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Effect of Organic and Inorganic Fertilizers on Soil Properties and the Growth, Yield and Quality of Tomato in Mymensingh, Bangladesh

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Abstract: Field trials were conducted on tomato for yield and quality of fruits using different types of organic and inorganic fertilizers at the horticulture farm of Bangladesh Agricultural University (BAU), Mymensingh. Fertilizer treatments were tested on two varieties of tomato ca. Roma VF and BARI 15. The fertilization treatments were T_1, vermicompost (12 t/ha); T_2, compost (10 t/ha); T_3, integrated plant nutrient system (IPNS) or mixed fertilizers (organic 2/3 part and inorganic 1/3 part); T_4, inorganic fertilizers; and a control (T_5). Results showed growth and yield (20.8 t/ha) in tomato were higher in the IPNS treatment. A higher number of fruits per plant (73.7) and plant height (73.5 cm) were obtained from mixed fertilizers (organic 2/3 + inorganic 1/3) or IPNS (integrated plant nutrient system) in Roma VF than other treatments. Fruit yield and diameter were found statistically significant. No significant difference was observed in the quality (total soluble solids) of tomato fruits in both varieties' response to the treatments. The electrical conductivity and pH of the soil were improved by the application of organic manure.

Keywords: compost; nutrient management; production; sustainable; vegetables

1. Introduction

The organic production system aims at supporting and sustaining healthy ecosystems, soil, farmers, food production, the community, and the economy. Reduction and elimination of the adverse effects of synthetic fertilizers and pesticides on human health and the environment is a strong indicator that organic agriculture is gaining worldwide attention [1,2]. Organic fertilizers are environmentally friendly, since they are from organic sources [3]. The current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. The cost of inorganic fertilizers is increasing enormously, to the extent that they are out of reach for small and marginal farmers. The organic fertilizers provide nutritional requirements, suppress plant pest populations, and increase the yield and quality of agricultural crops in ways similar to inorganic fertilizers [4–10]. Solaiman and Rabbani [11] reported results and their findings on the application of a combination of cow dung and a half dose of inorganic fertilizer. Bio fertilizers such as *Trichoderma* enriched with inorganic fertilizers play a significant role in the growth and yield of crops, e.g., mustard and tomato, and have the potential to reduce 50% of the cost of inorganic fertilizers [12]. Microorganisms or plant growth promoting rhizobacteria (*Bacillus* spp) inoculant help to reduce the application of inorganic

fertilizers and contribute to improving soil fertility and reducing a negative environmental impact [13]. Organic fertilizers contain macro-nutrients, essential micro-nutrients, vitamins, growth-promoting indole acetic acid (IAA), gibberellic acid (GA) and beneficial microorganisms [14]. The sustainability of conventional agriculture in Bangladesh is under threat from the continuous degradation of land and water resources and from declining yields due to the indiscriminate use of agro-chemicals. Soil quality has been affected by excessive applications of chemical farming in Bangladesh [15]. Tomato (*Solanum lycopersicum*) is one of the important vegetable crops grown throughout the world and ranks next to the potato and sweet potato in terms of area, but ranks first as a processing crop [16]. The cultivated area under tomato was 18.8 thousand hectares with a total production in Bangladesh of 251 thousands metric tons [17]. Tomato is grown in the summer and winter seasons in Bangladesh; however, production varies in various regions due to varieties, seasons, climatic conditions, planting times, management practices and soil properties [18,19]. Ahammad et al. [20] found that planting time and varietal selection influenced tomato production from 4.51 to 55.91 t/ha. The objective of this research project was to evaluate the effect of organic and inorganic fertilizers combined on the growth, yield and quality of tomato and on soil properties.

2. Materials and Methods

An open-field experiment was conducted at the Horticulture Farm (24°26′ and 24°54′ N latitude and 90°15′ and 90°30′ E longitude), Bangladesh Agricultural University (BAU), Mymensingh in Fall 2014 to Spring 2015.

Two factors experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The double factor experiment consisted of 5 treatments (T) is presented in Table 1:

Table 1. Fertilizer treatments and doses.

