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Consequence of Organic- Inorganic Fertilizer on the Growth and Yield Performance of Tomato

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Abstract: An experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during November 2011 to March 2012 to assess the consequence of organic-inorganic fertilizer on the growth and yield performance of tomato (*Lycopersicon esculentum*). The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications and 9 different treatment combinations. The treatments were, T_1 - 180 kg N/ha from Urea + 25kg P/ha from TSP + 60kg K/ha from MoP (Only inorganic); T_2 - 155 kg N/ha from Urea+ 25kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP; T_3 - 130 kg N/ha from Urea + 50kg N/ha from Cowdung + 25kg P/ha from TSP+ 60kg K/ha from MoP; T_4 - 105 kg N/ha from Urea + 75kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP; T_5 - 80 kg N/ha from Urea + 100kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP; T_6- 55 kg N/ha from Urea + 125kg N/ha from Cowdung+ 25kg P/ha from TSP + 60kg K/ha from MoP; T_7 - 30 kg N/ha from Urea + 150kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP; T_8 - 180 kg N/ha from Cowdung and T_9 - Control. BARI Tomato-2 variety was used for the experiment. Data were collected from different parameter. The tallest plant (67.03 cm) and maximum number of leaves per plant (98.89) was recorded from treatment T_4, while the shortest plant (47.50 cm) and minimum number of leaves per plant (61.59) was obtained from control treatment. The highest number of fruits per plant (67.07) was obtained with treatment T_5 and the lowest number of fruits per plant (38.51) was produced by control treatment. Plant receiving N at the rate of 80 kg/ha from Urea+100 kg/ha from cowdung (T_5) gave significantly higher yield (77.39 t/ha). The lowest yield (44.43 t/ha) was recorded in control treatment. The highest concentration of N and P in plant was 1.63% and 0.386% which was observed in treatment T_4 and T_1, respectively. On the contrary, the lowest N (0.82%) and P (0.124%) content was found in control treatment. In case of post harvest soil, the highest total N content (0.081 %), available P (25.67 ppm) and available sulphur (14.45 ppm) was found in the treatment T_1, T_4 and T_5. The lowest total N (0.05%), available P (20.60 ppm) was found in control treatment and available sulphur (11.28 ppm) was obtained from T_2 treatment. From the present study it can be concluded that integrated application of N from both organic and inorganic sources found to be positive and significant on the growth and yield performance of tomato.

Key words: Nitrogen · Urea · Tomato · Integrated · Yield

INTRODUCTION

Tomato (*Lycopersicon esculentum*), belonging to the family Solanaccae, is one of the most popular vegetables grown in Bangladesh. It is originated in tropical America and ranks third in terms of world vegetables production [1] and tops the list of canned vegetables [2]. It is adapted to a wide range of climates ranging from tropic to within a few degree of the Arctic Circle. It is a nutritious and delicious vegetable used in salads, soups and processed into stable products like ketchup, sauce, marmalade, chutney and juice. These are extensively used in canning industry for canning. Nutritive value of the fruit is an important aspect of quality of tomato and public demand. Food value of tomato is very rich because of higher contents of vitamins A, B and C including Calcium and Carotene [3]. Tomato flavor to the foods and it is also rich in medicinal value. The soil and winter season climatic condition of Bangladesh is congenial for tomato cultivation. Among the winter vegetable crops in Bangladesh, tomato ranks second in respect of production and third in respect of area [4]. A wide range of latitude, soil types and methods of cultivation is suitable for tomato production.

