and altogether 16 treatment combinations. The treatments were designed in factorial arrangement of 2 × 8, along with two cherry tomato varieties *viz*. V_1-Binatomato-10, V_2- BARI Tomato 11 and eight organic manure treatments *viz*., T_0 = control (no organic manures applied), T_1 = cowdung @ 3 kg/m^2, T_2 = mustard oilcake (MOC) @ 0.6 kg/m^2, T_3 = poultry manure @ 3 kg/m^2, T_4 = cowdung + MOC @ (3 + 0.6) kg/m^2, T_5 = cowdung + poultry manure @ (3+3) kg/m^2, T_6= MOC + poultry manure @ (0.6 + 3) kg/m^2, T_7 = cowdung + MOC + poultry manure @ (3+ 0.6 + 3) kg/m^2.

Construction of vertical staking and application of the treatments

Cherry tomato seedlings were raised in two separate seedbeds of 1 m × 1 m size. One gram seed of each variety were sown on separate seedbeds on 21 September 2019 and after sowing, seeds were covered with light soil. The emergence of seedlings took place within 5 to 6 days after sowing. The healthy seedlings of uniform size were transplanted on 22 October 2019 in the evening at a spacing of 50 cm × 30 cm. Each unit plot was 1.25 m x 1.0 m in size, which consisted of 6 plants. The spacing between plots and blocks were 50 cm and 100 cm, respectively. Organic manure treatments were applied to different unit plots at 21 days before planting of seedlings and incorporated into the soil carefully. After transplantation, irrigation, weeding and staking were done as and when necessary. After 15 days of transplanting when the plants were well established vertical staking was provided using bamboo sticks to keep the plants erect and around 1.5 m high trellis type vertical staking were constructed in each plot for proper growth and fruiting of cherry tomatoes.

Data collection

Data were recorded from one week after transplanting of seedlings up to the harvesting of fruits from all six plants of each plot under each treatment and replications on the parameters *viz*., plant height (cm), number of leaves per plant, days of first flowering, number of flower cluster per plant, number of flowers per plant and yield and quality parameters *viz*., number of fruits per plant, individual fruit weight (g), length and breadth of fruit (cm), fruit yield (t/ha), and TSS content (% brix).

Plant height was measured from each sample plants in cm from the ground level to the tip of the longest stem by using meter scale and mean was calculated. Number of leaves per plant was recorded by counting all leaves from each plant and mean was calculated. Date of first flowering was recorded, and the number of days required for first flowering was calculated. The number of flower clusters was counted from the plants periodically, and average number of flower clusters produced per plant was recorded. Total number of flower was counted from the plants and then recorded until last flowering. The number of fruit per plant was counted from each plants periodically, the number of fruit produced per plant was recorded. Fruit length and diameter were measured using Slide Caliper. Mean was calculated for each treatment. Fruit weight was measured by a Table Top Electric Balance (BP 2100, Sartorius, Germany) and expressed in gram (g). The total weight of fruit per plant was calculated by adding the weight of all the fruits collected from each plant after final harvest and then fruit yield per plant was recorded in kg. Fruit yield of tomato per plant was converted into fruit yield in ton (t) per hectare. Fruit yield (t/ha) = Fruit yield per plant (kg) × total number of plants of 1 ha land/1000.Total soluble solids (TSS) content of cherry tomato was determined from fruit juice by using a hand refractometer (Model N-1 α, Atago, Japan). Before measurement, the refractometer was calibrated with distilled water. One or two drops of the filtrate were placed on the prism of the refractometer to obtain the %TSS reading. The reading was multiplied by dilution factor to obtain an original %TSS of the pulp tissues. Since differences in sample temperature could affect the TSS measurement, temperature corrections were made by using the methods described by Ranganna (1994).

