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Growth and yield of tomato as affected by organic and inorganic fertilizers

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ABSTRACT

Unscrupulous use of synthetic fertilizers are not only increasing cost of tomato production but also decreasing tomato yield and quality, deteriorating soil health and environment. Organic manures can produce quality product as well as maintain soil health. Considering this verity an experiment was carried out at the Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna to evaluate the performance of tomato crop under application of different organic and inorganic fertilizers. The experiment was designed in RCBD using two varieties (BARI Tomato-14 and BARI Tomato-15) and eight treatments [i) 100% Recommended fertilizer dose (RFD) for N, P and K; ii) 100% cowdung (CD); iii) 100% poultry manure (PM); iv) 100% vermi-compost (VC); v) 100% Mustard oil cake (MOC); vi) 100% organic manures (25% of each of CD , PM , VC and MOC); vii) 80% organic manure (20% of each of CD, PM, VC and MOC) + 20% RFD; viii) 60% organic manure (15% of each of CD, PM, VC and MOC) + 40% RFD].The tallest plant (77.5 cm) with maximum fruit length (5.98 cm), maximum number of flower clusters plant^{-1} (16.24), number of flowers cluster^{-1} (13.07), number of fruit clusters plant^{-1} (8.20) and number of fruits cluster^{-1} (6.97) were observed from combined effect of 60% organic manures with 40% RFD in BARI Tomato-15. On the contrary, this treatment produced maximum fruit diameter (6.29cm), maximum weight of individual fruit (91.43g) and the highest yield (87.17 t/ha) in BARI tomato-14. From economic point of view, maximum net return (Tk. 841345) as well as benefit cost ratio (5.11) was also observed from 60% organic manure + 40% RFD. Thus, BARI tomato-14 with combination of organic manures (60%) and inorganic fertilizers (40%) provided better performance concerning growth, yield and economic aspects.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetables in the world and in terms of area, it ranks next to potato and sweet potato but ranks first as the processing crop (FAO, 2010). It can be consumed either as raw, or as soup, sliced, dried and juice (Musa *et al*., 2007). In Bangladesh, the area under tomato cultivation is 27518.62 hectare with a total production of 3, 89,000 metric tons having an average yield of 14.05 t/ha (BBS, 2018) whereas, the world tomato production is 200.95 million tons from the area of 4.8 million hectare with an average yield of 41.45 t/ha (FAOSTAT, 2018). Unfortunately, the average yield of tomato in Bangladesh is very low compared to that of neighboring countries like China (56.2 t/ha) and India (24.2 t/ha) (Halder *et al*., 2003).

This low yield of tomato in Bangladesh is not a sign of low potentiality of the crop, but it may be due to a number of causes, for example, unavailability of good quality seeds of superior varieties and improper fertilization, irrigation and disease control measures, etc. As varietal difference, balanced fertilization and other inputs are the key indicators of increasing yield as well as quality of tomato. It is essential to find out the best productive variety with optimum fertilizer dose for maximum production (Latha *et al*., 2002). In this regard, synthetic fertilizers are the best way of crop production, but continuous application of chemical fertilizer increases organic matter depletion and damages the chemical and physical properties of soil. Moreover, those fertilizers are expensive and sometimes they are not readily available in the market. Considering these facts, the society is being increasingly concerned about environmental hazard especially with respect to health hazards which are created by the indiscriminate use of agrochemicals (Van der Berge *et al*., 2000). As a consequence, many countries are considering organic agriculture as the well-established and certified forms of cropping systems among all the alternative cropping patterns (Adediran *et al*., 2003).

On the contrary, organic manures are easily available to the growers and their price is lower than that of chemical fertilizers (Alam *et al*., 2007). In addition, organic fertilizers improve higher growth, yield and quality of crops. They also contain essential macro and micro

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nutrients, many vitamins, growth promoters and some beneficial microorganisms (Natarjan, 2007; Sreenivasa *et al*., 2010). Farmers apply various types of organic manures such as cowdung, poultry manure, goat manure, farmyard manure, compost, vermicompost, mustard oil cake, etc. for tomato production. Among these organic manures, cowdung @ 15 t/ha can play a key role in increasing growth and yield of tomato when it is applied in combination with chemical fertilizers (Rahman *et al*., 1996). Poultry manure also enriches the soils by enhancing the nutrient status and improving the structure of the soil (Odiete and Ogunmoye, 2005). Shaheed (1997) described mustard oil cake (150 g/plot) as an alternative of poultry dropping and cowdung which may contribute to improve the yield of grafted tomato.