Treatments (T)	Dose/ha
Vermicompost (T_1)	12 ton
Compost (T_2)	10 ton
Integrated plant nutrient system (IPNS)/Mixed fertilizers (T_3)	(organic 2/3 + inorganic 1/3); 8 ton vermicompost + N = 40 kg, P = 14 kg, K = 24 kg, S = 5 kg, Zn = 0.7 kg, B = 700 g
Inorganic fertilizers (T_4)	N = 120 kg, P = 40 kg, K = 70 kg, S = 15 kg, Zn = 2 kg, B = 1 kg
Control (T_5)	No fertilizers and manures

Two varieties of tomato ca Roma VF (V_1) and BARI tomato 15 (V_2) were selected for the study. Soil samples were collected from the experimental field before and after research trial and analyzed at the Agrivarsity Humboldt Soil Testing Laboratory (Table 2). Seeds were sown in nursery beds (3 m × 1 m), one seedbed/variety. Weeding, mulching and watering in seedbeds were done as needed. Seedlings germinated within a week and transplanted (25 days) in the field. Plant spacing kept at 80 cm × 60 cm) in the field plots (2.8 m × 1.8 m) and watered. Vermicompost and compost was applied during land preparation. Urea, MoP, TSP, Borax and Zn fertilizers were applied at recommended doses in the inorganic plots (Table 1). Nitrogen and potassium was applied in two equal splits at 15 and 35 days after transplanting (DAT). The research plot was irrigated after fertilizer application. Botanical pesticides (neem extract) were used to control the insect pests and diseases except the T_4 experimental plot where inorganic fertilizers and fungicide (Dithane M-45 @2 g/L fortnightly during the early vegetative stage) were applied. Staking was done with bamboo sticks to support tomato plants. Data were collected from five plants of nine planted in each plot (one replication).

Table 2. Soil nutrients before planting and after harvesting of tomato.

	pH	EC (µc/cm)	O.M (%)	N (%)	P (ppm)	K (ppm)	S (ppm)	Clay (%)	Slit (%)	Sand (%)	Soil Texture
Before planting	6.43	72.54	2.55	0.11	15.38	47.13	13.18	6.15	62.62	35.40	Silt loam
After harvesting	6.68	98.54	2.60	0.11	15.54	50.13	13.18	6.15	62.62	35.40	Silt loam

Plant height (15, 35 and 45 DAT) was recorded (cm) from the ground to the tip of stem. Data on number of fruits, flower clusters and number of fruit clusters per plant were recorded. Twenty fruits per plot and replication were measured for fruit length (cm) and fruit diameter (cm) by caliper. Total seven harvest recorded from 20 January to 15 February. Fruits were harvested at the maturing index (when fruits become 10% red color) and stored at the horticulture research laboratory, and total soluble solid (TSS) recorded from the marketable fruits. Mean comparisons between treatments were performed by the least significant difference (LSD) test. All statistical calculations were performed using F-variance test, statistical significance was indicated at 5% and 1% level of probability [21].

3. Results and Discussion

The analysis of variance results showed that the effect of mixed fertilizers on tomato yield was significant ($p < 0.01$). Higher yields were obtained from mixed fertilizer treatments compared to the control (no fertilizer application). The application of T_3 (mixed fertilizers, organic 2/3 + inorganic 1/3) produced the highest number of flower clusters (31.2), fruit clusters (24.9), fruit yield (15.3 t/ha) and plant height (71.6 cm). T_5 (control or no fertilizer) had the lowest number of flower clusters per plant (27.22), number of fruit clusters per plant (20.1 cm), yield (9.4 t/ha) and plant height (62.1 t/ha).

The plant height was significantly different in different fertilizer treatments between varieties. The maximum plant height (73.5 cm) was recorded in the IPNS (organic 2/3 + inorganic 1/3) application (Figure 1) in variety 1 (Roma VF) (Figure 2). IPNS treatment produced a 38.5% higher yield compared to the control. Similarly, 7.3%, 8.2%, 21.8% higher yields were recorded in the vermicompost, compost and chemical fertilizer applications respectively, compared to the control (Table 3). The results obtained concur with earlier findings reported by Patil et al. [22] and Reddy et al. [23]. The mixed fertilizer treatment was the best for tomato production, which could be interpreted as the release of nutrients from organic and inorganic fertilizers at different times. Fertilizer treatment (mixed or IPNS) produced a higher yield compared to organic fertilizers and inorganic fertilizers alone in cabbage [24] and in eggplant [25].

