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Research Article

INFLUENCE OF ROOTSTOCKS AND SCIONS ON HORTICULTURAL TRAITS AND QUALITY OF TOMATO UNDER PROTECTED CONDITIONS

KUMAR PARDEEP*, SHARMA PARVEEN AND VATS BINNY

Department of Vegetable Science and Floriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh 176062 India
*Corresponding Author: Email-pardeepsangla@gmail.com

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Abstract- A study was undertaken to identify best rootstock and scion for tomato growth, development and yield under protected conditions at CSKHPKV, palampur. The experiment consisted of eight rootstocks *viz.* Pumpkin Jalag, 2123 A-1 (Tomato), Hawaii 7998 (Tomato), Palam Pink (Tomato), Hawaii 7996 (Tomato), Palam Pride (Tomato), Arka Nidhi (Brinjal) and Arka Keshav (Brinjal) and three tomato varieties as scions *viz.* Rakshita, Naveen 2000+ and GS-600.Results obtained indicated that treatment T-2(2123 A-1 + Rakshita) resulted in highest fruit yield per plant, longest harvest duration, highest TSS, maximum plant height and maximum number of fruits per plant. Treatment T-7 (Palam Pride + Naveen 2000+) took minimum days to first harvest whereas, treatment T-9 (Arka Keshav + Naveen 2000+) and T-8 (Arka Nidhi + Rakshita) recorded highest ascorbic acid and highest lycopene contents, respectively. Suitable rootstocks identified for tomato are 2123 A-1, Arka Nidhi, Arka Keshav, Palam Pride. These results showed that grafting could be an advantageous alternative in tomato production under protected conditions.

Keywords- Tomato, Grafting, Rootstock, Scion, Bacterial wilt, Protected Cultivation.

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Introduction

Tomato (*Solanum lycopersicum* L.), is a widely grown off-season commercial vegetable crop under polyhouse conditions in Himachal Pradesh. It is grown worldwide for its delicate taste, flavour and is also the most leading crop under protected structures. India is the leading vegetable producer in the world, occupying around 7.8 million hectares with an annual production of more than 126 million tonnes, and ranks next to China. In spite of country's significant position in vegetable production in the world, its export share is quite meager and is based on few traditional vegetables like onion, garlic, okra and potato. The protected cultivation of vegetables not only overcomes the biotic and abiotic stresses but it also opens the gates for ensuring off-season and year-round supply of quality vegetables with remunerative prices to their growers.

Globally, there is a need to increase productivity and quality of the produce to meet the demand of ever increasing quality and health conscious consumers. Greenhouse vegetable production has tremendous scope in hilly regions of the country because of continuous increase in availability of up-markets and liking of consumers towards off-season and high-quality produce of different horticultural crops. Himachal Pradesh is also not an exception to this cultivation and most of the growers in the lower mid hills and mid hills are adopting this technology on a large scale due to more than 80% subsidy on construction of protected structures. As per recent estimates, area under protected cultivation in Himachal Pradesh is approximately 350 hectares [1]. The area under protected cultivation is increasing day by day with interventions of the state and central government funded schemes. However, it occupies an area of 10,370 hectares with the production of 430790 metric tonnes in the state under open field conditions [2].

The production under protected conditions has suffered in mid hills of Himachal Pradesh due to biotic and abiotic stresses. Among biotic stresses bacterial wilt caused by *Ralstonia solanacearum* is the most devastating disease in Himachal Pradesh which affects tomato production in protected as well as under open field conditions. Bacterial wilt was first reported in Kangra valley in 1981 on solanaceous crops, and now it become endemic in Kangra and Mandi districts [3]. The chemical control is not effective and resistant varieties are scanty, therefore vegetable grafting is the effective alternative technique to combat this problem [4]. Grafting is the union of two or more pieces of living plant tissues that grow as a single plant [5]. It is usually used to reduce infections by soil borne pathogens and to enhance tolerance against abiotic stresses such low and high temperature, salt, flooding etc. Vegetable grafting is now common in Asia, parts of Europe and the Middle East. In Korea, about 90% of the cucurbitaceous vegetable and 30% of solanaceous vegetable are grafted on various rootstocks [6].