Although organic manure is eco-friendly, it renders lower yield in comparison to inorganic fertilizers. In this regard, by applying organic manure in combination with inorganic fertilizer we can increase production as well as improve soil health. In addition, this combined application maximizes the use of available organic resources and minimizes the use of expensive inorganic fertilizers (Manral and Saxena, 2003; Ghosh *et al*., 2004). We hypothesized that incorporation of organic and inorganic fertilizers may provide better yield and quality of crop with improvement in soil health. Therefore, the present study was conducted to evaluate the performance of two tomato varieties with different combinations of organic and inorganic fertilizers.

Materials and Methods

Experimental site and soil

The experiment was conducted at the Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline (AEZ-13, i.e. Ganges Tidal Floodplain) of Khulna University in Khulna, Bangladesh during the period from October 2014 to March 2015. Soil samples of the experimental plots were collected from a depth of 0 to 15 cm before conducting the experiment and analyzed in SRDI laboratory at Daulatpur, Khulna. The soil was clay loam in texture having pH 7.8, organic matter content 2.03%, total nitrogen 0.125%, available phosphorus 10.20 ppm, available potassium 5.2 ppm, zinc 1.57 ppm and boron 0.75 ppm.

Treatments and design of the experiment:

Two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of 8 treatments (T) and 2 varieties (V).

Factor A: Manure and fertilizer treatments as presented in Table 1.

Factor B: Variety
V_1= BARI Tomato-14
V_2= BARI Tomato-15

Table 1. Manure and fertilizer doses per hectare as applied in different treatments

Treatment	Manure and fertilizer doses per hectare						
	Fertilizer kg/ha			Manure ton/ha			
	Urea	TSP	MoP	CD	PM	VC	MOC
T_1 = 100% RFD for N, P, and K	350.00	200.00	220.00	-	-	-	-
T_2 = 100% cowdung (CD)	-	-	-	16.00	-	-	-
T_3 = 100% poultry Manure(PM)	-	-	-	-	10.75	-	-
T_4 = 100% vermi-compost (VC)	-	-	-	-	-	16.00	-
T_5 = 100% mustard oil cake (MOC)	-	-	--	-	-	-	3.25
T_6 = 100% organic manures (25% of each of CD, PM, VC and MOC)	-	-	-	4.00	2.68	4.00	0.80
T_7 =80% organic manures (20% of each of CD, PM, VC and MOC) + 20% RFD	70.00	40.00	44.00	3.20	2.15	3.20	0.65
T_8 = 60% organic manure (15% of each of CD, PM, VC and MOC) + 40% RFD	140.00	80.00	88.00	2.40	1.60	2.40	0.48

Treatments of organic manures are based on nitrogen (N %) content

Application of manures and fertilizers

The entire amount of well decomposed cowdung, poultry manure, mustard oil cake and vermicompost were applied immediately after opening the land and the total amount of TSP was applied as basal dose during final land preparation. The urea and MoP were applied in two equal installments [21 and 35 days after transplanting (DAT)] by using ring method.

Seed sowing and intercultural operations

Five grams of seeds were sown in each seedbed (3m × 1m). Heptachlor 40 WP was applied @ 4 kg ha^{-1} in each seedbed as precautionary measure against ants and worms. Weeding, mulching and irrigation were done as and when necessary. The emergence of seedlings took place within 5 to 6 days after sowing. Healthy seedlings were uprooted from the seedbeds and transplanted in the plots (spacing 60 cm × 40 cm, 12 plants per plot) followed by watering. Various intercultural operations

such as weeding, gap filling, staking and irrigation practices were conducted as required. Malathion 57EC was applied @ 2 mL L^{-1} as preventive measure against insect pests like cut worms, leaf hoppers and fruit borers. Dithane M-45 @ 2 g L^{-1} was applied fortnightly during the early vegetative stages against diseases.