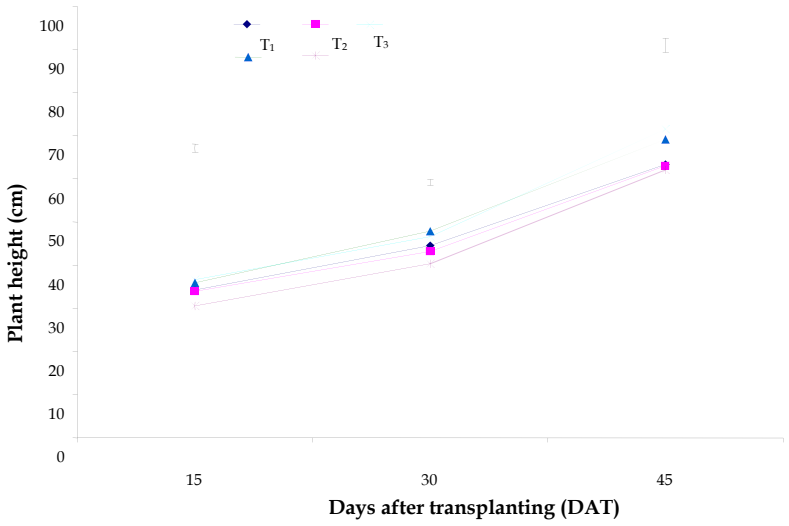

Figure 1. Effect of fertilizer treatments on plant height on different days after transplanting (DAT). Vertical bars represent Least Significant difference (LSD) at 1% level of probability. T_1 = Vermicompost, T_2 = Compost, T_3 = Integrated plant nutrient system (IPNS) (organic 2/3 + inorganic 1/3), T_4 = Inorganic fertilizers, T_5 = Control.

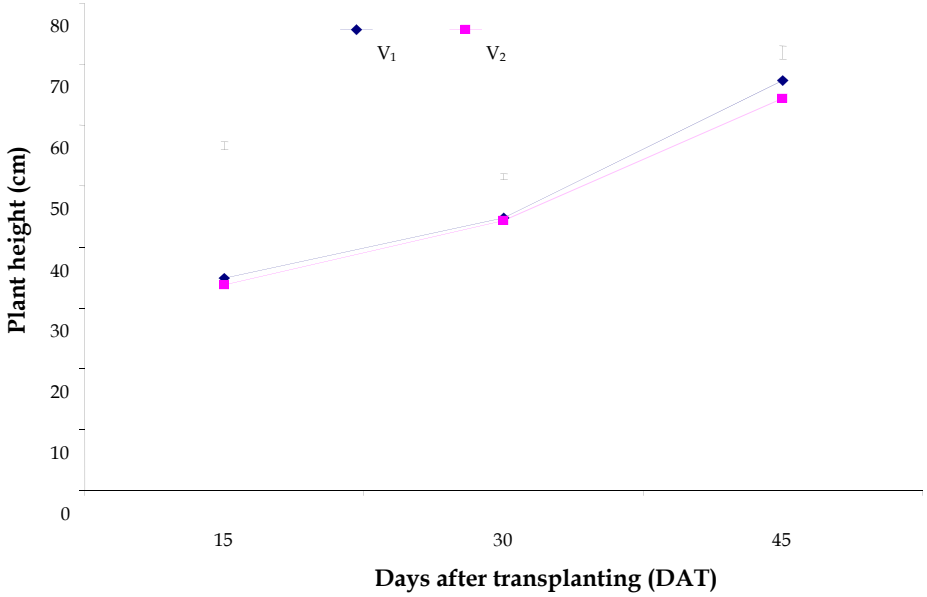

Figure 2. Plant height of two tomato varieties on different days after transplanting (DAT). Vertical bar represents LSD at 1% level of probability (V_1 = Roma VF and V_2 = BARI tomato 15).

