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Efficacy of Different Organic Manures on Growth and Yield Performance of Organically Grown Tomato

Sohely Parvin[1], Md. Nasir Hossain Sani[2*], Sourav Modak[2], Saleh Ahmed Shahriar[3] and Jasim Uddain[2]

[1]*Department of Agricultural Extension (DAE), Government of the People's Republic of Bangladesh, Bangladesh.*
[2]*Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.*
[3]*Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.*

Authors' contributions

This work was carried out in collaboration between all authors. Authors SP and MNHS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SAS and JU managed the analyses of the study. Author SM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during the period from October 2014 to March 2015 to find out the efficacy of different organic manures and different varieties on the growth, yield performance of organically grown tomato. The experiment comprised of two different factors: Factor A. four types of organic manure [M_0= Control (No organic manures application), M_1 = Cow dung (30 $t.ha^{-1}$), M_2 = Poultry manure (25 $t.ha^{-1}$) and M_3 = Vermicompost (20 $t.ha^{-1}$)] Factor B. three types of variety V_1 = BARI tomato 15, V_2 = BARI tomato 14 and V_3 = BARI tomato 2. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Encouraging responses were monitored in all respects. Among the treatment combination M_2V_1 (Poultry manure + BARI Tomato 15) showed the highest plant height, maximum number of flower cluster, number of flower per cluster, number of fruits per cluster and number of fruit per plant with

*Corresponding author: Email: nsanisau@gmail.com;

improved fruit size. The maximum yield (86.25 t/ha) was recorded from the treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15), while the treatment combination of M_0V_3 (Control treatment + BARI Tomato 2) gave the minimum yield (31.25 t/ha). Therefore, BARI Tomato 15 coupled with poultry manure can be the most suitable for enhanced yield and can be considered a noble practice in sustainable agriculture.

Keywords: Manures; organic; tomato; vermi-compost; yield.

1. INTRODUCTION

Over the last two decades, organically grown vegetables have generated significant interest among consumers and scientists due to healthier products and safer characteristics of human health. Consumers demand for organic vegetables has also on the rise. Therefore, the sustainability of vegetable production with a higher yield is the prime need to meet consumer demand. Furthermore, sustainable vegetable production has been often reported as an environmentally-friendly production system able to produce food with minimal hazardous effect on ecosystems and the environment as well as minimal use of off-farm resources [1]. However, the major drawback of organic vegetable production is the lower yield compared to conventional agriculture [2,3]. Therefore, farmers prefer to use commercial synthetic chemical fertilizers for vegetable production. However, extensive use of inorganic fertilizer may lead to environmental pollution, including contamination of groundwater, and soil acidification as well as increase de-nitrification resulting in higher emission of nitrous oxide (N_2O) to the atmosphere which is responsible for global warming. Therefore, there is a prime need to bring the new management practice to increase nutrient availability, plant uptake, and assimilation, reduce disease intensity in order to close the gap between organic and conventional yields [4,5]. Application of organic manures can be an effective practice to produce tomato in a sustainable production system. Organic manure is a source of food for the innumerable number of microorganisms and creatures like earthworm who breaks down these to micronutrients, which are easily absorbed by the plants. Organic manure plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, improving the physical and physiological properties of soils. Organic manures such as cow dung, poultry manure, and vermicompost improve the soil structure, aeration, slow release nutrient which supports root development leading to higher growth and yield of tomato plants. The macronutrient calcium and micronutrients boron, manganese, molybdenum and iron are important for tomato cultivation. Biologically active soils with adequate organic matter usually supply enough of these nutrients [6]. Tomato (*Lycopersicon esculentum* L.) is one of the most popular and versatile vegetables in the world which is cultivated in almost all parts of Bangladesh under both field and greenhouse conditions. Tomato fruits are eaten raw or cooked and other dishes like as soups, juice, Jam, Jelly, ketchup, pickles, sauces, conserves, puree, paste, powder, and other products. In terms of human health, tomato is a major component in the daily diet and constitutes an important source of minerals, vitamins, and antioxidants, like lycopene. Lycopene pigment is a vital anti-oxidant that helps to fight against cancerous cell formation as well as another kind of health complications and diseases [7]. Nevertheless, it plays a vital role in providing a substantial quantity of vitamin C and A in the human diet [8]. Increasing the production and improving the keeping quality of tomato are of paramount importance, now-a-days, for meeting the internal demand of the consumers'. Hence efforts should be given to identifying varieties with high yield potential in an organic production system influenced by the application of different organic manures. Considering the above perspective, the present study was undertaken to identify the suitable tomato variety and the efficacy of different organic manures which can promote growth, increase the yield of tomato in a sustainable and environment-friendly way.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from October 2015 to February 2016. The location of the experimental site was 23º74$^{/}$N latitude and 90º35$^{/}$E longitude and at an elevation of 8.2 m from sea level. The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from October to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October.The soil of the experimental area belongs to the Modhupur Tract (AEZ No 28). It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon. The physicochemical properties of the soil in the experimental site are as follows-

