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Enhancement of Growth and Yield of Tomato by Poultry Manure

M. Islam[1], M.G. Kibria[2] and K.T. Osman[3*]
[1,2,3] *Department of Soil Science, University of Chittagong, Chittagong-4331, Bangladesh*

Abstract
A field experiment was conducted to study the enhancement of growth and yield of tomato by poultry manure (PM) in combination with or without inorganic fertilizers. Two tomato (Lycopersicon esculentum) varieties BARI-14 and BARI-15 were used in this experiment. There were six treatments- T1(control; no poultry manure + no fertilizer), T2 (100% RDF; i.e. recommended doses of fertilizers NPK@ 120 kg N ha^{-1}, 60 kg P ha^{-1} and 80 kg K ha^{-1}, T3 (30 t ha^{-1} PM i.e. poultry manure), T4 (75% RDF+ 7.5 t ha^{-1} PM), T5 (50% RDF + 15 t ha^{-1} PM) and T6 (25% RDF + 22.5 t ha^{-1} PM). The treatments were arranged in a randomized block design with three replications. The data collected were plant height, number of branches plant^{-1} and number of leaves plant^{-1}, number of fruits plant^{-1}, single fruit weight and yield. The results showed that application of poultry manure or recommended doses of fertilizer alone and their different combinations significantly increased plant height, number of branches plant^{-1} and number of leaves plant^{-1}. The number of fruits plant^{-1}, single fruit weight, weight of fruits plant^{-1} and fruit yield ha^{-1} were significantly increased by application of poultry manure alone @ 30 t ha^{-1} and its different combination with NPK fertilizers but not by 100% RDF. The combined use of NPK fertilizers and poultry manure proved most effective in ensuring good performance in growth and yield of tomato compared to NPK fertilizers or poultry manure alone and is therefore recommended for sustainable productivity in valley soils of Chittagong.

Key words: *Growth, yield, tomato, poultry manure.*

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I. Introduction

Tomato (*Lycopersicon esculentum* P. Mill) is the second most important vegetable around the world, next to potato [1]. The major tomato growing countries are China, USA, Italy, Turkey, India and Egypt. Total area under tomato is 4582438 thousand ha with production of 150513813 thousand tons and with productivity of 32.8 tons/ha. It occupies an important place in healthy daily diet. In terms of total contribution of vitamins and minerals to the diet, tomato outranks all others mainly because of the large volume consumed both in fresh and processed forms. It is consumed either raw as salad or cooked. It is used for seasoning vegetables, curries and to impart them special color, flavour, taste and is used in many other ways. Tomato is adapted to wide range of soils and grown extensively during winter season in Bangladesh. However, the average yield of tomato in Bangladesh is very low as compared to neighboring country like India and Pakistan [2]. Higher production of tomato depends upon adoption of high yielding varieties, appropriate crop management practices and balanced fertilization, timely irrigation, control of diseases and insect pests. Sustainable agriculture is a system of food production that excludes the use of synthetic fertilizers and pesticides and use of environmentally friendly organic inputs. According to Olatunji *et al*.[3], the application of organic manure had been found to have higher comparative economic advantage over the use of inorganic fertilizer. A study conducted by Nwajiuba and Akinsanmi [4], in Southeastern Nigeria, showed that returns per ha were higher in organic farms though outputs were slightly less in inorganic farms.

Poultry manure is capable of enhancing soil fertility since it is a good depositor of major and minor mineral elements [5]. It is primarily considered as a nitrogen source and to a lesser extent potassium too. Its application is believed to improve soil physical properties and enhances nutrient cycling as it exerts direct enzymatic or hormonal effects on plant roots thereby inducing growth [6, 7]. Recently there has been boost in poultry production in Bangladesh which leads to piling of poultry wastes. This constitutes environmental pollution and health hazards. Several studies carried out in Nigeria and elsewhere confirm poultry manure as effective nutrient sources for increasing yield and nutrient status of crops such as maize, amaranths, sorghum and pepper [8, 9] and it also improves soil fertility and physical properties. The suitability and usefulness of poultry manure as an organic fertilizer has been attributed to high availability of NPK content it contains [10]. However, research information is scarce on response of tomato, nutrient composition and yield to application of

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poultry manure in the Chittagong hilly region of Bangladesh. With these views in mind the objectives of this study was to determine the optimum rate of poultry manure and its effect on growth characteristics and yield of tomato relative to the recommended level of NPK fertilizer in the valley soils of Chittagong.