Grafting tomato scions on compatible rootstocks improves quality parameter of the plant. Grafting scions on resistant rootstocks makes it possible to control soil borne diseases and increase yield of susceptible cultivar [5]. The use of resistant rootstocks reduces dependence on agrochemicals, so the technique is therefore, considered to be ecofriendly for sustainable vegetable production [7]. Grafted seedlings were used to induce resistance against low and high temperature [8], enhance nutrient uptake [9], increase synthesis of endogenous hormones [10], and improve water use efficiency [11]. The main purpose of grafting seedlings is to increase the yield and tolerance to biotic and abiotic stresses. This technology was ignored because the focus of the breeders remained only to develop suitable varieties or hybrids resistant to biotic stresses.

Since, there is no other alternative method or strategy to control serious diseases like bacterial wilt, grafting has become an essential technique for the production of repeated crops of fruit bearing vegetables grown in polyhouse. The recent studies showed that the use of the suitable rootstocks will help to improve biotic and abiotic stresses in tomato has positively increased the yield, particularly under greenhouse conditions.

Materials and Methods

The experiment was conducted in a modified naturally ventilated Quonset polyhouse (25m×10m) at Experimental Farm, Department of Vegetable Science and Floriculture, CSKHPKV, Palampur during 2014-15. The experimental area is situated at $32^{0}6$ N latitude and $76^{0}3$ E longitude at an elevation of 1290.80m above mean sea level with East-West orientation under mid hill zone of Himachal Pradesh.

The study was undertaken to identify the best rootstock and scion for protected cultivation of tomato. The experiment consisted of 8 different rootstocks *viz;* Pumpkin Jalag, Tomato 2123 A-1, Hawaii 7998 (Tomato), Palam Pink (Tomato), Hawaii 7996 (Tomato), Palam Pride (Tomato), Arka Nidhi (Brinjal) and Arka Keshav (Brinjal) and three tomato varieties *viz;* Rakshita, Naveen 2000^{+} and GS-600. Various treatment combinations i.e. T-1 (Pumpkin Jalag + Naveen 2000^{+}), T-2 (2123 A-1 + Rakshita), T-3 (Hawaii 7998 + Rakshita), T-4(Palam Pink + Naveen 2000^{+}), T-5 (Hawaii 7996 + GS-600), T-6 (Hawaii 7996 + Naveen 2000^{+}), T-7 (Palam Pride + Naveen 2000^{+}), T-8 (Arka Nidhi + Rakshita), T-9 (Arka Keshav + Naveen 2000^{+}) were laid out in a Randomized Block Design. Data was recorded on various horticultural and quality traits such as days to first harvest, number of marketable fruits per plant, marketable fruit yield per plant (kg), harvest duration (days), plant height (cm), TSS (°Brix), Ascorbic acid (mg/100g) and Lycopene (mg/100g) content.

Table-1 *List of different rootstocks and scion cultivar*

Sr. No.	Rootstock	Source	Salient features
1	Hawaii 7996 (Tomato)	AVRDC-Taiwan	Resistant to bacterial wilt
2	Hawaii 7998 (Tomato)	AVRDC-Taiwan	Resistant to bacterial wilt
3	Palam Pink (Tomato)	CSKHPKV-Palampur	Resistant to bacterial wilt
4	Palam Pride (Tomato)	CSKHPKV-Palampur	Resistant to bacterial wilt
5	2123 A-1 (Tomato)	CSKHPKV-Palampur	Resistant to bacterial wilt
6	Arka Nidhi (Brinjal)	IIHR-Bengaluru	Resistant to bacterial wilt
7	Arka Keshav (Brinjal)	IIHR-Bengaluru	Resistant to bacterial wilt
8	Local Pumpkin (Jalag)		Resistant to downy mildew
	Scion		
1	GS-600	Commercial hybrid from Golden seeds,UPL Ltd.	Fruits round, pericarp thick, high TSS. Average yield: 2-3 kg/plant under polyhouse conditions.
2	Rakshita	Indo-American hybrids Pvt Ltd.	Recommended for polyhouse cultivation
3	Naveen2000^{+}	Indo-American hybrids Pvt Ltd.	Recommended for polyhouse cultivation

Results and Discussion

An examination of data presented in [Table-2] indicated that different rootstocks and scions used in the study affected the fruit yield/ plant significantly. The treatment T-2 (2123 A-1 + Rakshita) recorded highest fruit yield/ plant (4.25 kg) followed by treatment T-5 (GS 600 + Hawaii-7996), 4.11 kg fruit yield/plant and treatment T-9 (Arka Keshav + Naveen 2000^{+}), 3.89 kg fruit yield/plant.The treatment T-2 (2123 A-1 + Rakshita) was statistically at par with treatment T-5 (GS 600 + Hawaii-7996). Lowest fruit yield/plant was recorded in treatment T-3 (Hawaii 7998 + Rakshita), (2.83 kg fruit yield/ plant).