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Recent statistics showed that tomato was grown in 50470 acres of land of Bangladesh and the total production was approximately 150720 metric tons in 2008-2009 [5]. Thus the average yield of tomato was 7.38 t/ha [5], while it was 69.41 t/ha in USA, 14.27 t/ha in India, 26.13 t/ha in China, 13.25 t/ha in Indonesia and 9.26 t/ha in Japan. The low yield of tomato in Bangladesh, however, is not an indication of low yield potentiality of this crop, but the fact that the lower yield may be attributed to a number of reasons, viz., unavailability of quality seeds of improved varieties, improper management of fertilizers, irrigation, disease control etc. Proper fertilizer management practices can improve this situation. Nitrogen, phosphorus and potassium fertilizer significantly increased the yield of tomato [6]. The farmers of Bangladesh used only nitrogen, phosphorus, potassium and sulphur fertilizer for the cultivation of tomato. The importance of the use of micro nutrient is mostly ignored although it can be a chief limiting factor for crop production.

Organic manure plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms by mineralization, improving the physical and physiological properties of soils. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter [7]. Organic manure improves the soil structure, aeration which support root development leading to higher growth and yield of tomato plants. Both macro and micro nutrient like calcium, boron, manganese, molybdenum and iron are important for tomato cultivation. Biologically active soils with adequate organic matter usually supply enough of these nutrients. Presently there has been great increase of fertilizer use, yet the proportion of different nutrients used in the country is not at all balanced. N along constitutes about 78% of the total nutrients used in the country which may not help improve crop productivity unless other limiting nutrients are supplemented along with nitrogen. In order to improve crop productivity, the limiting micronutrient(s) must be identified and the soils should be enriched with addition of these nutrients in properly balanced fertilizer programmed. Integrated nutrient management (INM) integrates the use of all natural and man- made sources of plant nutrients, so that productivity and nutrient status of food increases in an efficient and environmentally benefiting manner without sacrificing soil productivity of future generations. Considering the above facts, the present research was undertaken to evaluate the consequence of organic-inorganic fertilizer on the growth and yield performance of tomato.

MATERIALS AND METHODS

Experimental Site: The experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during November 2011 to March 2012 to examine the consequence of integrated nutrient application on the growth and yield performance of tomato. The soil of the experimental site belongs to Tejgaon series under the Agro-ecological Zone Madhupur Tract (AEZ - 28), which falls under Deep Red-Brown Terrace soil under Bangladesh soil classification system.

Soil Characteristics: The textural class of soil was silty clay loam having pH 5.8 and contains organic matter 0.98%, total nitrogen 0.07%, available phosphorus 25.0 ppm, exchangeable potassium 0.15 meq./100g soil and available sulphur 20.0 ppm. The climate is characterized by heavy rainfall during May to September and scant rainfall during rest of the year. The average maximum temperature is 30.34°C and average minimum temperature is 21.21°C. The average mean temperature is 25.17°C. The experiment was done during the robi season. BARI Tomato-2, a variety released by BARI was used for the experiment. Seedlings were collected from Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Treatment of the Experiment: The treatments are as follows:

T_1 - 180 kg N/ha from Urea + 25kg P/ha from TSP + 60kg K/ha from MoP (Only inorganic)
T_2 - 155 kg N/ha from Urea+ 25kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP
T_3 - 130 kg N/ha from Urea + 50kg N/ha from Cowdung + 25kg P/ha from TSP+ 60kg K/ha from MoP
T_4 - 105 kg N/ha from Urea + 75kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP
T_5 - 80 kg N/ha from Urea + 100kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP
T_6 - 55 kg N/ha from Urea + 125kg N/ha from Cowdung+ 25kg P/ha from TSP + 60kg K/ha from MoP
T_7 - 30 kg N/ha from Urea + 150kg N/ha from Cowdung + 25kg P/ha from TSP + 60kg K/ha from MoP
T_8 - 180 kg N/ha from Cowdung
T_9 - Control

Design and Layout of the Experiment: The experiment was laid out in a Randomized Complete Blok Design (RCBD) with three replications. Treatments consist of 8 levels of N and single level of P & K. An area of

12m×23m was divided into 3 equal blocks. The layout of the experiment was prepared for distributing the treatment combinations into the every plot of each block. There were 27 unit plots altogether in the experiment. The size of the each plot was $6m^2$ (3 m × 2 m). The distance maintained between two blocks and two plots were 1 m and 0.5 m respectively. At first the land was leveled and the weeds, crop residues and stubbles were removed from the field. After final land preparation the experimental plot was laid out.

