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Growth and Yield of Tomato as Influenced by Stem Pruning

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Abstract
An experiment was conducted to investigate the influence of four levels of stem pruning (*viz*., no pruning, pruning to single-stem, pruning to two-stems and pruning to three-stems) on the growth and yield of three tomato cultivars (*viz*., Roma VF, Pusa Ruby, and Jessica). Varieties and stem pruning had significant influences, singly and in combination, on most of the characters studied. Considering varieties, the maximum record in plant height, number of fruits per cluster, weight of individual fruit, and fruit yield of tomato were obtained from Roma VF whereas Jessica showed the minimum values. In case of pruning, unpruned plants showed the maximum record in number of leaves per plant, number of flower clusters per plant, and number of flowers per plant whereas plants pruned to two-stems showed the minimum values. Pruning to two-stems, however, showed the maximum values of plant height, the number of fruits per plant, the weight of individual fruit, and fruit yield whereas the minimum values were found in the unpruned plants. Considering the combined treatments, the maximum number of fruits per plant (32.00 cm), weight of individual fruit (49.76 g), and fruit yield (79.61 t/ha) were obtained from Roma VF plants pruned to two-stems whereas the minimum values (19.87 cm, 40.20g, and 39.93 t/ha, respectively) were found in Jassica plants with no stem-pruning.

Keywords: Growth, Stem pruning, Tomato, Varieties, Yield

Introduction

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae and it is a self-pollinated annual crop. It is one of the most important and popular vegetable crops in Bangladesh that is usually grown from November to March (Rahman *et al*., 1998). The total production of tomatoes in Bangladesh is 415494 Metric tons from 70460 acres of land with an average yield of 5.896 Metric tons per acre (BBS, 2020). It is also a dependable source of vitamins A, B, C, and D, minerals, Ca, P, and Fe (Islam *et al*., 1996). The level of vitamin C increases with the gradual ripening of fruits (Valsikova-fery *et al*., 2017).

The yield of tomato in the tropics is much lower than that in the temperate zone due to several factors like high humidity, high temperature, excessive rainfall, disease, and pest (Villareal, 1980; Opena, 1985). The low yield of tomato in Bangladesh, however, is not an indication of low yield potentiality of this crop, but the low yield may be attributed to a number of reasons, among them, unavailability of quality seeds of improved varieties and improper management of seed production, lack of pruning and high yielding variety. Pruning encourages plant to grow in an upright form that reduces the risk of disease and increases the longevity of the fruit they produce. Stem pruning is considered to be one of the most important cultural practice in tomato that improves fruit quality by keeping plants and fruits off the ground thus reducing rotting, and regulates the size of the fruits by diverting nutrients to flower clusters and fruits on the main stem, and allows more efficient air circulation (Ali and Moniruzzaman, 2017). The present study was undertaken to investigate the effect of stem pruning on the growth and yield of three tomato varieties.

Materials and Methods

The two-factor experiment was conducted at the Horticulture Farm of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh, during the period from October 2018 to March 2019. The experiment, laid out in a Randomized Complete Block Design (RCBD) with three replications, consisted of four levels of stem pruning (no stem pruning, pruning to single-stem, pruning to two-stems, and pruning to three-stems) and three tomato cultivars *viz*., Roma VF, Pusa Ruby, and Jessica. The size of the experimental unit plot was 2m × 1.6m with a distance between the blocks as 100cm and that between the unit plots as 50cm. Seedlings of 25-days old were transplanted on 18 November 2018 at a spacing of 50cm x 40cm, accommodating 16 plants in each plot. The land was fertilized with well-decomposed cowdung, urea, triple super-phosphate, and muriate of potash at the rate of 12.5 ton, 275Kg, 250Kg, 200Kg, respectively. All other intercultural operations were done as and when necessary (Das, 2019). Fruits were harvested at 3 days' interval during early ripe stage when they attained slightly red colour. The harvesting was started from 23 January, 2019 and completed by 22 March, 2019. The collected data were analyzed using MSTAT-C. The means of all the treatments were calculated and the analysis of variance for each parameter was performed by the F-test. The differences among the treatment means were

evaluated by the Least Significant Difference (LSD) test for interpretation of results (Gomez & Gomez, 1984).

