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Performance of grafted tomato for horticultural and quality traits under polyhouse conditions

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Abstract

Present investigation was carried out for two successive years i.e. 2016-17 and 2017-18 to study the performance of grafted tomato with respect to growth, yield and quality of tomato under polyhouse conditions at Department of Vegetable Science and Floriculture, CSKHPKV, Palampur. Sixteen different rootstocks of tomato were grafted with scion cultivar 'GS-600'. The experiment was laid out in a Randomized Block Design with three replications and cleft grafting method was used. Plants grafted on rootstock LS-89 proved superior to other rootstocks for days to first flowering and days to first harvest. For prolonged harvest duration plants grafted on tomato rootstock Green Gourd found superior. Higher yield in terms of number of marketable fruits per plant, marketable fruit yield per plant and marketable fruit yield per square metre in were recorded plants grafted on tomato rootstock Green Gourd.

Key words: Rootstocks, scion, number of marketable fruits per plant, fruit yield per plant, fruit yield per square metre.

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetables owing to its wider adaptability, higher yielding potential and suitability both in fresh and processed food industries (He *et al.* 2003). It ranks second in importance to potato in many countries and is also one of the principle vegetables grown under protected conditions worldwide. Tomato production in H.P. has suffered due to bacterial wilt and nematode incidence under protected environments. Use of resistant rootstocks is the recent technique to counter these biotic stresses. Commercial vegetable grafting is a new technique and the area under vegetable grafting is progressively increasing (Kumar *et al.* 2018). The type of rootstock affects scion growth, yield and quality of fruits. Besides improving productivity, it also helps to ensure better fruit set during off-season. Proper rootstock and scion combinations should be carefully selected in accordance with the climatic and geographical conditions of the region to avoid soil borne diseases besides increasing the efficiency and the quality of fruits. Therefore, keeping in view all the above mentioned facts, the present investigation was planned to study the performance of promising rootstocks with respect to growth, yield and quality of tomato in polyhouse.

Materials and Methods

The experimental material used for the present study comprised of sixteen different rootstocks and horticulturally superior scion GS-600 which was used as a scion at seedling stage. The different rootstocks used in the present studies were procured from world vegetable centre- Taiwan, CSKHPKV, Japan, Palampur and IIHR-Bengaluru .Whereas, scion of tomato was a commercial private sector hybrid from Golden Seeds, UPL Ltd.The grafted seedlings were transplanted in a Randomized Block Design (RBD)

having three replications in a modified naturally ventilated Quonset polyhouse of the size 25 m × 10 m at a spacing of 70 x 30 cm. The scion variety GS-600 was grafted on various rootstocks using cleft grafting on attaining graft able height of 15-20 cm with stem thickness of 5-10 mm to ensure higher grafting success rate and compatibility. Scion seedlings were grafted on various rootstocks on 24th, 26th and 27th August 2017, while transplanting was done on 12th September 2017. Whereas, during 2018 seedlings were grafted on 12th, 14th and 15th April 2018 and transplanting was done on 24th May, 2018. Graft union was secured with a grafting clip or plastic tape to ensure good vascular connection and to ensure complete healing of grafted portions. Immediately after grafting the plants were sprayed with water and were kept inside grafting chamber for 3-4 days. Water was sprayed on grafted plants during day once or twice depending on weather conditions so as to avoid wilting and ensure complete healing. For successful healing of grafted seedlings reduced light intensity, moderate temperature 25-30^{0} C and high relative humidity 85-90% are essential to establish good vascular connection and continue to grow as single plant. After completion of healing processes the plastic clips were removed from graft union so as to avoid cessation and stunted growth of plants. For acclimatization grafted seedlings were taken outside the healing chamber and kept under sunlight so as to provide hardening prior to transplanting and to reduce transplanting shock. On an average grafted seedlings took three to four days for complete acclimatization and later they were transplanted in well prepared beds inside naturally ventilated polyhouse.

Results and Discussion

Out of sixteen rootstocks only thirteen rootstocks were found compatible with scion GS-600, whereas three rootstocks viz., PI-201232, AVPP0205 and Local pumpkin did not show compatibility. However, initially they showed some growth but later on their growth was ceased. Therefore, only one parameter i.e. plant height was observed on plants grafted on these rootstocks, whereas other parameters could not be recorded due to poor stock-scion compatibility. Days to first flowering were significantly affected by the different rootstocks used in the study. The pooled analysis of data in Table 1 shows that plants grafted on rootstock LS-89 were earlier in flowering with 28.00 days which were statistically at par with Arka Keshav(29.00 days), VI-45376 (29.52 days), Palam Pink (29.90 days), Hawaii-7996 (29.96 days) and VI-47335 (30.42days). The grafted plants were earlier in flowering due to use of efficient, improved and vigorous rootstocks, which might resulted in increase of both water and nutrient uptake more efficiently than the non-grafted plants .These results are in conformity with the findings of Ibrahim *et al.* (2014).