Application of Manure and Fertilizer: The sources of N were urea and cowdung, the sources of P_2O_5, K_2O was TSP and MoP, respectively. The entire amounts of well decomposed cowdung, TSP and MoP were applied during the final land preparation. As per treatment combination urea was applied in three equal installments at 15, 30 and 45 days after transplanting.

Seedling Transplanting and Intercultural Operation: Healthy and uniform sized 30 days old seedlings were transplanted in the experimental field maintaining a spacing of 60cm×55cm. The seedlings were watered after transplanting. Shading was provided by banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop for gap filling and to check the border effect. Weeding and irrigation was done several times when necessary.

Harvesting: Fruits were harvested at 5 days intervals during maturity to ripening stage. The maturity of the crop was determined on the basis of red coloring of fruits. Harvesting was started from 6 March, 2012 and completed by 29 March, 2012.

Data Collection: Five plants from each plot were selected randomly and were tagged for the data collection. The sample plants were uprooted and dried properly in the sun. Data were collected on plant height, number of leaves per plant, number of fruits per plant, yield per plot (kg) and yield per hectare (t).

Soil Sample Analysis

Particle Size Analysis of Soil: Particle-size analysis of the soil was done by hydrometer method [8]. The textural class was determined using Marshall's Triangular Co-ordinate as designated by USDA.

Organic Carbon (%): Organic carbon of soil was determined by [9] wet oxidation method. The underlying principle is to oxidize the organic carbon with an excess of 1 N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1 N $FeSO_4$ solution. The result was expressed in percentage.

Soil Organic Matter: Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 [10].

Soil pH: The pH of the soil was determined with help of a glass electrode pH meter using soil: water ratio being 1: 2.5 [11].

Total Nitrogen (%): Total nitrogen content in soil was determined by Kjeldahl method by digesting the soil sample with conc. H_2SO_4 , 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 100: 10: 1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 [12].

Available Phosphorus (ppm): Available Phosphorus was extracted from soil shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 [13]. The phosphorus in the extract was than determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdenum blue color was measured at 660 nm wave length by spectrophotometer and available P was calculated with the help of standard curve.

Available Sulphur: Available Sulphur in soil was determined by extracting the soil sample with 0.15 % $CaCl_2$ solution [14]. The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wave length.

Pant Sample Analysis: For determination of N and P content in plant, sample was first digested with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. 5H2O: Se = 100: 10: 1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4. An amount of 0.5g of plant was taken into a dry clean 100 ml Kjeldahl flask, 10 ml of di-acid mixture (HNO_3 and $HClO_4$ at the ratio of 2: 1) was added and kept for few minutes. Then, the flask was heated at a temperature rising slowly up to 200°C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling, 6 ml of 6 N HCl was added to it. The content of the flask was boiled until they become clear and colorless. This digest was used for determining N and P.

Statistical Analysis: The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameter was done. The significance of the differences among the pairs of treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 1% and 5% level of probability [15] for the interpretation of results.

RESULTS AND DISCUSSIONS

Effect of Integrated Nutrient Management on Growth and Yield of Tomato

Plant Height: Effect of integrated use of organic manure and inorganic fertilizers on plant height of tomato was significantly increased by different levels of nitrogen (Table 1). The tallest plant (67.03 cm) was produced with treatment T_5 which was statistically similar with treatment T_4, T_6 and T_7. Shortest plant (47.50 cm) was found in control treatment. It was observed that plant height increased gradually with the increasing level of nitrogen up to 105 kg/ha from Urea. This might be due to higher availability of N and their uptake that progressively enhanced the vegetative growth of the plant. These are in agreement with those [16, 17] who have reported that different levels of nitrogen significantly increased plant height.