Textural class	Silty clay loam to clay loam
Bulk density (g cm^{-3})	1.33
Particle density (g cm^{-3})	2.61
Porosity (%)	46.9
pH	6.2
Organic carbon (%)	0.75
Organic matter (%)	1.12
Total N (%)	0.092
Available P (µg/g)	18
Available K (meq/100g)	0.32

2.2 Planting Material

Three varieties of tomato were used in this experiment viz, V_1 = BARI tomato 15, V_2 = BARI tomato 14 and V_3 = BARI tomato 2.Tomato seeds were collected from Vegetable division, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

2.3 Organic Materials

Four types of organic manure coded as M_0 = Control (No organic manure), M_1 = Cow dung (30 $t.ha^{-1}$), M_2 = Poultry manure (25 $t.ha^{-1}$), M_3 = Vermicompost (20 $t.ha^{-1}$). Nutrient composition of different organic manures applied in the experiment is as follows-

Manure	N (%)	P (%)	K (%)
Cowdung (decomposed)	1.0±0.1	0.3±0.03	0.46±0.05
Poultry manure	1.25±0.13	0.70±0.07	0.95±0.10
Vermicompost	0.75±0.07	0.6±0.06	1.0±0.1

2.4 Experimental Design and Treatments

The experiment was laid out in Randomized Complete Block Design with three replications. There were altogether 12 (4 x 3) treatment combination used in each block were as follows; M_0V_1, M_1V_2, M_2V_3, M_0V_2, M_1V_3, M_3V_1, M_0V_3, M_2V_1, M_3V_2, M_1V_1, M_2V_2, M_3V_3. The experimental plot was first divided into three blocks. Each block consisted of 12 plots. Thus, the total numbers of the plot were 36. Different combinations of treatments were assigned to each plot as per the design of the experiment. The size of a unit plot was 2.4 m ×2.4 m. A distance of 0.5 m between the plots and 1.0 m between the blocks was kept.

2.5 Growth Condition of Tomato and Application of Manures

The experimental land area was prepared by several ploughing and cross ploughing with a power tiller followed by laddering to bring about a good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. The weeds, crop residues, and stables were removed from the field. Total organic manures were applied according to their treatment and finally leveled. Thirty days-old healthy seedlings were transplanted at the spacing of 60 cm × 40 cm in the experimental plots. Thus the 24 plants were accommodated in each unit plot.

2.6 Data Collection and Analysis

Five plants were randomly selected from each unit plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The height of the plants was measured from the ground level to the tip of the highest leaves. The data obtained for different parameters were statistically analyzed to find out the significant difference of variety and different manure application on yield and yield contributing characters of tomato. The mean values of all the characters were calculated and the analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Application of organic manures exhibited a significant influence on the height of tomato plants at 30, 45, and 60 days after transplanting (DAT) and at final harvest (Fig. 1). At 30 DAT, the tallest plant (35.68 cm) was found in the application of poultry manure (M_2) and the shortest plant (26.33 cm) was recorded from the control treatment (M_0). At 45 DAT, the plant height (59.32 cm) was recorded from M_2, while the lowest (43.88 cm) was recorded from M_0. At 60 DAT, the longest plant (77.35 cm) was recorded from M_2 and the shortest plant (62.08 cm) was recorded from M_0. At final harvest, plant height ranged from 67.44cm to 83.90 cm. The highest plant (83.90cm) was recorded from M_2, while the lowest (67.44 cm) was recorded from M_0. Poultry manure is rich in its nitrogen and nutrient content. This favorable condition creates better nutrient absorption and favors for vegetative growth. Consequently, longest plant was found by application of poultry manure. This is an agreement with the findings of [6].