Statistical analysis

The collected data on various parameters were analyzed statistically using MSTAT computer program. The significance of difference between pair of means was tested by the least significant differences (LSD) test at 1% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Effect of variety

Statistically significant variation was observed between the cherry tomato varieties in terms of all the growth parameters under study (Table 1). Results revealed that BARI Tomato-11 (Jhumka) recorded the highest plant height (108.71 cm) in comparison to the plant height (106.31 cm) of Binatomato-10. Plant height gradually increased with the age of plant and varied among the varieties of tomato due to the variation of varieties (Kallo *et al.,* 1998; Manoj and Ragav, 1998; Olaniyi *et al.,* 2010) which is controlled and expressed by certain genes (Fayaz *et al.,* 2007). Biswas *et.al* (2015) also signified disparity in varietal performance of tomato cultivars in plant height.

BARI Tomato 11 (Jhumka) produced significantly higher number of leaves per plant (41.55) compared to the number of leaves per plant (40.10) of Binatomato-10. The experimental data asserted an increasing propensity in the number of leaves per plant with an increase in plant height. These results are in an intimate similitude with the findings of Sharma and Rastogi (1993); Fayaz *et al.* (2007) and Biswas *et.al* (2015) who narrated that the number of leaves per plant varied significantly among the tomato cultivars.

Significant inequality was found in case of days to first flowering among the cherry tomato varieties under study. Minimum days required for first flowering was observed by BARI Tomato 11 (Jhumka) (69.13 days) and the maximum days (69.53 days) required by Tomato 10. This could be due to the higher capacity of BARI Tomato 11 (Jhumka) to supply assimilates to the apex during the sensitive phase before initiation (Prema *et al.,* 2011a). Peires (2002), Anand (2007) and Alam *et al.* (2014) also disclosed those days of first flowering vary among cherry tomato cultivars.

Binatomato-10 produced greater number of flower cluster per plant (27.45) and flowers per plant (337.86) compared to the number of flower cluster per plant (11.65) and flowers per plant (138.74) of BARI Tomato 11 (Jhumka). This might be due to the varietal differences of producing floral primordia cells (Wigge *et. al*., 2005). The process of primordium development is regulated by a set of genes. Since distinctive GA promoted to flower primordia production, the number of flower cluster varied among different tomato varieties (Onofeghara, 1983; Karim, *et. al*., 2015; Roy et. al., 2018; Khatun *et al.*, 2020). Hossain *et.al.* (2017) manifested similar aptitude of flower cluster production while studying different tomato varieties.

Yield and quality parameters were also significantly influenced by cherry tomato varieties (Table 1 and Figure 2). Binatomato-10 recorded the maximum number of fruits per plant (292.30), Fruit length (3.41cm), Fruit diameter (2.73cm), individual fruit weight (9.33g) compared to the number of fruits per plant (113.41), Fruit length (2.87 cm), Fruit diameter (2.24 cm), individual fruit weight (8.66 g) of BARI Tomato 11 (Jhumka). Maximum number of fruits might be due to the inherent ability of Binatomato-10 in pollination, fertilization and fruit formation over BARI Tomato 11 (Jhumka) Hossain *et.al,* (2017). Fruit length, Fruit diameter and individual fruit weight are varietal characteristics that are controlled by several genes and varies among different cherry tomato varieties. It is consistent with the findings of Venkadeswaran *et al*., (2018), Ramya *et al.,* (2016), Renuka *et al.,* (2014) and Najeema *et al*., (2018). Fruit yield is a compound parameter. It depends on its constituent parameters like number of fruits per plant, fruit weight. Any variation among these parameters varied the yield among the cherry tomato varieties. Binatomato-10 gave better fruit Yield (60.82 ton/ha) than the fruit Yield (24.40 ton/ha) of BARI Tomato 11 (Jhumka). It might be due to the maximum number of fruits and fruit weight in Binatomato-10 over BARI Tomato 11 (Jhumka) (Shivanand, 2008). The maximum TSS (7.94%) was recorded by Binatomato-10 in contrast to TSS (6.89%) of BARI Tomato 11 (Jhumka). Total Soluble Solids (% TSS) content differs in tomato varieties because of the distinction in their genetic composition (Swaroop and Suryanarayana, 2005; Ahmad *et al.,* 2007).