Number of Leaves per Plant: Effect of organic manure and inorganic fertilizers exhibited a significant influence on number of leaves per tomato plant (Table 1). The maximum number (98.89) of leaves per plant was obtained from T_4 treatment, while the minimum (61.59) was obtained from control treatment. It was observed that the application of N up to 105 kg/ha from Urea increased number of leaves per plant. Further addition of N decreased the number. Similar results were recorded by other investigators [18, 19].

Table 1: Effect of organic and inorganic fertilizer on plant height and number of leaves per plant of tomato

Treatments	Plant height/plot (cm)	Number of leaves per plant
T_1	52.09d	70.78e
T_2	55.83c	79.35d
T_3	58.85b	89.56c
T_4	66.56a	98.89a
T_5	67.03a	88.70c
T_6	65.66a	88.89c
T_7	65.89a	94.62b
T_8	50.68d	70.80e
T_9	47.50e	61.59f
CV(%)	2.43	2.82
LSD	3.42	5.12

Number of Fruits per Plant: Statistically significant result was found on number of fruit per plant by the application of organic and inorganic fertilizers (Table 2). Number of fruits per plant gradually increased with increasing levels of nitrogen up to 105 kg/ha. The highest number of fruits per plant (67.07) was obtained with the application of 80 kg N/ha from urea + 100 kg N/ha from CD, which was statistically different from other treatments. On the other hand, the lowest number of fruits per plant (38.51) was produced by control treatment. It was observed that the application of N up to 105 Kg/ha from urea increased number of fruits per plant. Further addition of N decreased the number of fruits per plant [20]. In some cases 120 kg N/ha gave highest number of fruits per plant.

Yield (kg/plot): Integrated effect of organic and inorganic fertilizers on yield per plant varied significantly due to the application of different levels of N in tomato (Table 2). Fruit yield per plant increased with increasing levels of N up to 105 kg/ha from urea. The highest fruit yield per plot (46.43 kg) was obtained in T_5 treatment and the lowest fruit yield per plot (26.66 kg) was recorded in control treatment [21]. Increasing levels of nitrogen increased the fresh weight of tomato fruit.

Yield (ton/ha): Plant receiving N at the rate of 80 kg/ha from Urea + 100 kg/ha from cowdung (T_5) gave significantly higher yield (77.39 t/ha), which was statistically similar with the treatment T_6. The lowest per hectare yield (44.43 t/ha) was recorded in control treatment.

Effect of Integrated Nutrient Management on Nutrient Content in Tomato Plants

Nitrogen Content in Plants: Effect of organic manure and inorganic fertilizers on N content of plant was positive and significant (Figure 1). The highest N content in plant was 1.63%, which was observed in T_4 treatment. The lowest N content in plant was 0.82%, which was found in control treatment. The result revealed that the N content in plant was increased with increasing rate of nitrogen up to 105 kg/ha from Urea, further addition of nitrogen it was decreased.

Phosphorus Content in Plants: There was a significant difference found among the different treatments of N in respect of P content in plants (Figure 1). Maximum P content of 0.386% was found in T_1 treatment and the minimum P content of 0.124 % was found in control treatment.

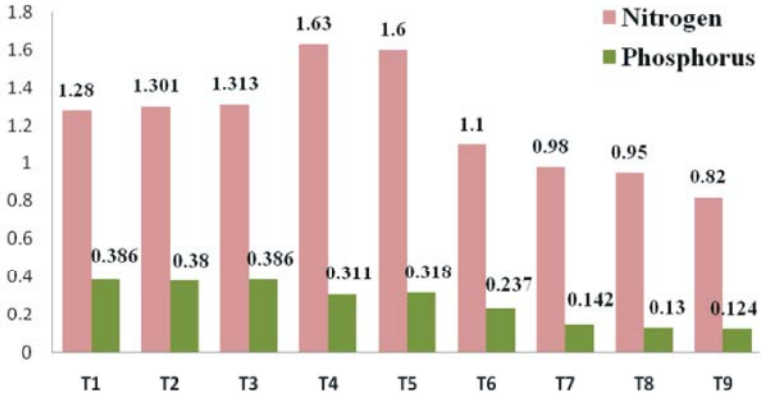

Fig. 1: Effect of organic and inorganic fertilizer on nutrient content in tomato plant