II. Materials and Methods

2.1 Pot experiment

A field experiment was conducted to study the effects of poultry manure and NPK fertilizers on growth and yield of tomato at research field of the Department of Soil Science, University of Chittagong. The treatments consisted of as the following:

T1 = Control (No fertilizer + No poultry manure)

T2 = 100% RDF (100% recommended dose of fertilizers NPK @ 120 kg N ha^{-1}, 60 kg P ha^{-1} and 80 kg K ha^{-1}) according to BARC (2005)

T3 = PM (poultry manure) @30 ton ha^{-1}

T4 = 75% RDF (NPK @ 90 kg N ha^{-1}, 45 kg P ha^{-1} and 60 kg K ha^{-1}) + 7.5 ton ha^{-1} PM

T5= 50% RDF (NPK @ 60 kg N ha^{-1}, 30 kg P ha^{-1} and 40 kg K ha^{-1})+ 15 ton ha^{-1} PM, and

T6= 25% RDF (NPK @ 30 kg N ha^{-1}, 15 kg P ha^{-1} and 20 kg K ha^{-1}) + 22.5 ton ha^{-1} PM

The whole experimental land was divided into unit plots maintaining the desired spacing. The whole area of the experimental land was divided into 3 blocks and each block was again subdivided into 12 unit plots (for 2 varieties× 6 treatments). Thus the total number of plots was 36. The experiment was laid out in a randomized complete block design with three replication of each treatment. The unit plots were 2 m×2 m size separated by 0.5 m margin. Seeds of two tomato varieties of BARI-14 and BARI-15 were collected from Bangladesh Agricultural Research Institute and the seedlings of the two tomato cultivars were raised in nursery bed. Thirty days old seedlings were transplanted in the main plots. The space between rows to row was 50 cm and seedling to seedling within a row was 40 cm. Poultry manure (PM) was collected from a poultry farm at Fatehpur in Chittagong. Poultry manure was applied in the plots before 3 weeks of transplantation. According to the recommendation of Bangladesh Agricultural Research Council [11], nitrogen and potassium was applied in two equal installments at 15 and 35 days after transplanting as ring method around the plants followed by irrigation. Full phosphorus was broadcast and incorporated during final land preparation.

2.2 Properties of soil and poultry manure

Surface soil sample was collected before conducting the experiment from the experimental site. Poultry manure (PM) was collected from a poultry farm at Fatehpur in Chittagong and separated some amount of poultry manure for laboratory analysis. Soil texture was determined by hydrometer method of Day [12], pH in a 1:2.5 soil/water suspension with glass electrode pH mater, organic carbon by wet-oxidation method [13], total nitrogen by Micro-Kjeldahl digestion and distillation and CEC by 1N NH_4OAC saturation [14], and available phosphorus by Bray and Kurtz II method [15]. Properties of soil and poultry manure are given in Table.1.

Table 1 Properties of soil and poultry manure

Properties	Value
Soil	
Texture	Clay loam
Sand	33%
Silt	19%
Clay	48%
pH	5.10
Cation exchange capacity(CEC)	8.76 cmol kg^{-1},
Total nitrogen	0.12%
Available P (Bray & Kurtz II)	12 mg kg^{-1}
Poultry manure	
pH	7.65
Total nitrogen	0.28%
Available P (Bray & Kurtz II)	14.17 mg kg^{-1}

2.3 Growth and yield components

Plant height, number of branches per plant and number of leaves per plant were recorded after 30 and 45 days after transplanting to assess the plant growth. The fruits were harvested at 3 to 4 days interval when matured and ripped. The number of fruits $plant^{-1}$, weight of fruits $plant^{-1}$, single fruit weight, and yield per unit area were recorded after harvest.

2. 4 Statistical analysis

The collected data were subjected to analysis of variance, and treatment means were compared using Duncan's Multiple Range Test (DMRT) at a 5% probability level. The statistical software Excel [16] and SPSS version 12[17] were used for these analyses.