Results and discussion

Plant height

The main effect of varieties of tomatoes on plant height at 30, 60, and 90 days after transplanting (DAT) was found to be statistically significant. In general, the plant height increased gradually with the advancement of time. In the earlier stage, the rate of plant growth was higher, but later it became slow. The maximum plant height at 90 DAT was obtained from Roma VF and the minimum plant height was obtained from Jessica (**Fig. 1**). Stem pruning, also had significant influence on plant height at different DAT. The maximum plant height at 90 DAT was recorded from pruning to two-stems whereas the minimum plant height was recorded from the unpruned plants (**Fig. 2**). The combined effect of variety and stem pruning on plant height was found to be statistically significant at different days after transplanting. A gradual increase in plant height with the age of the plant up to the final harvest was also noticed in all treatment combinations. The maximum plant height (50.40 cm) was observed from the treatment combination of Roma VF plants pruned to two-stems (V_1P_2) and the minimum (37.67 cm) was found from Jessica with no stem-pruning (V_3P_0) (**Table 3**). Alam *et. al.* (2016) reported that the increase in plant height of tomatoes might be due to the removal of branches which leads to the supply of nutrients in the remaining branches.

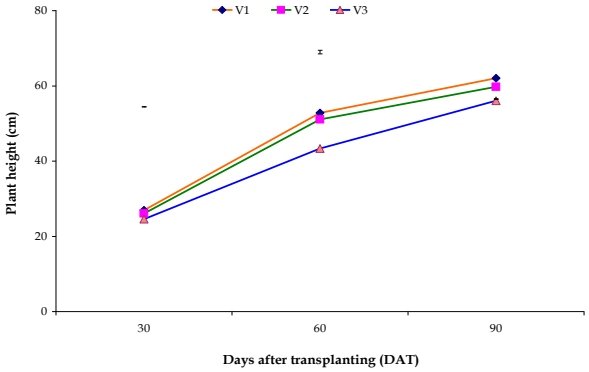

Fig. 1. Main effect of varieties on the plant height of tomato at different days after transplanting. Vertical bars represent LSD at a 1% level of significance. Here, V_1=Roma VF, V_2= Pusa Ruby, V_3= Jessica.

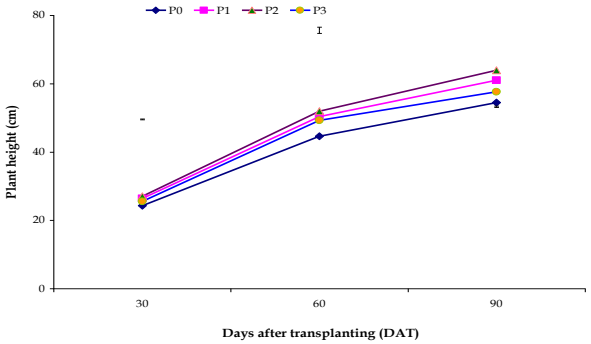

Fig. 2. Main effect of stem pruning on the plant height of tomato at different days after transplanting. Vertical bars represent LSD at a 1% level of significance. Here, P_0= No stem pruning, P_1= Pruning to single-stem, P_2= Pruning to double-stem, and P_3= Pruning to triple-stem.

Number of leaves

The varieties and different levels of pruning significantly affected the number of leaves per plant. The maximum number of leaves was obtained from Roma VF and the minimum number of leaves was obtained from Jessica (**Fig. 3**). Again, the maximum number of leaves per plant was obtained from unpruned plants and the minimum was obtained from plants pruned to two-stems (**Fig. 4**). Considering the combined treatments, the maximum number of leaves (23.49) was observed from Roma VF unpruned plants (V_1P_0) and the minimum number of leaves (19.40) was found from Jessica plants pruned to two-stems (V_3P_2) (**Table 3**). The benefits of pruning were reported by Sahu *et al*. (2018) as pruning directly stimulates the formation of enlarged leaves, increases mesophyll size and moisture content as well as lengthens the period of stomata opening.

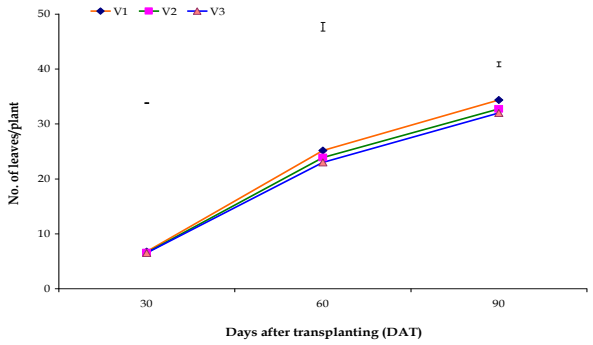

Fig.3. Main effect of different varieties on the number of leaves on different days after transplanting. Vertical bars represent LSD at a 1% level of significance. Here, V_1=Roma VF, V_2= Pusa Ruby, V_3= Jessica