Collection of experimental data

Plant height (cm) at 15, 30, 45, 60 and 75 DAT was recorded from the ground to the tip of stem. Then the number of fruits and flowers per cluster and number of fruit and flower clusters per plant were also recorded. Fruits were harvested at 4 days interval starting from the early ripening stage to attaining red color. After that, length (cm) and diameter (cm) of twenty fruits per plot were measured by slide calipers. Weight of individual fruit and total fruits per plant (g) was eventually recorded from the selected plants by an electric balance.

Economic analysis

Total material input costs, non-material input costs, interests on fixed capital of land and miscellaneous costs were considered for calculation of total cost of production. Interest was calculated @ 12% for six months and miscellaneous cost was considered as 5% of the total input cost.

Gross income was calculated based on the sale price (Tk kg^{-1}) of marketable fruit and net return was calculated by deducting the total production cost from the gross return for each treatment combination. Benefit cost ratio (BCR) was calculated using following formula (Reddy and Ram, 1996):

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income}}{\text{Total cost of production}}$$

Analysis of data

The data were statistically analyzed by using the MSTAT-C statistical package. The analysis of variance (ANOVA) was performed by F- test, and the treatment means were separated by the Duncan's New Multiple's Range test (DMRT).

Results

Effect of variety on plant height

The significant differences in plant height at different DAT except 15 DAT were observed for selected tomato varieties. BARI Tomato-15 was significantly taller variety starting from initial stage to maturity of plant in this experiment (Figure 1).

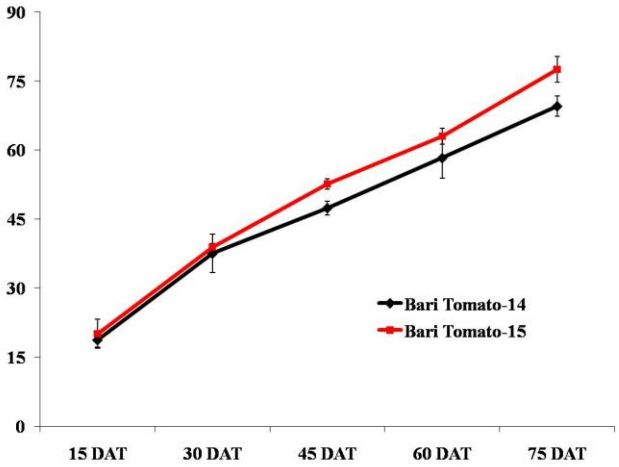

Fig. 1 Effect of variety on plant height of tomato at different growth stages

Effect of manures and fertilizer treatment on plant height

Significance difference among the plant heights were observed (P=0.01) in all the days of data collection except 15 days after transplanting. The height of the plant increased significantly with advancement of time in case of different manure and fertilizer treatments. At 75 DAT, the tallest plants (79.63 cm) were observed from the treatment T_8 (60% Organic manure + 40% RFD**)** which was statistically similar (78.63 cm) to T_1 (N, P, K RFD) and the shortest (67.13 cm) was from T_2 (100% cow dung) which was statistically similar (67.93 cm) to T_6 (100% organic manures) (Table 2).

Table 2. Effect of manures and fertilizer treatment on plant height

Treatment	Plant height (cm)				
	15DAT	30DAT	45DAT	60DAT	75DAT
T_1	20.05	40.43^{a}	52.87^{a}	64.22^{a}	78.63^{a}
T_2	19.12	36.87^{c}	47.69^{c}	57.58^{c}	67.13^{e}
T_3	19.55	39.40^{ab}	51.27^{b}	61.72^{b}	77.02^{ab}
T_4	19.58	36.37^{c}	47.73^{c}	57.52^{c}	68.80^{cd}
T_5	19.10	36.00^{cd}	47.67^{c}	57.05^{d}	68.90^{cd}
T_6	19.12	36.87^{c}	47.69^{c}	57.58^{c}	67.93^{e}
T_7	19.72	39.69^{a}	52.27^{a}	64.17^{a}	78.12^{ab}
T_8	19.45	40.18^{a}	53.00^{a}	65.20^{a}	79.63^{a}
Level of Significance	NS	0.01	0.01	0.01	0.01
CV (%)	12.25	9.54	9.20	10.10	10.33