Table 2: Effect of organic and inorganic fertilizer on number of fruits per plant, yield per plot and yield per hectare

Treatment	Number of fruits per plant	Yield per plot (kg)	Yield/ha (Ton)
T_1	48.8f	33.78d	56.31c
T_2	53.96e	37.36c	62.26b
T_3	56.67d	39.23b	65.39b
T_4	64.89b	44.92b	74.87b
T_5	67.07a	46.43a	77.39a
T_6	66.5c	46.04a	76.73a
T_7	62.5b	43.27b	72.12b
T_8	49.7f	34.41d	57.35c
T_9	38.51g	26.66e	44.43c
CV(%)	3.19	5.39	4.41
LSD	7.21	2.14	0.73

Table 3: Effect of organic and inorganic fertilizer on nutrient content of post harvest soil

	Nutrient concentration in post harvest soil		
Treatments	Total N (%)	Available P (ppm)	Available S (ppm)
T_1	0.081a	22.60a	12.37bcd
T_2	0.070abc	23.20a	11.28d
T_3	0.073abc	24.01a	12.00bcd
T_4	0.076ab	25.67a	11.80cd
T_5	0.067a-d	24.80a	14.45a
T_6	0.062b-e	23.72a	13.89ab
T_7	0.060cde	22.70a	13.60abc
T_8	0.055de	21.09a	13.58abc
T_9	0.05e	20.60b	12.50abc
CV(%)	3.37	0.92	2.05
LSD	2.16	0.24	0.20

Effect of Integrated Nutrient Management in Post Harvest Soil

Nitrogen Content: Different level of nitrogen showed a significant variation for total nitrogen content in soil under the present trial (Table 3).The maximum total nitrogen (0.081%) was recorded from T_1 and the minimum total nitrogen (0.05%) in soil is recorded from T_8 treatment.

Available Phosphorus Content: Different levels of nitrogen showed a significant variation for available P content in soil under the present trial (Table 3). The highest P content in soil was 25.67 ppm which was observed in T_4 treatment and it was statistically similar with T_5 and T_2 treatment. The lowest P content in soil was (20.60 ppm) found in control treatment.

Available Sulphur Content: Different levels of nitrogen showed a significant variation for available S in soil under the present trial. The highest sulphur content in soil was 14.45 ppm, which was observed inT_5 treatment and it was statistically similar with T_6, T_7, T_8 and T_9 treatments. The lowest sulphur content in soil was 12.28 ppm, which was found in T_2 treatment (Table 3).

CONCLUSION

From the abovementioned discussion it is evident that effect of integrated organic and inorganic fertilizers at different levels created a significant impact on growth, yield and nutrient content of tomato plants. The tallest plants, highest number of fruits per plant and highest

yield was produced with 80 kg N/ha from urea and 100kg N/ha from cowdung (T_5 treatment). It was observed that plant height, number of fruits per plant and yield increased gradually with the increasing level of nitrogen up to 80 kg N/ha from urea. Further addition of N above 80 kg/ha decreased the yield of tomato. Plant receiving N at the rate of 105 kg/ha from urea (T_4) produced significantly higher yield. In terms of post harvest soil nutrient status, integrated application of urea and cowdung gave better performance compared to single application of urea. For optimum growth and productivity of Tomato, application of 80 kg N/ha from urea with 100kg N/ha from cowdung might be the best possible treatment combination.

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