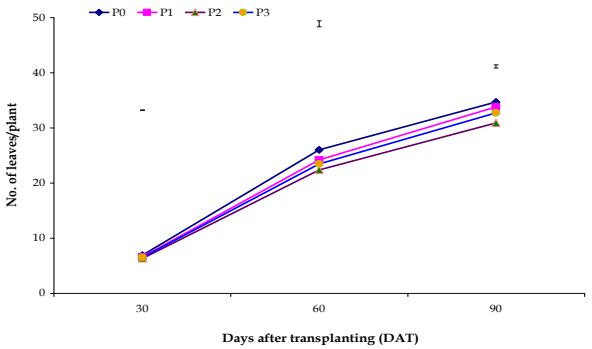

Fig. 4. Main effect of different pruning practices on the number of leaves on different days after transplanting. Vertical bars represent LSD at a 1% level of significance. Here, P_0= No stem-pruning, P_1= Pruning to single-stem, P_2= Pruning to two-stems, and P_3= Pruning to three-stems.

Number of flower cluster

The number of flower clusters per plant was significantly influenced by tomato varieties and stem pruning. The combined effect of variety and pruning on the number of flower clusters per plant was found to be statistically significant. The maximum number of flower clusters per plant (6.63) was found in Pusa Ruby and the minimum number of flower clusters (6.47) were found in Jessica (**Table 1**). The maximum number of flower clusters per plant (6.84) was produced by unpruned plants and the minimum number of flower clusters per plant (6.08) was produced by plants pruned to two-stems (**Table 2**).

Table 1. Effect of variety on the yield contributing characteristics and yield of tomato

Treatments	No. of flower cluster/ plant	No. of flowers/ plant	No. of fruits/ cluster	No. of fruits/ plant	Weight of individual fruit (g)	TSS of fruits (°Brix)	Fruit length (cm)	Fruit diameter (cm)	Yield of fruits (kg)/ plant	Yield fruits (kg)/p
V_1	6.52	22.83	5.21	28.72	46.81	4.42	7.66	4.89	1.35	21.58
V_2	6.63	21.33	5.05	27.98	45.25	4.17	5.80	4.54	1.27	20.34
V_3	6.47	22.50	4.97	24.14	42.84	3.92	5.22	4.19	1.04	16.62
$LSD_{0.05}$	0.12	0.17	0.046	0.060	0.089	0.054	0.120	0.089	0.008	0.046
$LSD_{0.01}$	0.17	0.24	0.063	0.081	0.121	0.073	0.163	0.121	0.012	0.063

V_1 = Roma VF, V_2 = Pusa Ruby and V_3 = Jessica

Table 2. Effect of stem pruning on the yield contributing characteristics and yield of tomato

Treatments	No. of flower clusters/plant	No. of flowers/ plant	No. of fruits/ cluster	No. of fruits/ plant	Weight of individual fruit (g)	TSS of fruits (°Brix)	Fruit length (cm)	Fruit diameter (cm)	Yield of fruits (kg)/ plant	Yield fruits (kg)/p
P_0	6.84	21.48	4.85	22.76	42.55	3.74	5.38	3.86	0.97	15.56
P_1	6.69	20.30	5.10	28.48	45.34	4.27	6.39	4.87	1.29	20.71
P_2	6.08	19.55	5.28	30.06	47.60	4.70	6.96	5.12	1.43	22.95
P_3	6.15	19.37	5.07	26.48	44.36	3.97	6.17	4.30	1.18	18.84
$LSD_{0.05}$	0.14	0.20	0.054	0.069	0.103	0.062	0.138	0.103	0.010	0.054
$LSD_{0.01}$	0.19	0.27	0.073	0.094	0.139	0.084	0.188	0.139	0.013	0.073

P_0= No stem-pruning, P_1= Pruning to single-stem, P_2= Pruning to two-stems, and P_3= Pruning to three-stems.

Considering the combined treatments, the maximum number of flower clusters per plant (7.67) was obtained from Roma VF with no stem-pruning (V_1P_0) and the minimum number of flower clusters per plant (5.78) was obtained from Jessica plants pruned to two-stems (V_3P_2) (**Table 3**). It was observed that the number of flower clusters per plant decreased with the increased level of pruning except for plants pruned to three-stems. Rahman *et. al*. (1988) reported that the number of flower clusters per plant was maximum in unpruned plant than in single- or two-stem plants. Baki (1987) also found a significant effect of pruning on the number of flower clusters per plant.