Table 3. Effect of various fertilizer treatments on tomato growth, fruit characteristics and yield.

Treatment	No of Fruits per Plant	No of Flower Clusters per Plant	No of Fruit Clusters per Plant	Fruit Length (cm)	Fruit Diameter (cm)	Yield (t/ha)
T_1	47.23	30.22	18.50	5.44	4.62	10.20
T_2	58.28	27.22	24.11	5.21	4.61	10.30
T_3	61.06	31.28	24.95	5.45	4.84	15.39
T_4	64.12	27.89	22.39	5.32	4.62	12.09
T_5	48.61	27.61	20.17	5.20	4.64	9.46
$LSD_{0.05}$	2.311	0.933	0.674	0.094	0.054	0.467
$LSD_{0.01}$	3.166	1.278	0.924	0.129	0.074	0.639
Level of significance	**	**	**	**	**	**

** indicate at the 1% level of significance.

Fertilizers and variety treatments influenced the number of fruits per plant. A higher number of fruits (73.7) was recorded in var. Roma VF (V1T3) with the mixed fertilizer treatment (organic 2/3 + inorganic 1/3), while the lowest number (41.3) was obtained in the control (no fertilizer) of the BARI tomato 15 (V_2T_5). Plant height of 61.1 cm was recorded in variety BARI tomato 15 in the control group (no fertilizer, V_2T_5) (Table 4). Both Roma VF (V_1) and BARI 15 (V_2) varieties showed enhanced performance with IPNS or mixed fertilizer applications. The results indicate that mixed fertilizers produced improved yield in tomato varieties. A high yield per hectare (15.3 t/ha) was obtained in T_3 (Mixed, organic 2/3 + inorganic 1/3), 12.1 t/ha in inorganic fertilizer (T_4), 10.2 t/ha in vermicompost (T_1) and 9.4 t/ha in compost (T_2) applications. Roma VF had significantly higher yields (12.8 t/ha) than BARI tomato 15 (10.1 t/ha). The maximum fruit yield (20.8 t/ha) was obtained from the mixed fertilizers (organic 2/3 + inorganic 1/3) with Roma VF (V_1T_3) and the minimum (8.4 t/ha) from the control (no fertilizer) with BARI tomato 15 (V_2T_5) (Table 5). The fruit length and diameter were higher under the IPNS treatment. Both varieties produced higher numbers of flower clusters and fruit clusters per plant. These findings trended significantly towards the higher production of tomato under the IPNS.

Roma VF produced a significantly higher yield (12.8 t/ha) than BARI tomato 15 (10.1 t/ha). A high fruit yield (20.8 t/ha) was obtained in the mixed fertilizer application (organic 2/3 + inorganic 1/3) for Roma VF (V_1T_3) and the lowest yield (8.4 t/ha) was obtained in the control (no fertilizer) with

BARI tomato 15 (V_2T_5). A significant difference in the fruit length and diameter was recorded in the two varieties. Flower and fruit clusters per plant were higher in Roma VF. The higher number of flower and fruit clusters per plant in both varieties was observed in the IPNS application (T_3). Combined effect of fertilizers and variety treatment observed higher yield in Roma VF, and the highest production under IPNS treatment of both varieties.

The improved yield in tomato in the combination of cow dung and inorganic fertilizer has been reported [11] in the literature. The enhanced performance of integrated nutrient management practices has been reported in vegetables such as brinjal, cabbage and mustard [12,24,25]. The application of the mixed fertilizer strategy and bio fertilizer *Trichoderma*-enriched fertilizer or the inoculation of rhizobacteria is gaining popularity in Bangladesh [12,13]. It has been found that microorganisms and plant growth promoting rhizobacteria (PGPR) *Bacillus* spp. enhance nutrient availability, nutrient use efficiency and increase the growth and yield of plants. Plant growth may be influenced by some PGPR through synthesizing plant hormones or facilitating the uptake of nutrients from the soil by different direct mechanisms, e.g., atmospheric nitrogen (N) fixation, solubilization of phosphorus (P), and synthesis of siderophores for iron sequestration, making nutrients available to plants [26,27].