Effect of organic manures

In present study organic manures had significant influence on all the vegetative growth parameters of cherry tomato varieties *viz*., plant height and number of leaves per plant (Table 1). Results revealed that highest plant height (123.88 cm) and number of leaves (50.88) were recorded from mixed application of cowdung, MOC and poultry manure (T_7) followed by plant height (118.67 cm) and number of leaves (47.04) with mixed application of MOC and poultry manure (T_6), while the lowest plant height (83.04 cm) and number of leaves (29.83) were recorded from control (T_0). This might be due to the high content of nitrogen, phosphorus and potassium contained in CD, PM and MOC (Reyhan and Amisalani, 2006) and release of nutrients that promoted vigorous plant growth along with effective photosynthesis (Sanni, 2016). Nitrogen helps in cell division and cell elongation and thus increases plant height (Mazumder *et al*., 2019). Soil rectified with organic manures could probably be imposed to enhance N availability, which promoted leaf number during the growth period (Cox *et al*., 1993). Organic manures increase both macro and micronutrients as well as enhances the physical and chemical properties of the soil which promoted high vegetative growth. Many researchers reported that application of CD, PM and MOC increased plant height and leaf number in vegetable crops that supported the present results (Mondal *et al*., 2019; Noor *et al*., 2007; Sanni, 2016).

Significant inequality was found in days to first flowering due to different organic manure treatments (Table 1). Earliest flowering (62.38 days) was observed in application of cowdung, MOC and poultry manure (T_7) followed by days to first flowering (66.63 days) with mixed application of MOC and poultry manure (T_6), while late flowering (73.58 days) was in control (T_0). Nath and Singh (2012) apprised that different combinations of organic manures have significant early start in flowering.

Combined application of cowdung, MOC and poultry manure (T_7) gave the maximum number of flower cluster per plant (23.12) and flower per plant (373.15), followed by number of flower cluster per plant (22.79) and flower per plant (331.78) with mixed application of MOC and poultry manure (T_6), while the minimum number of flower cluster per plant (14.29) and flower per plant (120.13) were obtained from control (T_0). This might be due to incorporation of different combination of organic manures (Chamani *et al.*, 2008). Organic manures are rich in NKP and micronutrients which promotes the growth and flowering of plant. Atiyeh *et al*. (2002), Arancon *et al.* (2008) and Hussena *et al.* (2013) stated that, organic manures stimulates flowering, increasing the number of the flowers produced in marigold, petunia and tomato, respectively. Similar findings were disclosed by Naidu *et al.* (2002) and Prativa and Bhattarai (2011) in tomato. Organic manures had significant effect on yield and quality characters of cherry tomato under study as well (Figure 1 and Table 1). Combined application of cowdung, MOC and poultry manure (T_7) gave the maximum number of fruits per plant (351.83) and individual fruit weight (11.95 g) followed by fruits per plant (296.54) and individual fruit weight (10.42 g) with mixed application of MOC and poultry manure (T_6), while the minimum number of fruits per plant (78.31) and individual fruit weight (6.52 g) were obtained from control (T_0).This might be due to the higher nutrient content of combined organic manure treatment and especially leading to increase uptake of NPK which help the plant to get adequate food and nutrients thus may help to increase the number and fruit weight (Mamta *et al.,* 2012; Subbaiah *et al.*, 1985). Results also indicated that the longest fruit length (3.99 cm) and breadth (2.94 cm) were recorded from the mixed application of cowdung, MOC and poultry manure (T_7), followed by fruit length (3.72 cm) and breadth (3.30 cm) with mixed

application of MOC and poultry manure (T_6), while the shortest fruit length (2.18 cm) and breadth (1.99 cm) were found from control (T_0). This might be due to the intimate correlation of large size fruit with fruit weight and total fruit weight (Hortynski *et al.*, 1991).

Figure 3 indicated that fruit yield per hectare was also found the highest (64.87 ton/ha) from cowdung, MOC and poultry manure (T_7) followed by T_6 (57.64 ton/ha), while the lowest (14.90 ton /ha) in control (T_0). The increase in yield per hectare might be due to the availability of nutrients that increased flower and fruit attributes like number per plant, size, weight and minimum number of fruits and yield in T_0- Control might be due to non- availability of nutrients during its development (Rajya Laxmi *et al*., 2015). These results are in close similitude with the findings of Rashid (2018) in strawberry.