Different varieties showed significant influence on plant height of tomato plants at different DAT and final harvest (Fig. 1). At 30 DAT, the tallest plant (33.71 cm) was found from V_1 (BARI Tomato 15) and the shortest plant (29.53 cm) was found from variety V_3 (BARI Tomato 2). At 45 DAT, the highest plant height (53.77 cm) was recorded from V_1, while the lowest (48.48 cm) was recorded from V_3. The plant height ranged from 70.31 cm to 75.33 cm at 60 DAT. The longest plant (75.33 cm) was recorded from V_1 and the shortest plant (70.31 cm) was recorded from V_3. At the final harvest, the highest plant (78.12 cm) was recorded from V_1, while the lowest (71.88 cm) was recorded from V_3. Organic matter improves soil structure, increases the water holding capacity and promotes biological transformations such as N-mineralization and enhances crop growth and development [9]. The results of this study are also in agreement with the findings of [10,11].

The variation was found due to the combined effect of organic manure and variety on plant height at different days after transplanting (Table 1). The maximum plant height (48.80cm) was recorded from the treatment combination of M_2V_1, while the treatment combination of M_0V_3 gave the minimum plant height (16.66 cm) at 30 DAT. At 45 DAT significant differences in terms of plant height was observed among the treatment combinations. However, the largest plant height (75.08 cm) was recorded from the treatment combination of M_2V_1 whereas the minimum (36.20 cm) was recorded from treatment combination of M_0V_3. At 60 DAT, the tallest plant (90.61 cm) was recorded from the treatment combination of M_2V_1, while the minimum plant height (51.22 cm) was recorded from treatment combination of M_0V_3. At harvest, the maximum plant height (97.80 cm) was obtained from the treatment combination M_2V_1 whereas the minimum (58.90 cm) was found from the treatment combination of M_0V_3.

3.2 Number of Flower Clusters per Plant

Application of organic manures exhibited a significant influence on the number of flower cluster per tomato plant (Table 2). The maximum number of flower clusters per plant (9.74) was recorded from M_2 (Poultry manure), which was statistically identical (8.89) to M_1 while the minimum (8.27) was obtained from M_0 (Control treatment).

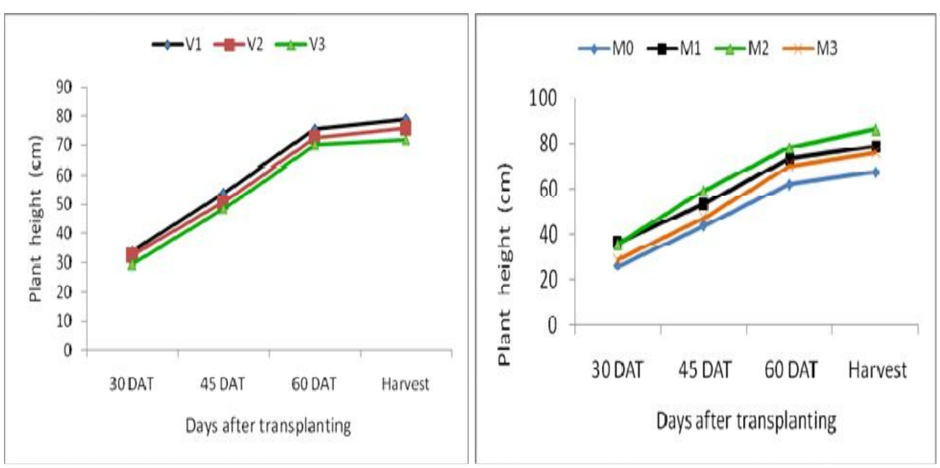

Fig. 1. Effect of manures and variety on plant height of tomato

(M_0 = Control, M_1 = Cowdung (30 t.ha^{-1}), M_2 = Poultry manure (25 t.ha^{-1}) and M_3 = Vermicompost (20 t.ha^{-1}), V_1 = BARI tomato 15, V_2 = BARI tomato 14 and V_3 = BARI tomato 2