III. Results and Discussion

3. 1 Plant height

Plant height is one of the most important characteristics of tomato plant. The plant height of tomato was measured after 30 and 45 days after transplantation (DAT) of tomato seedlings and the results are presented in the (Table 2). The range of plant height varied from 50 to 74 cm in BARI-14 and 68.00 to 92.00 cm in BARI-15 varieties at 30 DAT. At 45 DAT, the corresponding values were 64.33 to 95.33 cm in BARI-14 and 84.00 to108.00 cm in BARI-15 variety. The results indicated that there were significant variations in plant height among the treatments of both the varieties of this study. The plant height was the minimum in T1 (control) treatment and the maximum in T3 (poultry manure@ 30 ton ha^{-1}) treatment in both varieties at both 30 and 45 DAT. Addition of poultry manure and inorganic fertilizers alone or in their combinations significantly increased plant height than that of the control in both the varieties. However, the plant height with application of poultry manure @ 30 ton ha^{-1} (T3) was significantly higher than that with 100% RDF (T2) and with different combination of NPK fertilizers and poultry manure (T4, T5 and T6). There were no significant differences between the treatments of T5 (50% RDF + 15 ton ha^{-1} PM) and T6 (25% RDF+22.5 ton ha^{-1} PM) in producing plant height of both the varieties at both 30 and 45 DAT. The result of the present study is corroborated with the findings of Adekiya and Agbede [18] who reported that poultry manure and NPK fertilizer alone and NPK fertilizer + poultry manure significantly increased plant height of tomato. Plant height was better in BARI-15 variety than BARI-14 variety.

Table 2 Effects of poultry manure and NPK fertilizers on plant height of tomato

Variety	Treatment	Plant height (cm)	
		30 DAT	45 DAT
BARI-14	T1	50.00 i	64.33 g
	T2	55.00 h	77.67 f
	T3	74.00 cd	95.33 c
	T4	63.33 g	83.67 e
	T5	67.33 f	85.00 e
	T6	69.00 ef	90.00 cde
BARI-15	T1	68.00 f	84.00 e
	T2	73.00 de	89.00 de
	T3	92.00 a	108.00 a
	T4	77.67 c	93.67 cd
	T5	85.33 b	101.33 b
	T6	87.00 b	103.00 ab

Mean values in a column followed by the same letter(s) are not significantly different by DMRT ($p<0.05$)

3.2 Number of branches

The average number of branches $plant^{-1}$ was counted at 30 and 45 DAT. The number of branches $plant^{-1}$ is presented in Table 3. The average number of branches $plant^{-1}$ ranged significantly from 10.67 to 19.33 and 22.67 to 30.00 in BARI-14 and 14.67 to 23.33 and 27.33 to 37.00 in BARI-15 at 30 and 45 DAT, respectively. The highest number of branches $plant^{-1}$ in both BARI-14 and BARI-15 was recorded in T3 (30 ton ha^{-1} PM) treatment both at 30 and 45 DAT and the lowest number of branches $plant^{-1}$ was recorded in control treatment. Application of poultry manure and NPK fertilizers alone or in their different combinations significantly increased the number of branches $plant^{-1}$ than that with the control. Decreasing the proportion of recommended doses of NPK fertilizers and increasing poultry manure increased the number of branches $plant^{-1}$ over 100% RDF (T2) except in BARI -14 at 45 DAT. However, the number of branches $plant^{-1}$ of BARI-14 were statistically similar with each other among the treatments T4 (75% RDF + 7.5 ton ha^{-1} PM), T5 (50% RDF + 15 ton ha^{-1} PM) and T6 (25% RDF + 22.5 ton ha^{-1} PM) at 30 DAT. Similar results were found in BARI-15. However, the number of branches $plant^{-1}$ found with these treatments was significantly higher in BARI-15 than those in BARI-14 variety.

Table 3 Effects of poultry manure and NPK fertilizers on number of branches plant^{-1}.

