Yield and Economic Analysis of Tomato (*Lycopersicon Esculentum Mill.*) as Influenced by Potassium and Stem Pruning

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Abstract- The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during October 2012 to March 2013 to determine the effect of potassium and stem pruning on yield and economic analysis of tomato. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of two factors: Factor A: K_0=0 kg K_2O/ha, K_1=150 kg K_2O/ha, K_2=160 kg K_2O/ha and K_3=170 kg K_2O/ha; Factor B: P_0=No pruning; P_1=One stem pruning; P_2=Two stem pruning and P_3=Three stem pruning. In case of potassium, K_3 produced the highest yield (65.96 t ha^{-1}) and lowest yield (43.83 t ha^{-1}) was from K_0. For pruning, P_3 produced the highest yield (66.86 t ha^{-1}) and lowest yield (52.32 t ha^{-1}) was obtained from P_1. For combined effect, K_3P_3 produced the highest yield (74.77 t ha^{-1}) while the minimum yield (32.62 t ha^{-1}) was found from K_0P_0. The highest benefit cost ratio (3.72) was recorded from K_3P_3 and the lowest (1.17) was recorded from K_0P_0. It may be concluded that 170 kg K_2O ha^{-1} with three stem pruning was found suitable for growth and yield of tomato.

Index Terms- Tomato, potassium, pruning, yield and economic analysis.

I. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a member of Solanaceae family is one of the important, popular and nutritious vegetables grown in Bangladesh during winter season and cultivated mostly in all parts of the country [1]. At present, tomato ranks third, next to potato and sweet potato, in terms of world vegetable production [2]. Bangladesh produced 0.60 million tons of tomato in 0.15 million hectares of land and the average yield being 9.4 t ha^{-1} [3]. The yield of tomato in our country is not satisfactory enough in comparison to requirement [4]. The low yield of tomato in Bangladesh, however, is not an indication of low yielding ability of this crop, but of the fact that the tomatoes grown here are not always of high yielding cultivars and that the cultural practices commonly used by the growers are not improved. Potassium is especially important in a multi nutrient fertilizer application [5]. Potassium application increases the flower number, the peduncle length, the fruit set and the number of fruit [6]. It has marked effect on the quality of tomato fruits particularly on colour [7, 8]. Potassium also has an important role on balancing physiological activities. Tomato plant can be severely pruned without affecting the yield [9]. Proper pruning method gives the best quality and early fruit in tomato [10]. Although pruning needs extra cost, the practice could increase the economic return by increasing yields and improvement of the quality of fruits [11]. Pruning and training in tomato plants are practiced in certain areas of the United States, especially in some parts of the Southern States and in few other regions [12]. But majority of the tomato growers of Bangladesh have little knowledge about the advantage of pruning in tomato production. Pruning associated with different levels of potassium is an important factor for successful tomato production. However, the combined effects of these production practices have not been defined clearly and the information in this respect is meager in Bangladesh. Therefore, in accordance with recent agricultural policy to increase yield vertically and to get early yield and better quality fruit, an attempt was made to study the effects of different levels of potassium and different degrees of stem pruning for the following objectives: (i) to find out the suitable combination of potassium level and pruning practices for ensuring the maximum yield and (ii) to find out the suitable economic combination of potassium level and pruning practices for tomato cultivation.

II. MATERIALS AND METHODS

The experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during the period from October 2012 to March 2013. The location of the experimental site was at 23.75‘N latitude and $90^0$34‘E longitude with an elevation of 8.45 meter from sea level. Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with P^H 5.8-6.5, ECE-25.28 [13].

The tomato variety used in the experiments was "Ratan". This is a high yielding indeterminate type and the seeds were collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipur. Tomato seedlings were raised in five seedbeds of 3 m x 1m size. The experiment consisted of two factors as follows: factor A: K_0 = Control treatment (No fertilizer), K_1 =150 kg K_20 ha^{-1} (250 kg MP ha^{-1}), K_2 =160 kg K_20 ha^{-1}) (266 kg MP ha^{-1}) and K_3 =170 kg

K_20 ha^{-1} (284 kg MP ha^{-1}) and factor B: P_0=No pruning, P_1=One stem pruning, P_2=Two stem pruning and P_3 =Three stem pruning. The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. There were 48 unit plots in the experiment. The size of each plot was 3.2 m x 2 m. The soil was well prepared and good tilth was ensured for commercial crop production. Urea, triple super phosphate (TSP) and Muriate of potash (MoP) were applied as the source of nitrogen, phosphorus and potassium respectively as per treatment in each plot. Potassium was applied as per treatment and Urea and TSP was applied at the rate of 550 kg ha^{-1} and 450 kg ha^{-1} [14]. The quantity of manure, cow dung was also determined as recommended at the rate of 10 t ha^{-1} [15]. Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and maintaining a spacing of 50 cm x 40 cm between the rows and plants respectively. This allowed an accommodation of 32 plants in each plot. Fruits were harvested at 3 days intervals during early ripe stage when they attained slightly red color.