Mean values in a column having the same letter(s) do not differ significantly whereas mean values having different letter(s) differ significantly as per DMRT. NS= Not significant, CV= Coefficient of variation

Effect of treatments and variety on plant height

The combined effect of tomato variety and fertilizer treatments on plant height at different DAT except 15 DAT were found statistically significant (Table 2). The height of the plant increased significantly with advancement of time in case of both the varieties. Both BARI Tomato-14 and BARI Tomato-15 revealed the maximum plant height (76.07cm and 84.93cm, respectively) when they were treated with 60% organic manures (15% of each of CD, PM, VC and MOC) plus 40% RFD (T_8) at 75 DAT (Table 3). In BARI Tomato-15, the second highest plant height (82.20 cm) was found in T_7 treatment [80% orgnic manures (20% of each of CD, PM, VC and MOC) + 20% RFD] which was statistically identical with the maximum height (84.93 cm) as recorded in T_8.

Table 3. Combined effect of manures and variety on plant height at different days after transplanting (DAT)

Variety x Treatment	Plant height(cm)				
	15DAT	30DAT	45DAT	60DAT	75DAT
T_1V_1	19.03	40.13 ^{b}	48.07 ^{f}	61.10^{ef}	72.63^{gh}
T_2V_1	18.30	36.03^{ef}	45.87^{gh}	55.57 ^{hi}	64.53 ^{kl}
T_3V_1	19.80	38.70 ^{cd}	47.97 ^{f}	59.13^{fg}	72.77 ^{g}
T_4V_1	18.60	35.67 ^{f}	46.10 ^{g}	55.73 ^{hi}	65.23 ^{k}
T_5V_1	18.80	36.07^{ef}	45.83^{gh}	55.73 ^{hi}	65.83 ^{k}
T_6V_1	18.35	36.03^{ef}	45.87^{gh}	55.63 ^{hi}	64.60 ^{kl}
T_7V_1	18.63	38.67 ^{c}	48.77^{ef}	60.57 ^{f}	74.33 ^{f}
T_8V_1	18.77	38.87^{c}	50.77 ^{d}	62.63 ^{e}	76.07 ^{e}
T_1V_2	20.57	41.60 ^{a}	56.47 ^{a}	67.23 ^{b}	83.60 ^{a}
T_2V_2	19.93	37.70 ^{d}	49.50 ^{e}	59.60^{fg}	71.33 ^{h}
T_3V_2	20.30	40.10 ^{b}	54.57^{bc}	64.30 ^{d}	81.27^{bc}
T_4V_2	20.33	37.07 ^{de}	49.37 ^{e}	59.30^{fg}	72.37^{gh}
T_5V_2	19.40	35.93^{ef}	49.50 ^{e}	58.37 ^{g}	71.97^{gh}
T_6V_2	19.93	37.70 ^{d}	49.50 ^{e}	59.60^{fg}	71.33 ^{h}
T_7V_2	20.27	40.50^{ab}	54.97^{bc}	65.80 ^{c}	82.20^{ab}
T_8V_2	20.40	40.73^{ab}	57.23 ^{a}	69.83 ^{a}	84.93 ^{a}
Sg. level	NS	0.05	0.01	0.05	0.05
CV (%)	12.25	9.54	9.20	10.10	10.33

Mean values in a column having the same letter(s) do not differ significantly whereas mean values having different letter(s) differ significantly as per DMRT. NS= Not significant, CV= Coefficient of variation

Effect of manuring and variety on yield and yield contributing characteristics

Two tomato varieties differed significantly on yield and yield contributing characteristics (Table 3). Though BARI Tomato-15 generated higher number of flower clustersplant^{-1} (14.23), number of flowers cluster^{-1} (12.07), number of fruit clustersplant^{-1} (6.90), number of fruits cluster^{-1} (5.68) and fruit length (5.54) while BARI Tomato-14 produced higher fruit diameter (5.46 cm), weight of individual fruit (80.74 g) and yield (59.68 t ha^{-1}). The higher fruit diameter (5.46 cm) and individual fruit weight (80.74g) may result higher fruit yield (59.68 tha^{-1}) for BARI Tomato-14.