Table 1. Interaction effect of organic manures and varieties on plant height of tomato

Treatment	Plant height (cm)			
	Plant height at 30 DAT	Plant height at 45 DAT	Plant height at 60 DAT	Plant height at Harvest
M_0V_1	22.56 ef	37.92 e	62.08de	67.24 b-e
M_0V_2	17.02 f	36.89 e	61.15 de	62.98 c-e
M_0V_3	16.66 f	36.20 e	51.22 e	58.90 e
M_1V_1	24.40 ef	51.13 b-e	66.24 cd	69.67 b-e
M_1V_2	36.58 bc	57.18 b-d	78.42 abc	83.51 ab
M_1V_3	48.76 a	65.04 ab	80.90 a	81.16 a-c
M_2V_1	48.80 a	75.08 a	90.61 a	97.80 a
M_2V_2	34.76 b-d	47.10 c-e	64.92 cd	65.36 de
M_2V_3	35.68 b-d	55.78 b-d	78.24 abc	84.49 ab
M_3V_1	40.94 ab	45.56 c-e	73.29 bcd	79.29 a-d
M_3V_2	28.80 c-e	59.66 bc	85.02 ab	86.05 ab
M_3V_3	27.22 de	43.60 de	72.95 bcd	76.18 b-e
LSD (0.05)	8.021	13.81	12.19	9.45
CV (%)	7.35	8.95	10.36	7.45

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, M_0 = Control, M_1 = Cowdung (30 t.ha^{-1}), M_2 = Poultry manure (25 t.ha^{-1}) and M_3 = Vermicompost (20 t.ha^{-1}), V1 = BARI tomato 15,V_2 = BARI tomato 14 and V_3 = BARI tomato 2

Table 2. Effect of organic manure and variety on yield contributing attributes of tomato

Treatment	Flower cluster /plant	Flower/cluster	Flower/plant	Fruit/plant
M_0	8.27 b	8.41 a	36.11 b	26.83 b
M_1	8.89 b	8.76 a	47.12 ab	32.87 ab
M_2	9.74 a	9.24 a	58.25 a	42.07 a
M_3	8.99 b	8.81 a	43.10 ab	33.04 ab
LSD (0.05)	0.5963	1.744	19.46	10.61
CV (%)	6.26	7.15	7.25	9.26
Treatment	**Cluster/plant**	**Flower/cluster**	**Flower/plant**	**Fruit/plant**
V_1	10.61 a	10.52 a	48.05 a	36.65 a
V_2	9.25 b	8.83 a	45.92 a	32.83 a
V_3	7.49 c	7.07 b	44.47 a	31.63 a
LSD(0.05)	0.5963	1.744	19.46	10.61
CV (%)	6.26	7.15	7.25	9.26

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, M_0 = Control, M_1 = Cowdung (30 t.ha^{-1}), M_2 = Poultry manure (25 t/ha t.ha^{-1}) and M_3 = Vermicompost (20 t.ha^{-1}), V_1 = BARI tomato 15, V_2 = BARI tomato 14 and V_3 = BARI tomato 2

A significant variation was recorded due to the combined effect of different varieties on a number of flower clusters per plant under the present investigation (Table 2). The maximum number of flower cluster per plant (10.61) was recorded from V_1 (BARI Tomato 15) and the minimum number of flower cluster per plant (7.49) was obtained from V_3.

The variation was found due to the combined effect of organic manure and varieties for a number of flower cluster per plant (Table 3). The maximum number of flower cluster per plant (11.64) was recorded from the treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15) which was statistically identical to M_2V_2 (11.37) (Poultry manure + BARI Tomato 14), while the treatment combination of M_0V_3 (Control + BARI Tomato 2) gave the minimum (6.34) number of flower clusters per plant. This study is almost similar to the findings of [12].

3.3 Number of Flowers per Cluster

The number of flowers per cluster varied significantly due to the application of organic manures under the present study (Table 2). The maximum number of flowers per cluster (9.24) was recorded from M_2 (Poultry manure), while the minimum (8.41) was obtained from control

(M_0). These findings are similar to the findings [9,11].