Table 4. Combined effects of fertilizers and varieties on yield, plant height and fruits measurements.

Treatment Combination [1]	Plant Height (cm) at DAT [2]			No of Fruits per Plant	No of Flower Cluster per Plant	No of Fruit Clusters per Plant	Fruit Length (cm)	Fruit Diameter (cm)	Yield (t/ha)
	15	30	45						
V_1T_1	33.61	43.75	63.95	47.89	33.11	17.56	5.47	4.68	11.16
V_1T_2	32.07	42.10	62.59	70.44	28.22	25.44	5.21	4.62	10.12
V_1T_3	41.61	51.27	73.53	73.78	36.11	30.78	5.58	4.89	20.84
V_1T_4	35.97	45.10	73.38	60.67	28.89	22.89	5.29	4.69	11.71
V_1T_5	31.21	41.68	63.31	55.89	30.22	23.22	5.32	4.74	10.45
V_2T_1	35.05	45.32	62.82	46.56	27.33	19.44	5.40	4.56	9.23
V_2T_2	35.85	44.23	63.53	46.11	26.22	22.78	5.20	4.59	10.49
V_2T_3	30.23	44.72	64.87	48.33	26.44	19.11	5.32	4.79	9.94
V_2T_4	37.50	48.26	69.81	67.56	26.89	21.89	5.35	4.54	12.48
V_2T_5	30.06	39.09	61.07	41.33	25.00	17.11	5.08	4.53	8.47
$LSD_{0.05}$	1.247	0.932	2.189	3.268	1.320	0.954	5.47	4.68	11.16
$LSD_{0.01}$	1.708	1.276	2.999	4.477	1.808	1.306	5.21	4.62	10.12
Level of significance [3]	**	**	**	**	**	**	**	**	**

[1] T_1 = Vermicompost, T_2 = Compost, T_3 = Integrated plant nutrient system (IPNS) (organic 2/3 + inorganic 1/3), T_4 = Inorganic fertilizers, T_5 = Control, V_1 = Roma VF, V_2 = BARI tomato 15, [2] DAT: Days after transplanting, [3,**] indicate at the 1% level of significance.

Table 5. Fruit characteristics and yield in tomato varieties.

Variety	No of Fruits per Plant	No of Flower Clusters per Plant	No of Fruit Clusters per Plant	Fruit Length (cm)	Fruit Diameter (cm)	Yield (t/ha)
V_1	61.73	31.31	23.98	5.37	4.72	12.85
V_2	49.98	26.38	20.07	5.27	4.60	10.12
$LSD_{0.05}$	1.462	0.590	0.426	0.059	0.034	0.295
$LSD_{0.01}$	2.002	0.809	0.584	0.081	0.047	0.404
Level of significance	**	**	**	**	**	**

** indicate at the 1% level of significance, V_1 = Roma VF, V_2 = BARI tomato 15.

The total soluble solid (TSS) of Roma VF (V_1) and BARI 15 (V_2) was 9 and 10, respectively. Fertilizer treatments did not significantly influence the TSS of the tomato, and fruit quality was not affected in various fertilizer treatments.

4. Conclusions

This study illustrates that combinations of mixed fertilizers or an integrated plant nutrient system (IPNS) produced the best results on plant growth, fruit measurements and yield of both varieties Roma VF and BARI 15. On the other hand, Roma VF produced higher quality attributes and yield over the BARI tomato 15. Combined applications of organic and inorganic sources of nutrients are more productive and sustain soil fertility. For the determination of an appropriate ratio of organic and inorganic sources, the experiment may be repeated at different locations for different varieties of tomato.

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Author Contributions: M. Ashraful Islam designed field experiment, conducted data analysis and prepared manuscript. Sumiya Islam assisted in the field data collection. Ayasha Akter helped in writing manuscript. M. Habibur Rahman helped in design and manuscript review. D. Nandwani overall supervised the project.

Conflicts of Interest: The authors declare no conflict of interest.

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