Yield and yield contributing characteristics of tomato also differed significantly in respect of different treatments (Table 4). Among eight treatments, T_8 (60% organic manures plus 40% RFD) produced the maximum number of flower cluster plant^{-1} (14.3), number of flowers cluster^{-1} (7.25), number of fruit cluster plant^{-1} (11.72), number of fruits cluster^{-1} (6.55), fruit length (5.55cm), fruit diameter (5.40cm), individual fruit weight (82.53 g) and highest tomato yield (82.13 t ha^{-1}).

In case of combined effect of treatment and variety, two tomato varieties with different treatments differed significantly on yield and yield contributing characteristics (Table 5) of tomato. BARI Tomato-15 showed significantly better performance while they were treated with 60% organic manures plus 40% RFD. However, fruit diameter, individual fruit weight and yield were significantly higher in BARI Tomato-14 while they were treated with 60% organic manures plus 40% RFD. Specifically, maximum flower cluster plant^{-1} (16.24), number of flower cluster^{-1} (13.07), fruit cluster (8.20), fruit cluster^{-1} (6.97), maximum fruit length (5.98 cm) were observed in tomato variety of BARI Tomato-15 when treated with 60% organic manures plus 40% RFD. However, BARI Tomato-15 did not differ significantly in respect of number of flowers clusters plant^{-1} and number of flowers cluster^{-1} while they were treated with 100% organic manures and 80% organic manures.

BARI Tomato-15 showed statistically similar fruit length irrespective of the treatments. On the other hand, statistically higher yield (87.17 tha^{-1}), maximum fruit diameter (6.29 cm) and higher fruit weight (91.43 g) were recorded from BARI Tomato-14 when it was treated with 60% organic manures plus 40% RFD (Table 5).

Table 4. Effect of variety on yield and yield contributing characteristics of tomato

Variety	No. of flower cluster/plant	No.of flowers Cluster^{-1}	No. of fruit clusters plant^{-1}	No.of fruit Cluster^{-1}	Fruit length (cm)	Fruit diameter (cm)	Weight of individual fruit (g)	Yield (t ha^{-1})
BARI Tomato-14	10.24	8.68	5.51	4.68	4.33	5.46	80.74	59.68
BARI Tomato-15	14.23	12.07	6.90	5.68	5.54	4.09	67.33	52.34
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
LSD	1.34	3.33	0.60	0.54	0.63	0.57	7.78	6.57

Table 5. Effect of treatment on yield and yield contributing characteristics of tomato

Treatment	No. of flower cluster Plant^{-1}	No.of flower cluster^{-1}	No. of fruit clusters plant^{-1}	No.of fruits cluster^{-1}	Fruit Length (cm)	Fruit diameter (cm)	Weight of individual fruit (g)	Yield (t ha^{-1})
T_1	12.63ab	6.72 ab	10.57ab	5.38bc	5.23ab	5.17ab	79.43ab	69.75b
T_2	10.90cd	5.583cd	9.95 bc	4.61de	4.56bc	4.57 bc	69.82cd	41.78d
T_3	12.54ab	6.71ab	10.87ab	5.23cd	5.34ab	5.07ab	76.10ab	57.85bc
T_4	11.60bc	5.45 d	9.27cd	4.43ef	4.64 bc	4.34cd	66.30d	43.30d
T_5	9.33d	4.78d	8.66d	4.17f	4.20c	3.97d	65.4d	35.33de
T_6	13.07ab	6.27bc	10.80ab	5.03cd	4.74ab	4.55bc	71.07bc	51.13c
T_7	13.48a	6.87ab	11.17ab	6.03ab	5.24ab	5.17ab	81.55ab	66.57b
T_8	14.3 a	7.25a	11.72a	6.55a	5.55a	5.40a	82.53a	82.13a
Sig. level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	9.89	9.37	9.36	9.59	10.71	11.32	10.68	11.39

Mean values in a column having the same letter(s) do not differ significantly whereas mean values having different letter(s) differ significantly as per DMRT. CV= Coefficient of variation

Table 6. Effect of treatment and variety on yield and yield contributing characteristics of tomato