Total soluble solids (TSS) content was recorded highest (9.55%) by the application of cowdung, MOC and poultry manure (T_7) followed by TSS (8.80%) with the treatment comprising of MOC and poultry manure (T_6) while the lowest (5.48%) in control (T_0) as shown in Table 1. Increase in TSS content might be due to increased availability of major as well as minor nutrients especially nitrogen and potassium, as they play vital role in enhancing the fruit quality and minimum might be due to lack of availability of sufficient nutrients (Rajya Laxmi *et al.*, 2015). Similar findings were reported by Krishna and Krishnappa (2002) in tomato, Patil *et al*. (2004) in tomato, Singh *et al.* (2010) in field grown tomatoes.

Combined effect of variety and organic manures

Combined effect of cherry tomato cultivars and organic manures had significant impact on all the growth parameters under study *viz*., plant height, number of leaves per plant (Table 2). The highest plant height (127.75 cm) and number of leaves per plant (51.25) was found with BARI Tomato 11 (Jhumka) and mixed application of cowdung + MOC + poultry manure treatment (V_2T_7), followed by 120.67 cm and 47.83 with BARI Tomato 11 (Jhumka) with MOC + poultry manure (V_2T_6) treatment, while the lowest plant height (80.08 cm) and number of leaves per plant (27.17) were recorded in Binatomato-10 with control (V_1T_0). The study imparted that BARI Tomato 11 (Jhumka) cultivar treated with mixture of three manures performed best in terms of plant height and number of leaves per plant. All the nutrients supplied by the different organic manure sources might have been diverted to vegetative growth (Tiamiyu *et al.*, 2012) and as well potential ability of BARI Tomato 11 (Jhumka) cultivar of vigorous vegetative growth.

Earliest flowering (60.75 days) was observed in BARI Tomato-11 (Jhumka) with mixed application of cowdung, MOC and poultry manure (V_2T_7) followed by days to first flowering (64.00 days) with Binatomato-10 and mixed application of cowdung, MOC and poultry manure (V_1T_7), while late flowering (74.08 days) was in Binatomato-10 with control (V_1T_0). This earliness to flowering might be due to genetic factors and better translocation of nutrients to the aerial parts during floral initiation (Rajya Laxmi *et al.*, 2015).

Maximum number of flower cluster per plant (31.02) and No. of flowers per plant (525.84) were attained from Binatomato-10 with mixed application of cowdung + MOC + poultry manure (V_1T_7) followed by number of flower cluster per plant (30.97) and No. of flowers per plant (466.81) in Binatomato-10 with combine application of MOC + poultry manure (V_1T_6), while combination of BARI Tomato 11 (Jhumka) with control treatment (V_2T_0) gave the minimum number of flower cluster per plant (7.82) and flowers per plant (61.19). Availability of plant growth influencing substances such as hormones and humates produced by microorganisms due to organic manuring, probably contributed to increased flowering and number of flowers (Arancon *et al.*, 2008).

Yield and quality characteristics were also significantly influenced by combined application of cherry tomato cultivars and organic manures (Table 2 and Figure 4). Maximum number of fruits per plant (502.33) and individual fruit weight (12.50 g) were obtained from Binatomato-10 with mixed application of cowdung + MOC + poultry manure (V_1T_7), followed by Binatomato-10 with mixed application of MOC + poultry manure (V_1T_6) (416.00 and 11.00 g respectively), whereas the minimum number of fruits per plant (43.55) and individual fruit weight (6.23 g) were recorded from BARI Tomato 11 (Jhumka) with control treatment (V_2T_0). Maximum photosynthetic activity and accumulation of number of fruits might be due to increased no. of flowers which might have formed into fruits due to adequate availability of major and minor nutrients during its growth and development (Rajya Laxmi *et al.*, 2015). Combined application of organic manures reduces the C:N ratio which helps to increase the number and weight of fruit (Nagavallemma *et al.*, 2004). Results manifested that the longest fruit length (4.23 cm) and breadth (3.22 cm) were recorded from Binatomato-10 with the mixed application of cowdung + MOC + poultry manure (V_1T_7), followed by 3.89 cm and 2.86 cm from Binatomato-10 with the mixed application of MOC + poultry manure (V_1T_6), while the shortest fruit length (2.10 cm) and breadth (1.79 cm) were found from BARI Tomato 11 (Jhumka) with control (V_2T_0).