Different varieties showed a significant variation in the number of flowers per cluster under the present trial (Table 2). The maximum number of flowers per cluster (10.52) was recorded from V_1 (BARI Tomato 15) which was statistically similar to V_2 (BARI Tomato 14) and the minimum number of flowers per cluster (7.07) was found from V_3 (BARI Tomato 2).

The variation was also found due to the combined effect of organic manures and varieties on a number of flowers per cluster per tomato plant (Table 3). The maximum number of flower per cluster (11.43) was recorded from treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15), while the treatment combination of M_0V_3 (Control + BARI Tomato 2) gave the minimum number of flowers per cluster (5.58).

3.4 Number of Flowers per Plant

Number of flowers per plant varied significantly due to the application of different organic manures (Table 2). The maximum number of flowers per plant (58.25) was recorded from M_2 (Poultry manure), while the minimum (36.11) was obtained from control treatment (M_0).

Different varieties showed a significant variation in a number of flowers per plant under the present investigation (Table 2). The maximum number of flower per plant (48.05) was recorded from V_1 (BARI Tomato 15) and the minimum number of flowers per plant (44.47) was found from V_3 (BARI Tomato 2). Application of manure facilitates a slow release of nutrients and facilitates better nutrient uptake and assimilation during reproductive growth which might be the reason for the higher number of flowers per plant of tomato [11].

The variation was found due to the combined effect of organic manures and varieties on a number of flowers per plant (Table 3). The maximum number of flowers per plant (91.16) was recorded from the treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15), while the treatment combination of M_0V_3 (Control +BARI Tomato 2) performed the minimum number of flowers per plant (26.40).

3.5 Number of Fruits per Plant

Number of fruits per plant differed significantly by application of different organic manures under the present investigation (Table 2). The maximum (42.07) number of fruits per plant was recorded from M_2 (Poultry manure), while the minimum (26.83) was recorded from M_0 (Control treatment). It was revealed that the number of fruits per plant increased in poultry manure. This might be caused that Poultry manure content high amount of nitrogen and nitrogen enhance photosynthesis, cell division, and cell enlargement. A similar trend of the results was found by Ajlouni et al. [13] who reported that application of manure improves microbial population and facilitates better nutrient uptake and increased the number of fruits per plant.

Different varieties showed a significant variation in a number of fruits per plant under the present trial (Table 2). The maximum (36.65) number of fruit per plant was recorded from V_1 (BARI Tomato 15) and the minimum (31.63) number of fruits per plant was observed in V_3 (BARI Tomato 2). The reports also supported by the results of [5,9,11].

Significant differences on a number of fruits per plant were recorded due to the combined effect of organic manures and varieties (Table 3). The maximum (55.91) number of fruit per plant was recorded from treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15), while the treatment combination M_0V_3 (Control +BARI Tomato 2) gave the minimum (15.70) number of fruits per plant.

3.6 Length of Individual Fruit (cm)

Length of individual fruit varied significantly for different organic manures (Table 4). The maximum length of individual fruit (7.97 cm) was recorded from M_2 (Poultry manure), while the minimum (6.29 cm) was recorded from M_0 (Control) which was statistically identical (7.71 cm) to M_3 (Vermicompost). Similar types of results can be found by [14,15].

Different varieties showed a significant variation in the length of individual fruit under the present investigation (Table 4). The maximum (7.66 cm) length of individual fruit was recorded from V_1 (BARI Tomato 15) and the minimum (6.66 cm) length of individual fruit was obtained from V_3 (BARI Tomato 2).

The variation was found due to the combined effect of organic manures and varieties for the length of individual fruit under the present trial (Table 5). The maximum (10.94 cm) length of individual fruit was recorded from treatment combination of M_2V_1 (Poultry manure + BARI tomato 15), while the treatment combination of M_0V_3 (Control treatment + BARI Tomato 2) performed the minimum (4.08 cm) length of individual fruit.

3.7 Diameter of Individual Fruit (cm)

Diameter of individual fruit significantly influences by different organic manures (Table 4). The maximum (10.43 cm) diameter of individual fruit was recorded from M_2 (Poultry manure), which was statistically identical with M_3 (9.44 cm) and M_1 (10.35), while the minimum (8.84 cm) was recorded from M_0 (Control treatment). This trend is similar to [16,17].