Variety x Treatment	No. of flower clusters plant^{-1}	No.of flowers cluster^{-1}	No. of fruit clusters plant^{-1}	No. of fruits cluster^{-1}	Fruit length (cm)	Fruit diameter (cm)	Weight of individual fruit (g)	Yield (t ha^{-1})
T_1V_1	10.83^{de}	8.67^{gh}	6.13^{d}	5.10^{de}	4.70^{cd}	5.92^{a}	88.53^{ab}	73.04^{b}
T_2V_1	9.27^{f}	8.07^{hi}	4.90^{ef}	4.10^{gh}	3.93^{ef}	5.13^{b}	75.50^{c}	45.90^{d}
T_3V_1	10.61^{de}	9.17^{fg}	5.93^{d}	4.53^{fg}	4.97^{bc}	5.86^{a}	83.10^{b}	60.67^{c}
T_4V_1	9.67^{ef}	7.33^{ij}	4.60f	4.00^{hi}	3.97^{ef}	4.80^{bc}	71.20^{cd}	46.03^{d}
T_5V_1	7.70^{g}	6.83^{j}	4.37^{f}	3.8^{1i}	3.23^{f}	4.75^{bc}	71.00^{cd}	39.33^{de}
T_6V_1	10.34^{ef}	9.33^{fg}	5.77^{d}	4.33^{gh}	4.14^{de}	5.03^{bc}	74.27^{cd}	53.73^{cd}
T_7V_1	11.09^{d}	9.67^{ef}	6.10^{d}	5.43^{cd}	4.60^{cd}	5.96^{a}	90.90^{a}	70.60^{b}
T_8V_1	12.37^{c}	10.37^{de}	6.30^{cd}	6.13^{b}	5.13^{ab}	6.29^{a}	91.43^{a}	87.17^{a}
T_1V_2	14.43^{b}	12.47^{ab}	7.30^{b}	5.67^{bc}	5.75^{ab}	4.413^{bc}	70.33^{cd}	66.01^{bc}
T_2V_2	12.57^{c}	11.83^{bc}	6.27^{cd}	5.13^{de}	5.18^{ab}	4.01^{de}	64.13^{ef}	37.66^{de}
T_3V_2	14.47^{b}	12.57^{ab}	7.50^{b}	5.93^{b}	5.72^{ab}	4.28^{cd}	69.10^{cd}	55.03^{cd}
T_4V_2	13.53^{bc}	11.20^{cd}	6.30^{cd}	4.87^{ef}	5.32^{ab}	3.88^{ef}	61.40^{fg}	40.56^{de}
T_5V_2	10.96^{d}	10.50^{de}	5.20^{e}	4.53^{fg}	5.17^{ab}	3.18^{f}	59.97^{g}	31.33^{e}
T_6V_2	15.80^{a}	12.27^{ab}	6.77^{c}	5.73^{bc}	5.33^{ab}	4.08d^{e}	67.87^{de}	48.53^{d}
T_7V_2	15.87^{a}	12.67^{ab}	7.63^{b}	6.63^{a}	5.88^{a}	4.38^{bc}	72.20^{cd}	62.53^{c}
T_8V_2	16.24^{a}	13.07^{a}	8.20^{a}	6.97^{a}	5.98^{a}	4.51^{bc}	73.63^{cd}	77.09^{ab}
Sig. level	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.01
CV (%)	9.89	9.37	9.36	9.59	10.71	11.32	10.68	11.39

Mean values in a column having the same letter(s) do not differ significantly whereas mean values having different letter(s) differ significantly as per DMRT. CV= Coefficient of variation

Table 7. Cost and return of tomato from application of different fertilizers

Variety X Treatment	Total cost of production (Tk./ha)	Gross Return (Tk./ha)	Net return (Tk./ha)	BCR
T_1V_1	179656	876480	696824	4.87
T_2V_1	187440	550800	363360	2.93
T_3V_1	187732	728080	540348	3.87
T_4V_1	318480	552360	233880	1.73
T_5V_1	218445	471960	253515	2.16
T_6V_1	228024	644760	416736	2.82
T_7V_1	216360	847200	630840	3.91
T_8V_1	204695	1046040	841345	5.11
T_1V_2	179656	660100	480444	3.67
T_2V_2	187440	376600	189160	2.01
T_3V_2	187732	550300	362568	2.93
T_4V_2	318480	405600	87120	1.27
T_5V_2	218445	313300	94855	1.43
T_6V_2	228024	485300	257276	2.12
T_7V_2	216360	625300	408940	2.89
T_8V_2	204695	770090	565395	3.76