Variety	Treatment	Number of branches plant^{-1}	
		30 DAT	45 DAT
BARI-14	T1	10.67 g	22.67 f
	T2	13.67 f	26.33 e
	T3	19.33 bc	30.00 c
	T4	15.67 def	25.67 e
	T5	16.33 de	26.67 e
	T6	17.00 d	29.33 cd
BARI-15	T1	14.67 ef	27.33 de
	T2	17.67 cd	31.33 c
	T3	23.33 a	37.00 a
	T4	19.67 bc	34.00 b
	T5	20.33 b	34.33 b
	T6	21.00 b	35.33 ab

Mean values in a column followed by the same letter(s) are not significantly different by DMRT ($p<0.05$)

3.3 Number of leaves

The average number of leaves plant^{-1} was counted at 30 and 45 DAT. The average number of leaves plant^{-1} in BARI-14 varied significantly from 115 to 150 and 274 to 382 at 30 and 45 DAT, respectively (Table 4). The corresponding numbers of leaves plant^{-1} were in the ranges from 151 to 186 and 305 to 420 in BARI-15. The highest number of leaves plant^{-1} was found in treatment T6 and T3 at 30 and 45 DAT respectively in both BARI-14 and BARI-15. The lowest number of leaves plant^{-1} was recorded in control treatment both at 30 and 45 DAT. Addition of NPK fertilizers and poultry manure alone or in different combinations significantly increased the number of leaves plant^{-1} over control in both the tomato varieties. The number of leaves plant^{-1} with 30 ton ha^{-1} PM was significantly higher than that with 100% RDF in BARI-14 and BARI-15 both at 30 and 45 DAT. There were no significant differences among the treatments T2 (100% RDF), T4 (75% RDF +7.5 ton ha^{-1} PM) and T5 (50% RDF + 15 ton ha^{-1} PM) in producing the number of leaves plant^{-1} in BARI-14 at 30 DAT. Similar results were found in BARI-15variety. The numbers of leaves plant^{-}at 45 DAT were statistically similar among the treatment T3 (30 ton ha^{-1} PM), T5 (50% RDF + 15 ton ha^{-1} PM) and T6 (25% RDF +22.5 ton ha^{-1} PM^{1}) in BARI-14 and BARI-15. Adekiya and Agbede [18] found that poultry manure @ 30 ton ha^{-1} gave the highest number of leaves of tomato where poultry manure @ 10, 20, 30 and 40 ton ha^{-1} alone, NPK @300 kg ha^{-1} alone and NPK150 kg ha^{-1}+10 ton ha^{-1} PM were applied. It was observed that BARI-15 variety had shown comparatively better performance in producing the number of leaves plant^{-1} than BARI-14 variety in the present study.

Table 4 Effects of poultry manure and NPK fertilizers on number of leaves plant^{-1}.

Variety	Treatment	Number of leaves plant^{-1}	
		30 DAT	45 DAT
BARI-14	T1	115 e	274 g
	T2	132 d	307 ef
	T3	149 c	382 b
	T4	133 d	319 e
	T5	140 d	379 b
	T6	150 c	375 b
BARI-15	T1	151 c	305 f
	T2	168 b	336 d
	T3	185 a	420 a
	T4	169 b	349 c
	T5	176 b	409 a
	T6	186 a	413 a

Mean values in a column followed by the same letter(s) are not significantly different by DMRT ($p<0.05$)

3. 4 Number of fruits

Number of fruits plant^{-1} is the most important yield attributing character of tomato plant. The observed results are presented in the Table 5. The value of total number of fruits plant^{-1} ranged from 42.55 to 102.06 in BARI-14 and 65.72 to 160.23 in BARI-15. The highest number of fruits plant^{-1}was observed in treatment T6 where poultry manure @ 22.5 ton ha^{-1} was applied in combination with 25% RDF (NPK @ 30 kg N ha^{-1}, 15 kg P ha^{-1} and 20 kg K ha^{-1}). The lowest number of fruits plant^{-1} was observed in control treatment T1 where no fertilizer and no poultry manure was applied. Application of 100% RDF (T2) did not significantly increase the number of fruits plant^{-1} from that of the control. But poultry manure alone @ 30 ton ha^{-1} (T3) and its combination with NPK fertilizer in treatment T4 (75% RDF + 7.5 ton ha^{-1} PM), T5 (50% RDF + 15 ton ha^{-1} PM) and T6 (25 % RDF + 22.5 ton ha^{-1} PM) produced significantly higher number of fruits plant^{-1} compared to control treatment (T1). However, the treatments T3 (30 ton ha^{-1} PM), T5 (50% RDF + 15 ton ha^{-1} PM) and T6 (25 % RDF + 22.5 ton ha^{-1} PM) were statistically similar with each other in producing the number of fruits plant^{-1} in both the tomato varieties in the present study.

Table 5 Effects of poultry manure and NPK fertilizers on number and weight of fruits.

