Himachal Journal of Agricultural Research 41(1): 100-103 (2015)

Short Note

Evaluation of different rootstocks for bacterial wilt tolerance in bell pepper [*Capsicum annuum* (L.) var. *grossum* (Sendt.)] under protected conditions

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Received: 01.05.2015; Accepted: 15.06.2015

Abstract

Bell pepper (*Capsicum annuum* L. var. *grossum* Sendt.) is an important commercial crop grown under protected condition in Himachal Pradesh. Being long duration under protected environment, it is the principle money spinner off-season crop. Production of bell pepper under protected conditions in the state is very low as compared to the National and International levels because of lack of suitable Cultivars and hybrids resistant to bacterial wilt. Among biotic stresses bacterial wilt caused by *Ralstonia solanacearum* is the most devastating disease under protected as well as open field conditions in mid hills of HP which reduces yield of capsicum to very low levels. Numerous attempts have been made to develop bacterial wilt resistant varieties, but till date no resistant hybrid is available. The best option to overcome this problem is grafting scions of horticulturally superior hybrids on resistant rootstocks. The study revealed that chilli rootstock PI-201232 was the most suitable bacterial wilt resistant rootstock of bell pepper whereas; brinjal rootstocks were not suitable for bell pepper scions.

Key words: Bell pepper, grafting, rootstock, scion, bacterial wilt, protected cultivation

Polyhouse technology is becoming popular in Himachal Pradesh and a large number of polyhouses are being constructed at farmer's fields. The geographical conditions of the state are quite suitable for cultivation under protected conditions, due to prevalence of near optimum growing climatic conditions. Among vegetable crops, bell pepper (*Capsicum annuum* L. var. *grossum* Sendt.), is the most widely grown off-season crop under polyhouse conditions in Himachal Pradesh. It is cultivated on an area of 2240 ha with production of 39500 MT and productivity of 17.63 MT/ha in HP under open field conditions, whereas area under polyhouse conditions is approximately 300 ha (Anonymous 2013). Vegetable production and productivity is very high under protected environments as compared to open field conditions. But production of bell pepper under polyhouse conditions in HP is very low as compared to national and international levels.

Bell pepper production in Himachal suffered a great setback due to biotic and abiotic stresses. Among biotic stresses bacterial wilt caused by *Ralstonia solanacearum* is the most devastating disease under protected as well as open field conditions in mid hills of HP which reduces capsicum yield to very low levels. Lack of bacterial wilt resistant cultivars and hybrids is the main reason for low production under polyhouse conditions in Himachal Pradesh. The disease was first reported in Kangra valley in 1981 on solanaceous crops, and it remained sporadic in nature till 1985, and now it has become endemic in Kangra and Mandi districts (Sood and Singh, 1992). Numerous attempts have been made to develop bacterial wilt resistant varieties, but till date no source possessing resistance is available. In order to combine various desirable horticultural traits in capsicum along with resistance to diseases, the best strategy to combat bacterial wilt is grafting of desirable scion with resistant rootstocks.

Grafting is an environment-friendly alternative method to control bacterial wilt. Grafting scions on resistant rootstocks makes it possible to control soil borne diseases and increase yield of susceptible cultivars (Lee and Oda, 2003). Grafting of vegetable seedlings in India is still in infancy due to lack of knowledge, awareness and non-identification of resistant rootstocks. This technology was ignored because the focus of the breeders remained only to develop suitable varieties or hybrids resistant to biotic stresses. Since grafting gives increased disease tolerance and vigour to crops so it will be useful in the low-input sustainable horticulture of the future.

The present investigation was carried out at Palampur during 2014 using five rootstocks of chilli and three of brinjal plus one control (non grafted plots of hybrid Indra). Commercial hybrid 'Indra' was used as a scion. The seeds of different rootstocks were procured from different sources. Some rootstocks were imported from AVRDC- Taiwan while others were the locally identified resistant to bacterial wilt (Table 1). The nursery of different rootstocks was raised in disposable cups whereas, nursery of scion was raised in plug trays by using soil-less media having mixture of cocopeat: perlite: vermiculite :: 3:1:1 on 10th January, 2014 in growth chamber. Grafted seedlings were transplanted on 17th April 2014. Ten plants of each treatment were planted at inter row distance of 45 cm and plant to plant distance of 30 cm by using black polythene (30 micron thick) mulch of one meter width. Eight rootstocks and one control (non grafted) were planted in Randomized Block Design with three replications in 250 m^2 modified naturally ventilated quonset polyhouse. Observations were recorded on five randomly selected plants in each plot *viz*., days to first flowering, days to first harvest, number of marketable fruits per plant, average fruit weight (g), marketable fruit yield per plant (kg), marketable fruit yield per square metre (kg), fruit length (cm), fruit width (cm), harvest duration (days), plant height (cm) and bacterial wilt incidence (%). Screening of rootstocks against bacterial wilt *(Ralstonia solanacearum)* was done. TZC broth specific for *Ralstonia solanacearum* was prepared and bacterial culture was taken from Department of Plant pathology. Then the culture was inoculated in broth and broth was kept in incubator for 1 hr. Soil was inoculated with *Ralstonia* culture and then different rootstocks were transplanted in different pots containing sick soil. After one month it was recorded that all the rootstocks were resistant to bacterial wilt. The observations were recorded on bacterial wilt incidence at weekly intervals under protected conditions. The data regarding above mentioned characters were averaged and subjected to analysis of variance (Panse and Sukhatme, 2000).