Figure 1. Different growth and development stages of cherry tomato. 1a. Seedling stage, 1b. Growth stage under vertical staking,1c. Flowering stage,1d. Fruiting stage

Table 1. Main effects of variety and organic manures on growth, yield and quality characters of cherry tomato

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 1st flower (DAS)	No. of flower cluster/ plant	No. of flowers/ plant	No. of fruits/ plant	Fruit length (cm)	Fruit diameter (cm)	Individual fruit wt. (g)	TSS (%brix)
Factor A: Variety										
V_1	106.31	40.10	69.53	27.45	337.86	292.30	3.41	2.73	9.33	7.94
V_2	108.71	41.55	69.13	11.65	138.74	113.41	2.87	2.24	8.66	6.89
$LSD_{0.05}$	0.97	0.33	0.16	0.62	16.62	16.45	0.08	0.06	0.16	0.12
$LSD_{0.01}$	1.30	0.45	0.22	0.83	22.38	22.16	0.10	0.08	0.21	0.17
Sig. level	**	**	**	**	**	**	**	**	**	**
Factor B: Organic manures										
T_0	83.04	29.83	73.58	14.29	120.13	78.31	2.18	1.99	6.52	5.48
T_1	96.63	33.96	72.50	16.10	154.55	106.37	2.43	2.11	7.37	6.07
T_2	107.92	41.21	70.17	19.39	220.07	174.86	3.07	2.31	8.62	7.20
T_3	103.00	36.96	71.88	18.15	177.52	147.25	2.83	2.20	8.22	6.73
T_4	114.96	44.08	68.25	21.55	287.00	256.36	3.57	2.61	9.93	8.15
T_5	112.00	42.67	69.25	21.02	242.21	211.32	3.33	2.46	8.93	7.32
T_6	118.67	47.04	66.63	22.79	331.78	296.54	3.72	3.30	10.42	8.80
T_7	123.88	50.88	62.38	23.12	373.15	351.83	3.99	2.94	11.95	9.55
$LSD_{0.05}$	1.81	0.62	0.30	1.16	31.09	30.78	0.14	0.12	0.30	0.23
$LSD_{0.01}$	2.43	0.84	0.40	1.56	41.87	41.45	0.19	0.16	0.40	0.31
Sig. level	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability, V_1 = Binatomato-10, V_2 = BARI Tomato 11 (Jhumka), T_0 = Control, T_1 = Cowdung @3 kg/m^2, T_2 = Mustard oil cake (MOC) @ 0.6 kg/m^2, T_3 = Poultry manure @ 3 kg/m^2, T_4 = Cowdung +MOC @ (3+0.6) kg/m^2, T_5 = Cowdung + Poultry manure @ (3+3) kg/m^2, T_6 = MOC + Poultry manure @ (0.6+3) kg/m^2, T_7 = Cowdung + MOC + Poultry Manure @ (3+0.6+3) kg/m^2