Table 3. Combined effects of variety and pruning on the yield contributing characteristics and yield of tomato

Treatment combination	Plant height (cm)	No. of leaves/plant	No. of flower clusters/ plant	No. of flowers/ plant	No. of fruits/ cluster	No. of fruits/ plant	Weight of individual fruit (g)	TSS of fruits (°Brix)	Fruit length (cm)	Fruit diameter (cm)	Yi fru (kg Pla
V_1P_0	43.82	23.49	7.67	24.56	4.96	24.60	44.79	4.13	7.27	4.10	1.1
V_1P_1	48.47	22.35	7.40	23.22	5.20	30.17	46.93	4.43	7.82	5.45	1.4
V_1P_2	50.40	20.62	6.35	21.00	5.49	32.00	49.76	4.90	7.92	5.54	1.5
V_1P_3	46.29	21.82	6.79	22.89	5.20	28.11	45.75	4.23	7.62	4.45	1.2
V_2P_0	41.80	22.49	6.92	22.11	4.85	23.82	42.67	3.67	4.50	4.03	1.0
V_2P1	47.20	21.58	6.67	20.56	5.05	29.48	45.77	4.27	5.83	4.63	1.3
V_2P_2	49.00	19.6	6.08	18.56	5.29	30.89	47.78	4.80	7.33	5.07	1.4
V_2P_3	44.38	20.58	6.29	20.11	5.00	27.72	44.78	3.93	5.52	4.43	1.2
V_3P_0	37.67	21.60	6.47	21.11	4.75	19.87	40.20	3.43	4.38	3.44	0.8
V_3P_1	42.18	20.67	6.22	18.67	5.05	25.80	43.33	4.10	5.50	4.54	1.1
V_3P_2	43.53	19.40	5.78	17.33	5.07	27.28	45.27	4.40	5.64	4.75	1.2
V_3P_3	41.76	20.31	5.98	18.22	5.00	23.60	42.55	3.73	5.36	4.02	1.0
$LSD_{0.05}$	0.82	0.21	0.25	0.35	0.093	0.120	0.178	0.107	0.239	0.178	0.0
$LSD_{0.01}$	1.12	0.28	0.33	0.47	0.126	0.163	0.241	0.146	0.326	0.241	0.0

V_1 = Roma VF, V_2 = Pusa Ruby and V_3 = Jessica; P_0= No stem-pruning, P_1= Pruning to single-stem, P_2= Pruning to two-stems, and P_3= Pru

Number of flowers per plant

The varieties and stem pruning had significant effect on the number of flowers. Roma VF produced the highest number of flowers (22.83) and Pusa Ruby produced the lowest number of flowers (21.33) (**Table 1**). The highest number of flowers per plant (21.48) was obtained from unpruned plants and the lowest number of flowers per plant (19.37) was obtained from plants pruned to three-stems (Table 2). Considering the combined treatments, the highest number of flowers per plant (24.56) was obtained from Roma VF plants with no stem-pruning (V_1P_0) and the lowest number (17.33) was recored in Jessica plants pruned to two-stems (V_3P_2) (**Table 3**). Aung (1976) reported that the flower number in a plant is associated with the characteristics of an cultivars.

Number of fruits per clustert

Tomato varieties and the levels of stem pruning, singly or in combination had significant influenc on the number of fruits per cluster. Roma VF produced the highest number of fruits per cluster (5.21) and the lowest (4.97) in Jessica (**Table 1**). The highest number of fruits per cluster (5.28) were obtained from plants pruned to two-stems, while the lowest (4.85) was from unpruned plants (**Table 2**). Considering the treatment combinations, the highest number of fruits per cluster (5.49) was obtained from Roma VF plants pruned to two-stems (V_1P_2) and the lowest number (4.75) was obtained from Jessica with no stem-pruning (V_3P_0) (**Table 3**). Campos *et. al.* (1987) reported that stem pruning increased the number of fruits per cluster.

Number of fruits per plant

The single and combined effects of variety and pruning had significant influence on the number of fruits per plant. The maximum number of fruits per plant (28.72) was produced by Roma VF whereas the minimum (24.14) was found in Jessica (**Table 1).** The highest number of fruits per plant (30.06) was obtained from plant pruned to two-stems and the lowest number (22.76)

was obtained from unpruned plants (**Table 2**). In combination, the highest number of fruits per plant (32.00) was obtained from Roma VF plants pruned to two-stems (V_1P_2) and the lowest number (19.87) was obtained from Jessica with no stem-pruning (V_3P_0) (**Table 3**).