Pooled analysis of data presented in Table 1 showed that plants grafted on rootstock LS-89 produced first harvest in 57.88 and was at par with rootstock VI- 45376 with 59.26 days. Grafted plants were earlier in harvest because of successful interactions between rootstocks and scion which ensures full compatibility, capacity of great assimilations of photosynthates, better nutrient use efficiency as rootstocks have strong and vigorous root system. These results found similarity with the findings of Velkov and Pevicharova, 2016 who also observed similar observations. Maximum harvest duration in the rootstock Green Gourd (72.62 days) which was significantly superior over other rootstocks and were followed by Arka Nidhi (69.70 days), Hawaii-7998 (69.48 days), Palam Pink (69.22 days) and Palam Pride (67.97 days) (Table 2). Prolonged harvest duration in grafted plants may be the result of enhanced nutrient and water uptake by the rootstocks as they are more vigorous, efficient in utilizing nutrients to the maximum extent which led to extended period of harvest duration even under adverse stress conditions. Plants grafted on rootstock Back Attack also produced maximum plant height of 278.80 cm which were followed by Arka Nidhi (227.33 cm), LS-89 (221.95 cm), Hawaii-7998 (214.27 cm) and Palam Pride (212.83 cm) (Table 2). Thus, grafted plants had greater plant height of 46.20% as compared to non-grafted ones. Similar results were also observed in the studies of Khiareddine *et al*. (2019). Maximum plant height of grafted plants as compared to the grafted may be due to good compatibility between rootstocks and scions during early stages of growth, which resulted in proper translocations of minerals and hormones

Table 1. Effect of rootstocks on growth parameters in tomato under protected conditions

Rootstocks	Days to first flowering			Days to first harvest		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Back Attack	40.00	24.67	32.33	84.59	60.33	72.46
Palam Pride	35.60	26.00	30.80	73.48	66.88	70.18
Palam Pink	34.80	25.00	29.90	76.44	66.55	71.50
Hawaii-7998	34.75	26.80	30.78	63.55	57.07	60.31
Green Gourd	36.89	30.00	33.45	77.00	74.00	75.50
Hawaii-7996	34.58	25.34	29.96	65.18	73.99	69.59
LS-89	32.00	24.00	28.00	56.76	59.00	57.88
VI-34845	37.00	25.67	31.33	81.63	66.03	73.83
Arka Nidhi	34.67	32.00	33.33	72.00	74.12	73.06
Arka Keshav	35.33	22.67	29.00	82.00	53.11	67.56
Solanum torvum	35.68	26.33	31.00	76.55	73.33	74.94
VI-47335 (EG-195)	34.33	26.50	30.42	69.77	56.14	62.96
VI-45376 (EG-203)	34.70	24.33	29.52	63.11	55.40	59.26
Control (GS-600)	34.00	27.00	30.50	70.44	69.66	70.12
CD (0.05)	1.81	4.21	2.45	2.58	1.88	1.47
CV (%)	3.74	11.90	5.85	2.57	2.17	1.57

Table 2. Effect of rootstocks on other growth parameters in tomato

Rootstocks	Harvest Duration			Plant Height		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Back Attack	58.50	62.00	60.25	304.27	253.33	278.80
Palam Pride	70.40	65.54	67.97	228.33	197.33	212.83
Palam Pink	68.78	69.67	69.22	201.67	219.67	210.67
Hawaii-7998	71.56	67.39	69.48	230.87	197.67	214.27
Green Gourd	74.68	70.57	72.62	203.33	206.00	204.67
Hawaii-7996	63.00	59.44	61.22	176.47	230.00	203.23
LS-89	66.78	58.75	62.77	228.23	215.67	221.95
VI-34845	60.67	58.76	59.72	175.87	243.67	209.77
Arka Nidhi	72.50	66.89	69.70	201.33	210.00	227.33
Arka Keshav	56.00	70.00	63.00	198.20	239.00	218.60
Solanum torvum	52.55	62.34	57.45	137.80	213.33	175.57
VI-47335 (EG-195)	58.69	60.00	59.35	157.33	231.33	194.33
VI-45376 (EG-203)	60.00	57.77	58.89	151.33	205.33	178.33
PI-201232 (Chilli)	-	-	-	16.87	18.27	17.57
AVPP0205 (Chilli)	-	-	-	17.27	18.30	17.78
Local Pumpkin	-	-	-	13.33	12.80	13.07
Control (GS-600)	50.00	54.46	52.28	140.00	160.00	150.00
CD (0.05)	5.30	4.37	2.90	13.53	37.95	19.83
CV (%)	6.76	10.26	4.79	4.74	12.26	6.66