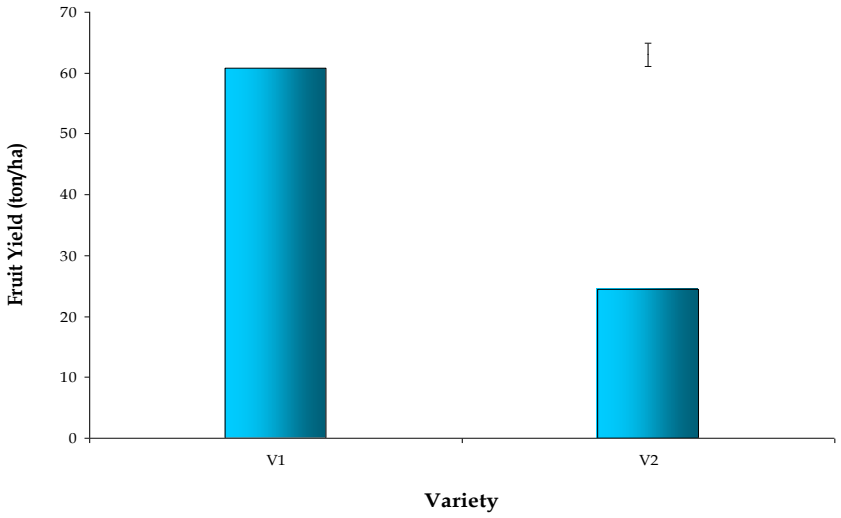

Figure 2: Main effect of variety on fruit yield of cherry tomato. The vertical bar represents LSD at 1% level of probability. V_1 = Binatomato-10, V_2 = BARI Tomato 11 (Jhumka)

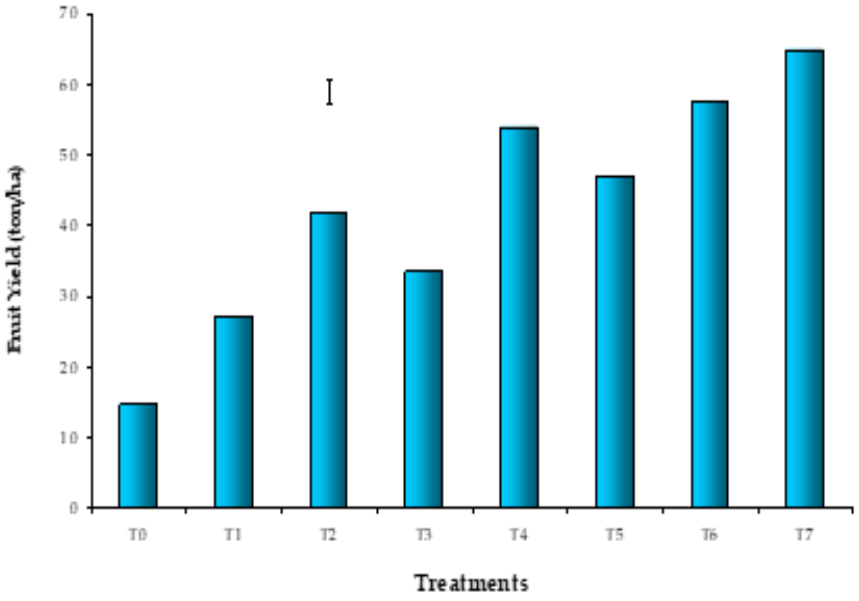

Figure 3. Main effect of organic manures on fruit yield of cherry tomato. The vertical bar represents LSD at 1% level of probability. T_0 = Control, T_1 = Cowdung @3 kg/m^2 , T_2 = Mustard oil cake (MOC) @ 0.6 kg/m^2, T_3 = Poultry manure @ 3 kg/m^2, T_4 = Cowdung +MOC @ (3+0.6) kg/m^2, T_5 = Cowdung + Poultry manure @ (3+3) kg/m^2, T_6 = MOC + Poultry manure @ (0.6+3) kg/m^2 , T_7 = Cowdung + MOC + Poultry Manure @ (3+0.6+3) kg/m^2