Ten plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. The cost of production was analyzed in order to find out the most economic treatment of potassium and pruning. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple interest rate. The market price of tomato was considered for estimating the cost and return. Analyses were done according to the procedure determining by Alam *et al.* [16]. The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

The collected data were analyzed with the help of MSTAT-C program and mean values of all the parameters were adjusted by Duncan's Multiple Range Test (DMRT) at 5% level of probability [17].

III. RESULTS AND DISCUSSION

Number of fruits per plant

Number of fruits per plant differed significantly due to the application of different level of potassium. Table 1 showed that number of fruits per plant increased with increasing potassium levels. The maximum (37.08) number of fruits per plant was recorded from K_3 (170 kg K_2O ha^{-1}), while the minimum (26.19) number of fruits per plant was obtained from K_0 (0 kg K_2O ha^{-1}) (Table 1). Number of fruits per plant varied significantly due to pruning. The maximum number of fruits per plant (35.33) was recorded from P_3 (Three stem pruning), while the minimum (27.05) was found from P_1 (one stem pruning) (Table 1). Sharfuddin and Ahmed [18] noted that plants under un-pruned treatment produced maximum number (36) of fruits plant^{-1} which was antagonistic to the present study. Combined effect of potassium and pruning showed significant differences on number of fruits per plant. The maximum number of fruits per plant (40.89) was recorded from K_3P_2 (170 kg K_2O + two stem pruning) and the minimum (15.89) was obtained from the treatment combination of K_0P_1 (no potassium + one stem pruning) (Table 1).

Table 1. Effect of potassium and pruning on yield contributing characters and yield of tomato

Treatment(s)	Number of fruits per plant	Diameter of fruit (cm)	Weight of Individual fruit (g)	Yield per plot (kg)	Yield (ton/ha)
Potassium					
K_0	26.19 c	5.17 b	77.03 c	28.05 c	43.83 c
K_1	32.52 b	5.85 a	89.89 b	37.15 b	62.18 b
K_2	34.46 ab	5.92 a	97.70 ab	40.41 a	64.05 a
K_3	37.08 a	6.15 a	102.45 a	42.22 a	65.96 a
$LSD_{(0.05)}$	2.961	0.296	8.770	2.216	1.728
Pruning					
P_0	33.97 a	5.64 b	86.89 b	34.97 bc	54.19 bc
P_1	27.05 b	6.40 a	103.26 a	33.49 c	52.32 c
P_2	34.11 a	5.47 b	86.25 b	36.57 b	57.53 b
P_3	35.33 a	5.67 b	90.67 b	42.79 a	66.86 a
$LSD_{(0.05)}$	2.729	0.239	8.170	2.234	1.528
Potassium × Pruning					
K_0P_0	25.22 d	4.94 de	66.33 f	20.88 g	32.62 g
K_0P_1	15.89 e	5.37 c-e	73.69 ef	22.62 g	35.34 g
K_0P_2	29.78 cd	4.73 e	80.58 d-f	30.26 f	47.27 f
K_0P_3	33.89 a-c	5.64 c	87.53 c-e	38.46 c-e	60.09 c-e
K_1P_0	34.22 a-c	5.74 c	84.96 c-f	38.39 c-e	59.98 c-e
K_1P_1	30.54 b-d	6.70 ab	103.93 bc	35.57 de	55.58 de
K_1P_2	31.81 b-d	5.62 c	83.32 c-f	33.95 ef	53.05 ef
K_1P_3	34.11 a-c	5.50 cd	87.47 c-e	40.74 b-d	63.55 b-d
K_2P_0	35.55 a-c	5.84 c	92.98 b-e	39.90 b-d	62.30 b-d
K_2P_1	30.77 b-d	6.73 ab	112.30 ab	38.42 c-e	60.03 c-e