throughout the plant system. The other reasons for the less plant height in control plants were due to incidence of bacterial wilt. The Chilli Rootstocks viz., PI-201232, AVPP0205 and Local Pumpkin in the present studies showed formation of vascular union in the initial stages grafted on tomato scions, but at later stages the growth of plants remained stunted, without flowering and fruiting at all in both years i.e. 2016-17 & 2017-18. The possible reasons for slow growth in plant height may be due to tissue and structure difference, physiological and biochemical characteristics, growing stage of rootstock and scion, hormones, environmental factors, failure of rootstock and scion to form a strong union. Rootstocks significantly affected the number of fruits per plant as evident from the Table 3. Pooled analysis of data showed maximum number of fruits per plant in plants grafted on rootstock Green Gourd (23.67) followed by *Solanum torvum* (21.67), Arka Keshav (21.17) and VI-47335 (21.17). The increased number of marketable fruits in grafted plants as compared to non- grafted was due to use of vigorous rootstocks which led to improvement of cytokinin content in scion which ultimately improved fruit load on the plants. Similar findings were also reported by Kumar *et al.* (2017).

It is apparent from the data presented in the Table 3that different rootstocks affected the fruit yield per plant significantly. Pooled analysis of data showed that plants grafted on rootstock Green Gourd resulted in maximum yield per plant (2.16 kg) followed by Palam Pride (1.92kg), Arka Keshav (1.80kg) and VI-45376 (1.78 kg). Thus, grafted plants produced 48.61% more yield than non-grafted. Higher yield in grafted plants is attributed to resistance provided by the rootstocks against soil borne diseases (Bacterial wilt & Nematodes), better absorption and translocation of phosphorus, nitrogen, magnesium and calcium which leads to improved nutrient uptake as rootstocks have well developed and strong root systems which release more cytokinins into the xylem sap resulting in increased yield and also due to increased the rate of photosynthesis.From the Data presented in the Table 3 it is inferred that rootstocks exerted significant influence on yield per square metre. Pooled analysis of data showed maximum yield per square metre in the rootstock Green Gourd (25.92 kg) followed by Palam Pride (23.04 kg), Arka Keshav (21.66 kg), VI-45376 (21.36 kg), Back Attack (20.52 kg) and LS-89 (20.04 kg). The higher marketable yield obtained by grafting was due to an improvement in water and nutrient uptake by the vigorous rootstocks more efficiently, prolonged harvest duration, earliness in flowering and fruiting, increased fruit weight, number of fruits per plant, rootstock scion combinations. These results are in conformity with the findings of Alvarado *et al*. (2017).Critical investigation of data presented in the Table 4 depicts that rootstocks played crucial role in increasing TSS of grafted tomatoes.Pooled analysis of data also showed maximum TSS by plants grafted on rootstock Arka Nidhi (5.48 °Brix) and was found significantly superior to other rootstocks. Total soluble solid contents in grafted plants were high as compared to non-grafted may be due to better light penetration in the crop canopy which leads to greater activity of photosynthesis. Pericarp thickness is an important quality parameter for increasing shelf life of tomato. Pooled analysis of data recorded maximum pericarp thickness in plants grafted on rootstock Palam Pride (6.60 mm) followed by Back Attack (6.26 mm), Hawaii-7998 (6.24 mm) and Hawaii-7996 (6.22 mm). Increased pericarp thickness in grafted plants might be due to multiple interactions between rootstocks and scion combinations. Similar findings were reported in the studies of Kyriacou *et al.* (2017). Data showed in Table 4 (Pooled) depicts maximum ascorbic acid content in plants grafted on the rootstock Palam Pink (21.94 mg/100 g) which was found statistically at par with VI-34845 (20.53 mg/100g). The possible reasons for increased Vitamin C in grafted plants may be attributed to influence of grafting and rootstock combinations used.