Variety	Treatment	Number of fruits plant^{-1}	Single fruit weight (g)	Weight of fruits plant^{-1} (kg)
BARI-14	T1	42.55 d	55.96 de	2.49 e
	T2	49.10 d	58.54 cde	2.96 de
	T3	97.64 bc	66.53 abc	6.51 bc
	T4	70.42 cd	67.82 ab	4.73 cd
	T5	96.81 bc	68.85 a	6.67 abc
	T6	102.06 b	59.95 bcd	6.12 c
BARI-15	T1	65.72 d	41.98 g	2.85 de
	T2	69.52 cd	43.91 fg	3.15 de
	T3	168.10 a	49.90 efg	8.41 ab
	T4	107.63 b	45.23 fg	4.90 cd
	T5	158.57 a	51.63 def	8.20 ab
	T6	160.23 a	54.23 de	8.69 a

Mean values in a column followed by the same letter(s) are not significantly different by DMRT ($p<0.05$)

The results of the present study are in agreement with the findings of Adekya and Agbede[18] who reported the increased number of fruits plant^{-1} by poultry manure alone and NPK fertilizer + poultry manure application compared to the control. Although the number of fruits plant^{-1} of BARI-14 were statistically similar to that of BARI-15 variety obtained with both of the treatments T1 and T2; but significantly higher numbers of fruits plant^{-1} were found in BARI-15 variety as compared to BARI-14 variety with the treatments T3, T4, T5 and T6.

3. 5 Single fruit weight

The single fruit weight of tomato varied from 55.96 to 68.85 g in BARI-14 and 41.98 to 54.23 g in BARI-15 variety (Table 5). The highest single fruit weight in BARI-14 and BARI-15 was found with treatment T5 (50% RDF + 15 ton ha^{-1} PM) and T6 (25% RDF + 22.5 ton ha^{-1} PM) respectively while the lowest single fruit weight in both the varieties was found with control treatment T1. A significantly higher single fruit weightin BARI-14 was found with treatments T3 (30 ton ha-1 PM), T4 (25% RDF + 7.5 ton ha-1 PM) and T5 (50% RDF + 15 ton ha-1 PM) as compared to the control but there were no significant differences among these treatments. Application of 25% RDF + 22.5 ton ha^{-1} PM (T6) in BARI-15 significantly increased the single fruit weight compared to the control. Single fruit weight of BARI-14 variety was significantly higher than that of BARI-15 variety with all the treatments except T6 (25% RDF + 22.5 ton ha^{-1} PM).

3. 6 Weight of fruits plant^{-1}

Weight of fruits plant^{-1} varied from 2.49 to 6.67 kg in BARI-14 and 2.85 to 8.69 kg in BARI-15 (Table 5). The minimum weight of fruits plant^{-1} in both the varieties was observed with control treatment T1 and the maximum weight of fruits plant^{-1} was found with T5 (50% RDF + 15 ton ha^{-1}PM) in BARI-14 and with T6 (25% RDF + 22.5 ton ha^{-1}PM) in BARI-15. Application of 100% RDF (T2) did not significantly increase the weight of fruits plant^{-1} in both the varieties compared to the control. Application of poultry manure alone @ 30 ton ha^{-1} (T3) and its combination with different rates of RDF (T4, T5 and T6) significantly increased weight of fruits plant^{-1} from that of the control treatment T1 in both the varieties. However, there was no significant difference among the treatments T3 (30 ton ha^{-1} PM), T5 (50% RDF + 15 ton ha^{-1}PM) and T6 (25% RDF + 22.5 ton ha^{-1}PM). Between two varieties, weight of fruits plant^{-1} of BARI-15 was significantly higher than that of BARI-14 variety when 25% RDF + 22.5 tons ha^{-1}PM (T6) was applied. There was no significant variation in weight of fruits plant^{-1} between two varieties with treatments T1, T2, T3, T4 and T5. This might be due to the cause of lower number of fruits plant^{-1} but higher single fruit weight of BARI-14 than those of BARI-15 variety.