There were significant differences in number of fruits/plant. Treatment T-5 (GS 600 + Hawaii-7996) produced maximum number of fruits /plant (38.00) followed by treatment T-2 (2123 A-1+ Rakshita) (37.66fruits/ plant) and was statistically at par with treatments T-4 (Palam Pink + Naveen 2000^{+}) and T-9 (Arka Keshav + Naveen 2000^{+}) (33.00fruits/ plant). Minimum number of fruits/ plant were recorded in treatment T-3 (Hawaii 7998 + Rakshita), (with 19.66fruits/ plant).

It is also amply clear from the data that days to first harvest ranged from 64.33 to 71.66 days. TreatmentT-7 (Palam Pride + Naveen 2000^{+}) observed to produced marketable fruits in minimum (64.33) days followed by treatmentT-3 (Hawaii 7998 + Rakshita) produce marketable fruits in minimum (67.33) days which were statistically superior to all other treatments used in the study. Treatments T-5 (GS 600 + Hawaii-7996) and T-9 (Arka Keshav + Naveen 2000^{+}) took maximum (71.66) days to produce marketable fruits. The early harvest in grafted plants may be due to the compatibility of various physiological traits such as photosynthetic rate, nutrient use efficiency, proper water flow and hormonal response which also influences plant growth and biomass production. The results are in line with the findings by Khah, *et al*., (2006); Gisbert, *et al*., (2010) and Ibrahim, *et al*., (2014) [12-14]. Yield is highly dependent on harvest duration of crop and different treatments influenced harvest duration significantly. Results indicated that harvest duration ranged from 27.66 to 40.00 days. Treatment T-2 (2123 A-1+ Rakshita) recorded maximum days (40.00) for harvest duration, followed by treatment T-5 (GS 600 + Hawaii-7996) which recorded 38.66 days and was statistically at par with treatment T-9 (Arka Keshav + Naveen 2000^{+}) recorded35.00 days. Treatment (T-8) Arka Nidhi + Rakshita recorded minimum days (35.00) for harvest duration. The prolonged harvest duration observed may be due to the rootstock with strong root system which supported a long season crop along with improved resistance to various diseases. The findings of Lee, *et al*., (2010) [6] and King, *et al*., (2010) [16] corroborate the above results.

From [Table-2] it is found that maximum plant height of 318.66 cm was recorded in treatment T-2(2123 A-1+ Rakshita)and was followed by treatments T-5 (GS 600 + Hawaii-7996) and T-8 (Arka Nidhi + Rakshita) whichrecorded(313.33 cm) of plant height. The reasons for taller plants may be due to indeterminate growth habit of rootstock, increased nutrient uptake and resistance to bacterial wilt incidence. Khah, *et al*., (2006); Passam, *et al*., (2005) and Marin, *et al*., (2013) [12,17,18] also reported similar results.

Results indicated that ascorbic acid content ranged from 20.83 to 39.80 mg/100g. It is found that different treatments influenced the ascorbic acid content significantly. The treatment T-9 (Arka Keshav + Naveen 2000^{+}) recorded highest ascorbic acid content of 39.80 mg/100g, followed by treatment T-8 (Arka Nidhi + Rakshita) which recorded 35.56 mg/100g of ascorbic acid content. Lowest content of ascorbic acid recorded in treatment T-5 (GS 600 + Hawaii-7996) which was 20.83mg/100g. The effect of rootstocks on vegetable quality depends upon the compatibility of the scion and stocks. The above findings are in conformity with Turhan, *et al*., (2011) and Barrett, *et al*., (2012) [19, 20].