Conclusion

Rootstocks exerted significant and positive effects on yield and other related traits during both the years of study. Higher yield in terms of number of marketable fruits per plant, marketable fruit yield per plant and marketable fruit yield per square meter were recorded in plants grafted on tomato rootstock Green Gourd. Grafted tomato plants excelled in quality over non-grafted plants. Maximum TSS was found in plants grafted on Arka Nidhi, whereas highest ascorbic acid was noticed in plants grafted on Palam Pink rootstock.

Table 3. Effect of rootstocks on horticultural traits in tomato under protected conditions

Rootstocks	Number of marketable Fruits/plant			Marketable fruit yield/plant (kg)			Marketable fruit yield/per square metre (kg/m^2)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Back Attack	21.33	22.33	21.83	1.66	1.76	1.71	19.92	21.12	20.52
Palam Pride	22.67	21.33	22.00	2.01	1.83	1.92	24.12	21.96	23.04
Palam Pink	21.67	19.33	20.50	1.80	1.56	1.68	21.60	18.72	20.16
Hawaii-7998	19.67	20.33	20.00	1.51	1.64	1.58	18.12	19.68	18.90
Green Gourd	24.33	23.00	23.67	2.21	2.12	2.16	26.52	25.44	25.92
Hawaii-7996	20.00	18.33	19.17	1.64	1.43	1.54	19.68	17.16	18.42
LS-89	19.00	22.67	20.83	1.49	1.84	1.67	17.88	22.08	20.04
VI-34845	19.33	18.00	18.65	1.54	1.38	1.46	18.48	16.56	17.52
Arka Nidhi	20.67	17.33	19.00	1.45	1.30	1.38	17.40	15.60	16.50
Arka Keshav	19.67	22.67	21.17	1.70	1.91	1.80	20.40	22.92	21.66
Solanum torvum	20.67	22.67	21.67	1.51	1.72	1.61	18.12	20.64	19.38
VI-47335 (EG-195)	21.33	21.00	21.17	1.55	1.57	1.56	18.60	18.84	18.72
VI-45376 (EG-203)	22.00	22.33	22.17	1.82	1.74	1.78	21.84	20.88	21.36
Control (GS-600)	15.33	16.67	16.00	1.07	1.15	1.11	12.84	13.80	13.32
CD (0.05)	1.78	2.23	1.49	0.03	0.02	0.02	0.96	1.18	0.74
CV (%)	6.33	7.87	5.28	1.43	1.18	1.02	5.04	6.25	3.90

Table 4. Effect of rootstocks on quality parameters of tomato under protected conditions

Rootstocks	Pericarp thickness (mm)			Total soluble solids (°brix)			Ascorbic acid (mg/100g)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Back Attack	6.60	5.92	6.26	4.89	4.70	4.80	16.33	16.97	16.65
Palam Pride	6.90	6.30	6.60	5.20	4.47	4.83	16.00	17.55	16.77
Palam Pink	5.88	5.74	5.81	5.55	4.83	5.19	23.33	20.55	21.94
Hawaii-7998	6.70	5.79	6.24	5.60	4.58	5.09	20.17	18.00	19.08
Green Gourd	6.00	5.89	5.94	4.95	4.90	4.92	15.33	17.66	16.50
Hawaii-7996	6.44	6.00	6.22	5.66	4.52	5.09	15.73	17.00	16.36
LS-89	5.86	5.56	5.71	5.17	4.60	4.88	18.30	17.40	17.85
VI-34845	6.20	5.70	5.95	5.13	4.85	4.99	23.13	17.93	20.53
Arka Nidhi	6.50	5.50	6.00	5.67	5.33	5.48	18.43	17.97	18.20
Arka Keshav	6.30	5.90	6.10	5.00	4.80	4.90	20.60	16.50	18.55
Solanum torvum	6.10	5.74	5.92	5.03	4.80	4.91	16.67	18.13	17.40
VI-47335 (EG-195)	5.82	5.60	5.71	5.52	4.63	5.07	18.40	16.40	17.40
VI-45376 (EG-203)	5.90	5.55	5.72	5.60	5.23	5.41	16.00	17.63	16.82
Control (GS-600)	5.70	5.47	5.58	4.85	4.44	4.64	15.00	16.00	15.50
CD (0.05)	0.11	0.02	0.05	0.39	0.55	0.42	1.86	2.62	1.78
CV (%)	12.53	3.86	7.52	5.74	8.46	6.34	7.48	11.31	7.42

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