Different varieties showed a significant variation on the diameter of individual fruit under the present investigation (Table 4). The maximum (10.18cm) diameter of individual fruit was recorded from V_1 (BARI Tomato 15) and the minimum (9.18cm) diameter of individual fruit was obtained from V_3 (BARI Tomato 2).

The combined effect of organic manure and varieties varied significantly on the diameter of individual fruit (Table 5). The maximum (13.31 cm) diameter of individual fruit was recorded from treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15), while the treatment combination of M_0V_3 (Control treatment + BARI Tomato 2) gave the minimum (6.60 cm) diameter of individual fruit. Our findings are in agreement with the findings of [18].

3.8 Weight of Individual Fruit (g)

Weight of individual fruit varied significantly due to the application of different organic manures (Table 4). The maximum (123.33 g) weight of individual fruit was recorded from M_2 (Poultry manure), while the minimum (91.69g) was recorded from M_0 (Control treatment).

A significant variation found different varieties on the weight of individual fruit under the present trial (Table 4). The maximum (134.58 g) weight of individual fruit was recorded from V_1 (BARI Tomato 15) and the minimum (99.18 g) weight of individual fruit was recorded from V_3 (BARI Tomato 2).

The variation was found due to combined effect of organic manures and varieties on weight of individual fruit (Table 5) The maximum (176.66 g) weight of individual fruit was recorded from treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15), while the treatment combination of M_0V_3 (Control treatment + BARI Tomato 2) performed the minimum (73.41 g) weight of individual fruit. Application of manure supplies slow release of nutrients and increase the accumulation of carbohydrates, which might be the reason for higher individual fruit weight. This was supported by [19,20,21].

Table 3. Combined effect of organic manure and variety on yield contributing attributes of tomato

Treatment	Cluster/plant	Flower/cluster	Flower/plant	Fruit/plant
M_0V_1	7.73 f	8.01 c	30.75 e	19.04ef
M_0V_2	7.27 f	6.12 d	26.89 e	19.62 def
M_0V_3	6.34 g	5.58 d	26.40 e	15.70 f
M_1V_1	8.40 e	8.24 c	28.75 e	19.71 ef
M_1V_2	8.61 de	8.29 c	43.78 cde	30.93 cd
M_1V_3	8.99 cd	8.57 bc	71.19 b	38.96 bc
M_2V_1	11.64 a	11.43 a	91.16 a	55.91 a
M_2V_2	11.37 a	10.57 a	36.44 de	31.71 c
M_2V_3	10.34 b	10.45 ab	54.83 bcd	41.71 bc
M_3V_1	9.08 cd	9.62 ab	38.20 de	29.93 cde
M_3V_2	9.27 c	10.25 ab	64.20 bc	50.58 ab
M_3V_3	10.34 b	8.54 bc	41.16 de	40.61 bc
LSD (0.05)	0.5963	1.744	19.46	10.61
CV (%)	6.26	7.15	7.25	9.26

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, M_0 = Control, M_1 = Cowdung (30 t.ha^{-1}), M_2 = Poultry manure (25 t.ha^{-1}) and M_3 = Vermicompost (20 t.ha^{-1}), V_1 = BARI tomato 15, V_2 = BARI tomato 14 and V_3 = BARI tomato 2

Table 4. Effect of organic manures and variety on fruit length, fruit diameter, individual fruit weight and fruity yield per plant of tomato

Treatment	Length of individual fruit (cm)	Diameter of individual fruit (cm)	Individual fruit weight(g)	Yield /plant(Kg)
M_0	6.290c	8.840a	91.69b	0.993 c
M_1	6.980b	10.35a	122.81ab	1.532 bc
M_2	7.977a	10.43a	123.33a	2.061 a
M_3	7.713a	9.446a	118.33ab	1.651 b
LSD(0.05)	0.6358	1.761	10.10	0.32
CV (%)	9.21	10.12	7.63	8.21
V_1	7.665a	10.18a	134.58 a	1.75 a
V_2	7.392a	9.938a	108.35 b	1.54 ab
V_3	6.662b	9.181a	99.18 bc	1.37 b
LSD(0.05)	0.6358	1.761	10.10	0.32
CV (%)	9.21	10.12	7.63	8.21