K_2P_2	34.50 a-c	5.73 c	88.03 c-e	39.16 b-e	61.19 b-e
K_2P_3	37.78 ab	5.79 c	97.89 b-d	44.19 ab	69.05 ab
K_3P_0	40.89 a	6.05 bc	103.45 bc	40.83 b-d	63.68 b-d
K_3P_1	31.71 b-d	6.97 a	123.13 a	37.34 de	58.35 de
K_3P_2	40.55 a	5.85 c	93.83 b-e	42.92 bc	67.07 bc
K_3P_3	35.61 a-c	5.63 c	88.99 c-e	47.85 a	74.77 a
$LSD_{(0.05)}$	6.278	0.615	18.24	4.570	5.421
CV (%)	11.54	6.36	11.92	7.42	7.42

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Weight of individual fruit

Weight of individual fruit differed significantly due to the application of different level of potassium. Table 1 showed that weight of individual fruit increased with increasing potassium levels. The maximum weight of individual fruit (102.45 g) was recorded from K_3 (170 kg K_2O ha^{-1}), while the minimum weight (77.03 g) was recorded from K_0 (0 kg K_2O ha^{-1}) (Table 1).Weight of individual fruit showed significant differences due to pruning. The maximum weight of individual fruit (103.26 g) was recorded from P_1 (one stem pruning), while the minimum (86.25 g) was found from P_2 (two stem pruning) (Table 1). Kusumo [19] obtained larger and smooth skin when the plants were restricted to single stem it was found that fruit size increased when plants were pruned. Rajendra and Patil [20] obtained maximum fruit weight (89.19 g) in case of single stem pruned plant while fruit weight was lowest (63.07) in un-pruned plants. Combined effect of potassium and pruning showed statistically significant differences for weight of individual fruit. The maximum individual fruit weight (123.13 g) was recorded from K_3P_1 (170 kg K_2O + one stem pruning) and the treatment combination of K_0P_0 (no potassium + no pruning) performed the minimum (66.33 g) (Table 1).

Diameter of fruit

Diameter of fruit varied significantly due to the application of different levels of potassium. Table 1 showed that diameter of fruit increased with increasing potassium levels. The maximum diameter of fruit (6.15 cm) was recorded from K_3 (170 kg K_2O ha^{-1}), while the minimum (5.17 cm) was found from K_0 (0 kg K_2O ha^{-1}) (Table 1). Diameter of fruit showed significant differences due to pruning. The maximum diameter of fruit (6.40 cm) was recorded from P_1 (one stem pruning), while the minimum (5.47 cm) was found from P_2 (two stem pruning) (Table 1). Rahman *et al.* [21] reported that fruit diameter were the highest from single stem pruning followed by two time pruning. Hernandez *et al.* [22] found that fruit diameter was highest in plants pruning to one stem and the number of fruits was higher. Combined effect of potassium and pruning showed statistically significant differences for diameter of fruit. The maximum (6.97 cm) diameter of fruit was recorded from the treatment combination of K_3P_1 (170 kg K_2O + one stem pruning) and the minimum (4.73 cm) was found from K_0P_2 (no potassium + two stem pruning) (Table 1).

Yield per plot (kg)

Yield per plot differs significantly due to the application of different level of potassium. Table 1 showed that yield per plot increased with increasing potassium levels. The highest yield per plot (42.22 kg) was recorded from K_3 (170 kg K_2O ha^{-1}), while the minimum (28.05 kg) was recorded from K_0 (0 kg K_2O ha^{-1}) (Table 1). Yield per plot showed significant differences due to the pruning of tomato. The maximum yield per plot (42.79 kg) was recorded from P_3 (three stem pruning), while the minimum (33.49 kg) was obtained from P_1 (one stem pruning) (Table 1). Patil *et al.* [9] pointed out that tomato plants can be severely pruned without affecting the yield. Combined effect of potassium and pruning showed statistically significant differences on yield per plot. The maximum yield per plot (47.85 kg) was recorded from K_3P_3 (170 kg K_2O + three stem pruning) and the minimum (20.88 kg) was recorded from K_0P_0 (no potassium + no pruning) (Table 1).