3. 7 Yield of tomato

Yield is the most important characteristics for the justification of evaluation of tomato genotypes and varieties. The tomato yields by the application of poultry and NPK fertilizer alone or their different combination under this study are presented in Table 6. It was observed that yield of tomato varied from 37.30 to 100.10 ton ha^{-1} in BARI-14 and 42.75 to 130.40 ton ha^{-1} in BARI-15 by the treatments. The highest yield of tomato was found with application of 50% RDF + 15 ton ha^{-1} PM (T5) and 25% RDF + 22.5 ton ha PM (T6) in BARI-14 and BARI-15, respectively. The lowest tomato yield was observed with control treatment T1 where no NPK fertilizer or poultry manure was applied in both the varieties. Application of 100% RDF (T2) did not significantly increase tomato yield from that of the control neither in BARI-14 nor in BARI-15. But application of poultry manure alone @ 30 ton ha^{-1} (T3) and its different combination with recommended doses of NPK fertilizer in treatment T4 (75% RDF +7.5 ton ha^{-1} PM), T5 (50% RDF+ 15 ton ha^{-1} PM) and T6 (25% RDF+ 22.5 ton ha^{-1} PM produced significantly higher yields in both the varieties compared to control treatment (T1).

However, the treatments T3, T5 and T6 were statistically similar with each other in producing yield of tomato in both BARI-14 and BARI-15.

Yield increase of tomato by application of poultry manure and NPK fertilizers over control was in the ranges from 19.16 to 168.36% in variety BARI-14 and from 10.53 to 205.03 % in variety BARI-15 (Table 4.10). The minimum increase was observed with the application of 100% RDF in both the varieties while the maximum increase was found with application of 50% RDF + 15 ton ha^{-1} PM (T5) in BARI-14 and with application of 25% RDF + 22.5 ton ha^{-1} PM (T6) in BARI-15 compared to control treatment. Yield increase with 100% RDF (19.16% in BARI-14 and 10.53% in BARI-15) over control did not differ significantly from that of the control treatment T1. Yield increase in treatment T3 (30 ton ha^{-1} PM), T5 (50% RDF + 15 ton ha^{-1} PM) and T6 (25% RDF + 22.5 ton ha^{-1} PM) were statistically similar with each other but they were significantly higher than those in treatment T1 (control), T2 (100%RDF) and T4 (75% RDF +7.5 ton ha^{-1} PM) in both the varieties.

This study agrees with the findings of Adekiya and Agbede[18] who reported the best performance of tomato in terms of growth and yield under NPK fertilizer + poultry manure application. The significant increases in yield components of tomato due to poultry manure and NPK fertilizers in relative to control were also reported by Adeniyan and Ojeniyi [8] and Adeniyi and Ademoyegun[19]. Hossain *et al*.[20]) found that integrated application of poultry manure and NPK fertilizer increased maize yield compared with poultry manure or fertilizer applications alone. Ayoola and Adeniyan[21] reported that nutrients from mineral fertilizers enhance the establishment of crops, while those from mineralization of organic manure promoted yield when both fertilizers were combined. There was no significant differences of tomato yield between two varieties with the treatments except T6 (25% RDF + 22.5 tons ha^{-1}PM). Tomato yield of BARI-15 was significantly higher than that of BARI-14 variety with 25% RDF + 22.5 tons ha^{-1}PM (T6) application.

Table 6 Effects of poultry manure and NPK fertilizers on tomato yield.

Variety	Treatment	Yield (ton $ha^{-1)}$	Yield increase (%)
BARI-14	T1	37.30 e	0.00 e
	T2	44.45 de	19.16 de
	T3	97.60 bc	161.66 a
	T4	71.00 cd	90.35 bc
	T5	100.10 abc	168.36 a
	T6	91.80 c	146.11 ab
BARI-15	T1	42.75 de	0.00 b
	T2	47.25 de	10.53 b
	T3	126.15 ab	195.09 a
	T4	73.50 cd	71.93 b
	T5	123.00 ab	187.72 a
	T6	130.40 a	205.03 a

Mean values in a column followed by the same letter(s) are not significantly different by DMRT ($p<0.05$)

IV. Conclusion

Application of poultry manure alone or in combination with NPK fertilizers significantly increased growth and yield of tomato compared to the control in valley soils of Chittagong. Poultry manure@ 22.5 ton ha^{-1} + 25% RDF (NPK @ 30 kg N ha^{-1}, 15 kg P ha^{-1} and 20 kg K ha^{-1}) proved most effective in ensuring good performance in terms of yield of tomato. The BARI-15 variety gave better yield than BARI-14.

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