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, M_0 = Control, M_1 = Cowdung (30 t.ha^{-1}), M_2 = Poultry manure (25 t.ha^{-1}) and M_3 = Vermicompost (20 t.ha^{-1}), V_1 = BARI tomato 15, V_2 = BARI tomato 14 and V_3 = BARI tomato 2

Table 5. Combined effect of organic manures and variety on fruit length, fruit diameter, individual fruit weight and fruity yield per plant of tomato

Treatment	Length of individual fruit (cm)	Diameter of individual fruit (cm)	Individual Fruit Weight (g)	Yield / plant (Kg)
M_0V_1	5.017 h	7.393 gh	95.0 e	1.18 cd
M_0V_2	4.697 hi	7.067 gh	95.0 e	1.03 de
M_0V_3	4.083 i	6.600 h	73.41 f	0.75 e
M_1V_1	5.327 h	8.147 fgh	96.77 e	1.19 d
M_1V_2	6.980 f	8.840 efg	115.0 cd	1.39 c
M_1V_3	9.263 c	12.71 ab	121.66 c	1.50 bc
M_2V_1	10.94 a	13.31 a	176.66 a	2.07 a
M_2V_2	6.223 g	10.43 cde	106.66 de	1.69 bc
M_2V_3	7.977 de	10.34 cde	108.33 d	1.75 b
M_3V_1	7.713 e	9.453 def	133.33 b	1.71 bc
M_3V_2	10.10 b	11.82 abc	113.33 cd	1.70 bc
M_3V_3	8.563 d	11.08 bcd	133.33 b	1.71 bc
LSD (0.05)	0.6358	1.761	10.10	0.32
CV (%)	9.21	10.12	7.63	8.21

In a column, means followed by same letter (s) do not differ significantly at 5% level of probability, M_0 = Control, M_1 = Cowdung (30 t.ha^{-1}), M_2 = Poultry manure (25 t.ha^{-1}) and M_3 = Vermicompost (20 t.ha^{-1}), V_1 = BARI tomato 15, V_2 = BARI tomato 14 and V_3 = BARI tomato 2

3.9 Yield (kg plant^{-1})

Yield per plant varied significantly due to the application of different organic manures (Table 4). The maximum (2.06 kg.plant^{-1}) yield was recorded from M_2 (Poultry manure), while the minimum (0.99 kg.plant^{-1}) was found from M_0 (Control treatment). Poultry manure is rich in its nitrogen and nutrient content. These favorable conditions create better nutrient absorption and favor the growth and development of the root system which in true reflects better vegetative growth, photosynthetic activity. Consequently a higher total yield would be obtained by poultry manure. The results also agreed to the findings of [22].

Different varieties showed a significant variation on yield per plant under the present investigation (Table 4). The maximum (1.75 kg.plant^{-1}) yield was recorded from V_1 (BARI Tomato 15) and the minimum (1.37 kg.plant^{-1}) yield was obtained from V_3 (BARI Tomato2). A similar trend of results was found by Ogundare et al. [23].

The variation was found due to the interaction effect of organic manures and varieties for yield per plant (Table 5). The maximum (2.07

kg.plant^{-1}) yield was recorded from treatment combination of M_2V_1 (Poultry manure + BARI Tomato 15), while the treatment combination M_0V_3 (Control treatment + BARI Tomato 2) gave the minimum yield (0.75 kg.plant^{-1}). Application of organic manure supply plant nutrients, including micronutrients, improve soil physical properties like structure, water holding capacity, increase the availability of nutrients and favors the beneficial microorganisms which positively increase the yield and quality of tomato [24,25].

4. CONCLUSION

In this study, organic manures played a significant role in enhanced growth and yield performance of tomato in a sustainable production system. BARI Tomato 15 coupled with poultry manure enhanced vegetative and reproductive growth with a higher yield of tomato by the slow and steady release of nutrients to the plants compared to other treatments. Thus the application of BARI Tomato 15 coupled with poultry manure can reduce the cultivation cost of tomato while minimizing pollution by excessive use synthetic fertilizers and could be considered as a good production strategy for obtaining high yields with lower impact on the environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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