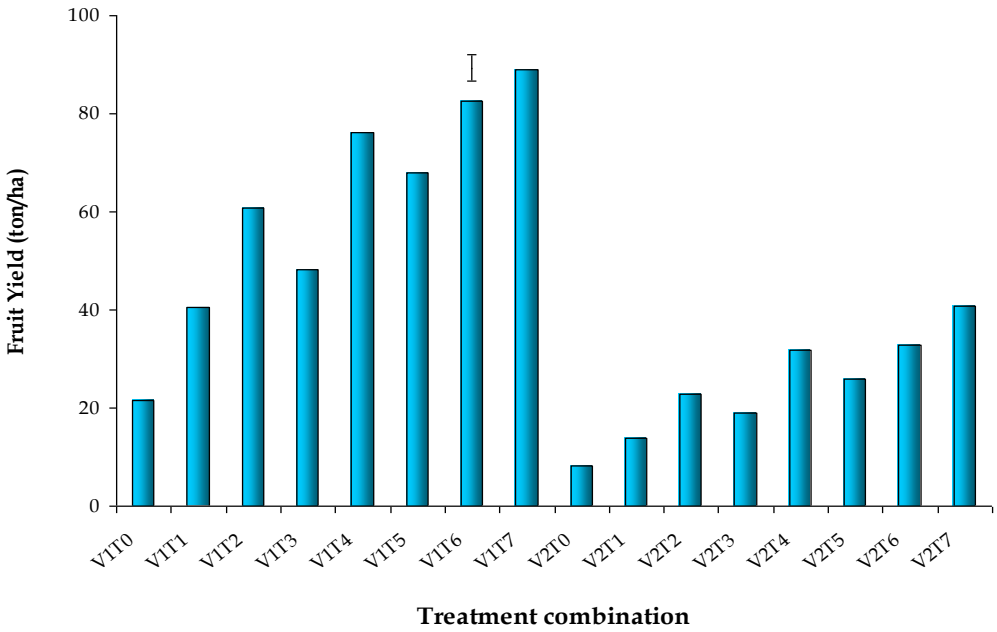

Figure 4. Combined effects of variety and organic manures on fruit yield of cherry tomato. The vertical bar represents LSD at 1% level of probability. V_1 = Binatomato-10, V_2 = BARI Tomato 11 (Jhumka). T_0 = Control, T_1 = Cowdung @3 kg/m^2, T_2 = Mustard oil cake (MOC) @ 0.6 kg/m^2, T_3 = Poultry manure @ 3 kg/m^2, T_4 = Cowdung +MOC @ (3+0.6) kg/m^2, T_5 = Cowdung + Poultry manure @ (3+3) kg/m^2, T_6 = MOC + Poultry manure @ (0.6+3) kg/m^2, T_7 = Cowdung + MOC + Poultry Manure @ (3+0.6+3) kg/m^2.

Table 2. Combined effects of variety and organic manures on growth, yield and quality characters of cherry tomato

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 1st flower (DAS)	No. of flower cluster/ plant	No. of flowers/ plant	No. of fruits/ plant	Fruit length (cm)	Fruit diameter (cm)	Individual fruit wt. (g)	TSS (%brix)
V_1T_0	80.08	27.17	74.08	20.75	179.06	113.06	2.27	2.19	6.80	6.17
V_1T_1	98.00	33.58	72.25	22.83	215.44	149.40	2.65	2.43	7.60	6.60
V_1T_2	107.67	40.75	70.08	27.75	309.23	257.98	3.52	2.48	8.80	7.70
V_1T_3	101.08	37.42	71.92	26.25	252.98	213.75	3.22	2.32	8.17	7.13
V_1T_4	115.42	43.25	68.00	30.04	408.77	373.75	3.83	2.77	10.43	8.70
V_1T_5	111.58	41.92	69.42	29.98	344.78	312.13	3.71	2.61	9.30	7.40
V_1T_6	116.67	46.25	66.50	30.97	466.81	416.00	3.89	2.86	11.00	9.40
V_1T_7	120.00	50.50	64.00	31.02	525.84	502.33	4.23	3.22	12.50	10.40
V_2T_0	86.00	32.50	73.08	7.82	61.19	43.55	2.10	1.79	6.23	4.80
V_2T_1	95.25	34.33	72.75	9.37	93.67	63.34	2.21	1.80	7.13	5.53
V_2T_2	108.17	41.67	70.25	11.03	130.91	91.73	2.62	2.13	8.43	6.70
V_2T_3	104.92	36.50	71.83	10.05	102.05	80.76	2.44	2.08	8.27	6.33
V_2T_4	114.50	44.92	68.50	13.06	165.24	138.97	3.32	2.44	9.43	7.60
V_2T_5	112.42	43.42	69.08	12.06	139.64	110.50	2.95	2.30	8.57	7.23
V_2T_6	120.67	47.83	66.75	14.60	196.74	177.08	3.55	2.74	9.83	8.20
V_2T_7	127.75	51.25	60.75	15.22	220.46	201.33	3.75	2.66	11.40	8.70
$LSD_{0.05}$	2.55	0.88	0.43	1.64	43.97	43.53	0.20	0.17	0.42	0.33
$LSD_{0.01}$	3.44	1.18	0.57	2.20	59.21	58.62	0.28	0.22	0.56	0.44
Sig. level	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability, V_1 = Binatomato-10, V_2 = BARI Tomato 11 (Jhumka), T_0 = Control, T_1 = Cowdung @3 kg/m^2 ,T_2 = Mustard oil cake (MOC) @ 0.6 kg/m^2,T_3 = Poultry manure @ 3 kg/m^2,T_4 = Cowdung +MOC @ (3+0.6) kg/m^2,T_5 = Cowdung + Poultry manure @ (3+3) kg/m^2,T_6 = MOC + Poultry manure @ (0.6+3) kg/m^2,T_7 = Cowdung + MOC + Poultry Manure @ (3+0.6+3) kg/m^2