It is observed from the data presented in [Table-2] that different treatments influenced the lycopene content significantly. Results indicated that lycopene content ranged from 15.96 to 22.90 mg/100g. Maximum lycopene content of 22.90 mg/100gwas recorded in treatment T-8 (Arka Nidhi + Rakshita) followed by treatment T-1 (Jalag + Naveen 2000^{+}) which recorded 22.66 mg/100g lycopene content and was statistically at par with treatmentT-2(2123 A-1+Rakshita). Lowest lycopene content was recorded in treatment T-3(Hawaii 7998 + Rakshita).

Table-2 *Effect of different rootstocks and varieties on horticultural traits and quality of tomato*

Treatments	Fruit Yield/Plant	No. of Fruits/Plant	Days to First Harvest	Harvest Duration	TSS (°Brix)	Ascorbic Acid (mg/100g)	Lycopene (mg/100g)	Plant Height (cm)
Jalag + Naveen 2000^{+}(T-1)	3.61	28.33	69.00	34.00	5.23	31.56	22.66	291.66
2123 A-1+ Rakshita (T-2)	4.25	37.66	70.33	40.00	6.13	34.73	21.56	318.66
Hawaii 7998 + Rakshita (T-3)	2.83	19.66	67.33	29.00	5.16	23.80	15.96	298.00
Palam Pink + Naveen 2000^{+}(T-4)	3.49	33.00	68.66	34.00	4.30	30.20	19.03	300.66
GS 600 + Hawaii-7996 (T-5)	4.11	38.00	71.66	38.66	4.66	20.83	17.26	313.33
Hawaii 7996 + Naveen 2000^{+}(T-6)	3.55	31.00	68.33	31.33	4.16	26.70	18.46	293.33
Palam Pride + Naveen 2000^{+}(T-7)	3.26	27.33	64.33	33.00	5.03	29.70	20.00	295.33
Arka Nidhi + Rakshita(T-8)	3.21	27.66	70.33	27.66	4.16	35.56	22.90	313.33
Arka Keshav + Naveen 2000^{+}(T-9)	3.89	33.00	71.66	35.00	4.10	39.80	19.70	303.33
Overall mean	**3.58**	**30.63**	**69.07**	**33.63**	**4.77**	**30.32**	**19.73**	**303.07**
CD	0.19	2.96	3.75	5.07	0.32	0.99	0.91	3.91

It is clear from table that different treatments influenced the TSS significantly. Maximum TSS of 6.13 ˚ brix was recorded in treatment T-2 (2123 A-1+ Rakshita), which was followed by treatment T-1 (Jalag + Naveen 2000+) recorded 5.23 ˚brix. Lowest content of TSS recorded in treatment T-9 (Arka Keshav + Naveen 2000+) was 4.10 ˚brix. The higher TSS content recorded in grafted plants is largely dependent on the local germplasm resources of rootstocks and also the compatibility of scion and stocks. These results are in accordance with the findings of Davis, *et al*., (2008); Poudel and (2009) [21,22].

The results revealed that treatment T-2(2123 A-1 + Rakshita) resulted in highest fruit yield per plant (4.25 kg) which also recorded longest harvest duration (40.00 days), highest TSS (6.13 °Brix), maximum plant height (318.67 cm) and maximum number of fruits per plant (38.00 fruits). Treatment T-7 (Palam Pride + Naveen 2000+) took minimum days to first harvest (64.33 days) whereas, Treatment T-9 (Arka Keshav + Naveen 2000+) and T-8 (Arka Nidhi + Rakshita) recorded highest ascorbic acid (39.80 mg/100g) and highest lycopene content (22.90 mg/100g), respectively.

Conclusion

From the present study it is concluded that grafting is an effective technique to improve various horticultural and quality traits in tomato under protected environment thereby, increasing total and early yield and also found as best alternative approach to combat bacterial wilt, increased disease tolerance and vigour to crops, so it will be useful in the low input sustainable horticulture of the future. Treatment T-2 in which 2123 A-1 was used as a rootstock and Rakshita used as a scion has been found more suitable in which highest fruit yield per plant, longest harvest duration, highest TSS, maximum plant height and maximum number of fruits per plant was recorded. Growth, yield and fruit quality of the scion is greatly influenced by the type of rootstock used.

Application of research: Research is applicable for bacterial wilt prone areas under open as well as protected environment

Research Category: Protected Cultivation, Vegetable Grafting

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***Principle Investigator: Dr Pardeep Kumar**
University: Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh 176062
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