Weight of individual fruits

There were significant variations among the three varieties, different levels of pruning, and their combined effects on the weight of individual fruit. The maximum individual fruit weight (46.81 g) was recorded in Roma VF and the minimum (42.84 g) was found in Jessica variety (**Table 1**). The maximum weight of individual fruit (47.60 g) was obtained from plants pruned to two-stems and the minimum (42.55 g) was obtained from unprunned plants (**Table 2).** Considering the treatment combinations, the maximum weight of individual fruit (49.76 g) was obtained from Roma VF plants pruned to two-stems and the minimum (40.20 g) was obtained from Jessica with no stem-pruning (V_1P_2) (**Table 3).** Kusumo (1978) reported that fruit size increased when plants were pruned. Rajendra and Patil (1979) reported that fruit weight was lowest in unprunned plants.

Total soluble solids of fruits

Significant variations were observed in total soluble solids (TSS) of fruits due to the influence of varieties, levels of stem pruning and their combined effects. Roma VF variety produced maximum (4.42) TSS content whereas the Jessica variety produced minimum (3.92) TSS content (**Table 1**). The maximum TSS content (4.70) was obtained from plants pruned to two-stems, while the minimum (3.74) was found in plants with no stem-pruning (**Table 2**). Considering the treatment combinations, the maximum TSS content of fruits (4.90) was found from Roma VF plants pruned to two-stems (V_1P_2) and the minimum (3.43) was obtained from Jessica plants with no stem-pruning (V_3P_0) (**Table 3**). Variety and stem pruning had an interaction effect on TSS content of tomato fruits.

Length of fruits

The varieties and stem pruning had highly significant effect, singly or in combination, on the fruit length of tomato. The maximum fruit length (7.66 cm) was measured in the Roma VF variety and the minimum was in Jessica variety (5.22 cm) (**Table 1**). The maximum fruit length (6.96 cm) was found in plants pruned to two-stems and the minimum was in the unpruned (5.38 cm) plants (**Table 2**). The treatment combination of Roma VF plants pruned to two-stems (V_1P_2) showed the maximum fruit length (7.92 cm) and the minimum (4.38) was found in Jessica with no stem-pruning (**Table 3**). Variety and pruning had an interaction effect on fruit length.

Diameter of fruits

Tomato varieties and stem pruning, singly or combined, exhibited significant influece on fruit diameter (**Tables 1-3**). Considering the treatment combinations, Roma VF plants pruned to two-stems (V_1P_2) gave the highest fruit diameter (5.54 cm) and Jessica with no stem-pruning (V_3P_0) gave the lowest (3.44 cm) fruit diameter (**Table 3**). Variety and stem pruning had an interaction effect on fruit diameter in tomato.

Yield of fruits per plant

Tomato varieties and different levels of stem pruning, singly or in combination, had significant influence on the weight of fruits per plant. The maximum yield of fruits per plant (1.35 kg) was found in Roma VF whereas the minimum (1.04 kg) was found in Jessica (**Table 1).** The maximum yield of fruits per plant (1.43 kg) was obtained from plants pruned to two-stems and the minimum yield of fruits per plant (0.97 kg) was obtained from the unpruned plants (**Table 2**). The maximum yield of fruits per plant (1.59 kg) was obtained from Roma VF plants prunned to two-stems and the minimum (0.80 kg) was obtained from Jessica with no stem-pruning (**Table 3**). Muhammad and Singh (2007) also reported that pruning increased the weight of fruit per plant.

Yield of fruits per plot

Both the varieties and stem prunuing, singly or in combination, played significant influences on the yield of fruits per plot. The highest yield fruits per plot (21.58 kg) was recorded in Roma VF while the lowest (16.62 kg) was found in Jessica (**Table 1**). The maximum yield of fruits (22.95 kg) was obtained from plants prunned to two-stems and the minimum yield of fruits (15.56 kg) was obtained from unpruned plants (**Table 2**). Considering the combined treatments, Roma VF plants prunned to two-stems showed the highest yield of fruits per plot (25.48 kg) variety and Jessica plants with no pruning resulted in the lowest (12.78 kg) yield of fruits per plot (**Table 3).**