Yield (t/ha)

Different level of potassium showed significant variation for yield per hectare of tomato. The highest yield (65.96 t ha^{-1}) was recorded from K_3 (170 kg K_2O ha^{-1}), while the lowest (43.83 t ha^{-1}) was found from K_0 (0 kg K_2O ha^{-1}) (Table 1). Pansare *et al.* [23] reported that the maximum yield tomato was obtained when straight fertilizers were added in the 100 kg K_2O ha^{-1}. Yield per hectare showed significant differences due to the pruning of tomato plant. The highest yield (66.86 t ha^{-1}) was recorded from P_3 (three stem pruning), while the lowest (52.32 t ha^{-1}) was recorded from P_1 (one stem pruning) (Table 1). Thompson and Kelly [12] reported the effect of pruning on tomato increased yield per acre for the first 2 or 3 weeks and further added that in most of the experiments there was little or no increase in early yield per acre from pruning unless the pruned plants were set closer together than the un-pruned ones. Homme [24] reported from an experiment that 2 and 3-stemmed plants gave the best yield then others single stemmed plants. Orzco *et al.* [25] reported that un-pruned plant gave the highest yield (58.09 t ha^{-1}) and 43.47 t ha^{-1} from pruned plants where the shoots were pinched after 3 months. Potassium and pruning showed significant combined effect on yield per hectare. The highest yield (74.77 t ha^{-1}) was obtained from K_3P_3 (170 kg K_2O + three stem pruning) and the lowest (32.62 t ha^{-1}) was recorded from K_0P_0 (no potassium + no pruning) (Table 1).

Gross return

In the combination of potassium fertilizer and pruning showed different gross return under the trial (Table 2). The highest gross return ($ 9671.86) per hectare was recorded from K_3P_3 (170 kg K_2O/ha + three stem pruning) and the second highest gross return ($ 8931.95) was recorded from K_2P_3 (160 kg

K_2O ha^{-1} + three stem pruning). The lowest gross return ($ 4219.55) was recorded from K_0P_0 (control).

Table 2. Cost and return of tomato production as influenced by potassium and pruning

Treatment Combinations	Cost of production (in USD ha^{-1})	Yield of tomato (t ha^{-1})	Gross return (in USD ha^{-1})	Net return (in USD ha^{-1})	Benefit cost ratio
K_0P_0	1941.01	32.62	4219.55	2278.55	1.17
K_0P_1	1984.41	35.34	4571.4	2586.99	1.30
K_0P_2	1998.87	47.27	6114.6	4115.73	2.06
K_0P_3	2013.33	60.00	7761.29	5747.96	2.85
K_1P_0	1973.55	59.98	7758.7	5785.15	2.93
K_1P_1	2016.95	55.58	7189.54	5172.59	2.56
K_1P_2	2031.41	53.05	6862.27	4830.86	2.38
K_1P_3	2045.88	63.55	8220.5	6174.62	3.02
K_2P_0	1975.61	62.30	8058.8	6083.19	3.08
K_2P_1	2019.01	60.03	7765.17	5746.16	2.85
K_2P_2	2033.47	61.19	7915.22	5881.75	2.83
K_2P_3	2047.93	69.05	8931.95	6884.02	3.35
K_3P_0	1977.67	63.68	8237.31	6259.65	3.16
K_3P_1	2021.07	58.35	7547.85	5526.79	2.73
K_3P_2	2035.53	67.07	8675.83	6640.3	3.25
K_3P_3	2049.99	74.77	9671.86	7621.87	3.72

Net return

In case of net return different treatment combination showed different amount of net return. The highest net return ($ 7621.87 ha^{-1}) was recorded from K_3P_3 and the second highest net return ($ 6884.02 ha^{-1}) was recorded from K_2P_3. The lowest net return ($ 2278.55) was recorded from K_0P_0 (Table 2).

Benefit cost ratio

The combination of potassium fertilizer and pruning for benefit cost ratio was different for treatment combination (Table 2). The highest (3.72) benefit cost ratio was recorded from K_3P_3 and the second highest benefit cost ratio (3.35) was recorded from K_2P_3. The lowest benefit cost ratio (1.17) was recorded from K_0P_0. From economic point of view, it was apparent from the above results that the treatment combination of K_3P_3 was more profitable compare to other treatments.

IV. CONCLUSION

It may conclude that the treatment combination of 170 kg K_2O ha^{-1} and three stem pruning performed the highest (74.77 t ha^{-1}) yield as well as the highest (3.72) benefit cost ratio. So, considering in all respects 170 kg K_2O per ha and three stem pruning may be allowed for higher yield of tomato.

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