Figure 5. Showing differences in combined effects of variety and organic manures treatments on fruit length and diameter of cherry tomato.

According to Edwards *et al.* (2004) organic manures can have dramatic effects upon fruiting, fruit size and weight of vegetable crops. It was also found that mixture of different organic manure application increases the length and breadth in strawberry fruit (Atefe *et al.,* 2012 and Rashid, 2018).

The highest fruit yield per hectare (89.07 t) was also obtained from Binatomato-10 with cowdung + MOC + poultry manure (V_1T_7), followed by 82.46 t from Binatomato-10 with MOC + poultry manure (V_1T_6), whereas the lowest yield per hectare (8.23 t) was recorded from BARI Tomato 11 (Jhumka) with control (V_2T_0). The results obtained were in compliance with the judgment of (Tiamiyu *et al.*, 2012) in which they stated that organic manure application ascribed to improved physical and biological properties of soil resulting in better supply of nutrients to the plants which results in higher yield response. Analogous outcome was traced in case of strawberry yield in Rashid (2018).

It was observed that the maximum TSS content (10.40%) was recorded from cherry tomato cultivar Binatomato-10 with cowdung + MOC + poultry manure (V_1T_7), followed by 9.40% in Binatomato-10 with MOC + poultry manure (V_1T_6), while the minimum TSS content (4.80%) was found from BARI Tomato 11 (Jhumka) with control (V_2T_0). Use of organic manures significantly increased levels of sugars (fructose, glucose and total sugars) (Shiow and Shin-Shan, 2002), soluble solids and insoluble solids (Federico *et al*., 2007). In addition due to the higher availability of macro and micronutrients and characters controls by genetic factors (Rashid, 2018) sweetness of Binatomato-10 cherry tomato cultivar was increased with the application of different organic manures.

Figure 6. Photographs showing differences in combined effect of variety and organic manures on cherry tomato. V_1 = Binatomato-10, V_2 = BARI Tomato 11 (Jhumka), T_0 = Control, T_1 = Cowdung @3 kg/m^2, T_2 = Mustard oilcake (MOC) @ 0.6 kg/m^2, T_3 = Poultry manure @ 3 kg/m^2, T_4 = Cowdung +MOC @ (3+0.6) kg/m^2, T_5 = Cowdung + Poultry manure @ (3+3) kg/m^2, T_6 = MOC + Poultry manure @ (0.6+3) kg/m^2, T_7 = Cowdung + MOC + Poultry Manure @ (3+0.6+3) kg/m^2.

Conclusions

From the above results, it can be concluded that the BARI Tomato-11 (Jhumka) along with combined application of cowdung + MOC + poultry manure @ (3 + 0.6 + 3 kg/m^2) found to be most effective in respect of vegetative growth, while Binatomato-10 along with combined application of cowdung + MOC + poultry manure @ (3+0.6+3 kg/m^2) was better in respect of yield and quality characters of cherry tomato.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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