Discussion

In this experiment, BARI Tomato-15 produced taller plant than BARI Tomato-14. In case of interaction effect, both of these varieties revealed the tallest plant when they were treated with 60% Organic manure and 40% RFD at 75 DAT. Similar result was obtained from Rodge and Yadlod (2009), where they found the highest tomato plant height with application of 50% Recommended dose of fertilizer and 50% Farm yard manure. Reddy *et al*. (2002) also found maximum plant height through the application of combination of organic and inorganic fertilizer. Similarly, Patil *et al*. (2004) reported the highest plant height by application of organic manure in combination with inorganic fertilizer. Islam *et al*. (2017) obtained the highest Plant height from mixed fertilizers (organic2/3+inorganic1/3) or IPNS (integrated plant nutrient system) in Roma VF.

In respect of varietal effect on yield contributing parameters BARI Tomato-15 resulted higher number of flower clusterplant^{-1}, number of flower cluster^{-1}, number of fruit clusterplant^{-1}, number of fruit cluster^{-1} and fruit length while BARI Tomato-14 produced higher fruit diameter, weight of individual fruit and yield. On the other hand, Islam *et al*. (2017) found that Roma VF produced significantly higher yield (12.8 t/ha) than BARI tomato 15 (10.1 t/ha).

Considering the effect of treatments on yield and yield contributing characters, T_8 (60% organic manures plus 40% RFD) resulted the best performance among eight treatments. Similar result obtained from Patil *et al*. (2004); Rodge and Yadlod (2009). Adekiya and Agbede (2009) stated combined use of NPK 15-15-15 fertilizer and poultry manure increased tomato yield compared to the application of NPK 15-15-15 fertilizer or poultry manure alone. Agele (2001) also found that poultry manure litters resulted in better growth and yield of tomato than NPK fertilizer alone. Qian and Schoenau (2002), and Okwugwu and Alleh (2003) reported that high and sustained crop yield could be achieved with a judicious and balanced NPK fertilizer treatment combined with organic matter amendments. The combined application of pig manure and NPK fertilizer also increased tomato fruit yield compared with pig manure or NPK fertilizer treatments alone (Giwa, 2004). Also, Adeniyan and Ojeniyi (2005) found that integrated application of poultry manure and NPK fertilizer increased maize yield compared with poultry manure or fertilizer applications alone. Similarly, Islam *et al*. (2017) concluded combined application of inorganic and organic sources of nutrients as more productive and sustainable.

The BARI Tomato-15 showed significantly better performance in respect of yield contributing parameters (maximum flower cluster plant^{-1}, number of flower cluster^{-1}, fruit cluster, fruit cluster^{-1}, Maximum fruit length) while they were treated with 60% Organic manure and 40% RFD. Whereas, fruit diameter, individual fruit weight and yield were significantly higher in BARI Tomato-14 while they were treated with60% Organic manure and 40% RFD. Reddy *et al*. (2002) found maximum number of tomato fruit per plant and maximum fruit weight with application of 50% nitrogen through Farm yard manure and 50% through Urea. Rafi *et al*. (2002) also obtained maximum fruit weight from treatment combination of 50% recommended dose of fertilizer + 50% farm yard manure. In case of benefit cost ratio, our experiment revealed maximum BCR from 60% Organic manure and 40% recommended doses of fertilizer which was coherent with the result of Reddy *et al*. (2002).

Conclusion

Combination of organic and inorganic fertilizers resulted better yield of tomato. From the findings of the present study, it may be concluded that integrated application of 60% organic manures and 40% RFD can provide the best results for growth and yield of tomato. This study suggests that the effect of these manures can compensate up to 60% reduction of recommended fertilizers. Hence, both organic and inorganic fertilizers should be used by the farmers for profitable tomato production. However, further trials in different locations of the country with other treatment combinations are necessary before final recommendation at farmer's level.

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