Yield of fruits per hectare

There were highly significant effects of varieties and stem pruning, singly and in combination, on the yield of tomato per hectare. The highest fruit yield (67.45 tons/ha) was obtained from Roma VF whereas the lowest yield (51.95 tons/ha) was obtained from Jessica (**Fig. 5**). The pruning to two-stems produced the highest fruit yield per hectare (71.73 ton/ha) and the no stem-pruning resulted in the lowest (48.61 ton/ha) fruit yield per hectare (**Fig. 6).**

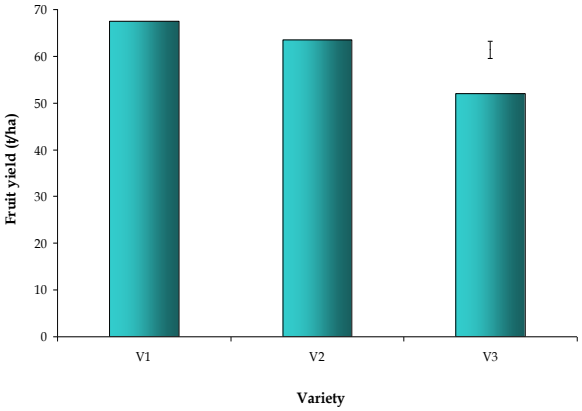

Fig. 5. Main effect of different varieties on yield of tomato (ton per hectare). The vertical bar represents LSD at a 1% level of significance. Here, V_1=Roma VF, V_2= Pusa Ruby, V_3= Jessica

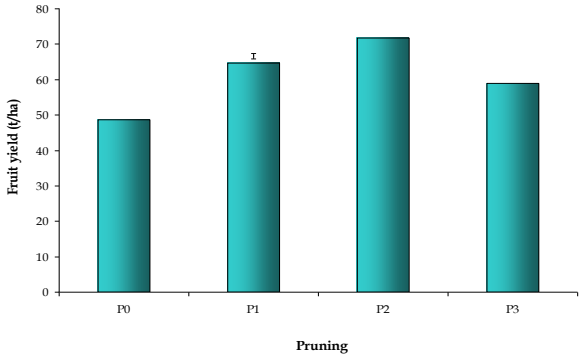

Fig. 6. Main effect of stem pruning on yield of tomato (ton per hectare). The vertical bar represents LSD at a 1% level of significance. Here, P_0= No stem-pruning, P_1= Pruning to single-stem, P_2= Pruning to two-stems, and P_3= Pruning to three-stems

As regards to the combined treatments, the highest yield of tomato was found from Roma VF plants pruned to two-stems (79.61 ton/ha), which was 99.37% higher compared to the lowest yield (39.93 ton/ha) found in Jessica variety with no-stem-pruning (**Fig. 7**).

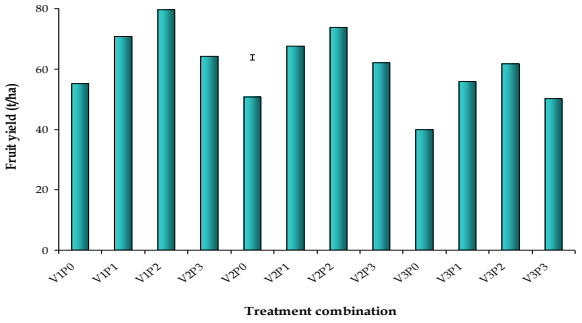

Fig. 7. Combined effect of variety and stem pruning on yield of tomato per hectare. The vertical bar represents LSD at a 1% level of significance. Here, V_1=Roma VF, V_2= Pusa Ruby, V_3= Jessica, P_0= No stem-pruning, P_1= Pruning to single-stem, P_2= Pruning to two-stems, and P_3= Pruning to three-stems.

The increase of yield and quality of fruits by pruning in tomatoes was previously reported by other researchers (Srinivasan *et al.*, 1999; Ara *et.al*., 2007). Baki (1987) and Dhar *et al*., (1993) also reported that the maximum yield of tomatoes was obtained from plants pruned to two-stem.

Conclusions

The plant varieties and stem pruning significantly affected the growth and yield parameters of tomato. The maximum number of leaves per plant, number of flower clusters per plant, and number of flowers per plant were obtained from unpruned plants whereas pruning to two-stems was most effective for all three tomato cultivars. Considering the combined effects, the highest number of fruits per plant (32.00), the maximum weight of individual fruit (49.76 g), and the highest yield (79.61 t/ha) were obtained from Roma VF plants pruned to two-stems.

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