Table 1. List of Rootstocks

Rootstocks	Source
Pant C-1 (Chilli)	GBPUAT- Pantnagar-India
Surajmukhi (Chilli)	CSKHPKV- Palampur-India
VI-37556 (Chilli)	AVRDC- Taiwan
PI-201232 (Chilli)	AVRDC- Taiwan
AVPP0205 (Chilli)	AVRDC- Taiwan
VI-045376 (Brinjal)	AVRDC- Taiwan
VI-047335 (Brinjal)	AVRDC- Taiwan
VI-034845 (Brinjal)	AVRDC- Taiwan

Different rootstocks under study significantly affected the number of days to flowering in capsicum (Table 2). Rootstock PI-201232 (RS4) took minimum number of days (48.79) to produce first flower. The other rootstocks of chilli were also superior to control (non-grafted) which took 52 days to produce first flower. Rootstock RS8 (VI-034845) took maximum days (53.05) for first flowering. Rootstock PI -201232 (RS4) took 4.26 days less than VI-034845 (RS8). Rootstock Pant C-1 (RS1) and Surajmukhi (RS2) took 49.73 and 49.78 days to reach flowering which were statistically at par with each other. In grafted plants the movement of endogenous flowering substances across the graft union is easy. The early flowering in grafted plants may be due to better and improved root system of the rootstocks used, which has resulted in increased water and nutrient uptake. These results are in conformity with the findings of Ibrahim *et al*. (2014). Rootstock PI-201232 was observed to produce marketable fruits in minimum (73) days which were statistically superior to all other rootstocks used in the study. It was also amply clear from the data that days to first harvest ranged from 73.00 to 80.49 days. 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 influenced plant growth and biomass production. The results are in line with the findings of Khah *et al*. (2006), Gisbert *et al.* (2010) and Ibrahim *et al*. (2014). Rootstocks significantly affected the number of fruits per plant. Rootstock RS4 (PI-201232) produced maximum number of fruits per plant (24.70) followed by RS5 (AVPP0205) and RS3 (VI-37556). The other chilli rootstocks were also significantly superior over control (8.56 fruits/plant). In vegetable crops grafting scion over vigorous rootstock improves cytokinin content in scion and improves fruit load on the plant. Similar

Table 2. Effect of different rootstocks on horticultural traits under protected environment

Rootstocks	Days to flowering	Days to harvest	Fruits/ plant (No.)	Fruit weight (g)	Fruit/plant (kg)	Yield (kg/ m^2)	Fruit length (cm)	Fruit width (cm)	Harvest duration (days)	Plant height (cm)
Pant C-1 (RS1)	49.73	77.60	14.13	93.16	1.30	4.32	8.29	7.29	150.53	125.88
Surajmukhi (RS2)	49.78	74.67	20.93	93.73	1.83	7.95	8.13	7.31	159.10	145.51
VI-37556 (RS3)	51.69	77.22	21.17	94.62	1.97	8.37	7.93	7.08	146.97	137.85
PI-201232 (RS4)	48.79	73.00	24.70	99.73	2.47	9.89	8.37	7.51	160.99	160.44
AVPP0205 (RS5)	49.81	75.67	21.20	95.73	1.91	9.03	8.52	7.17	151.20	148.81
VI-045376 (RS6)	52.25	79.68	8.27	90.75	0.72	1.44	7.74	6.52	145.23	113.92
VI-047335 (RS7)	52.40	80.49	8.11	87.40	0.51	0.51	7.63	6.25	146.14	110.35
VI-034825 (RS8)	53.05	80.07	8.26	88.95	0.55	1.00	7.66	6.35	144.61	112.61
Control	52.00	79.00	8.56	91.88	1.17	2.50	7.93	6.70	150.30	127.77
CD (0.05)	0.39	0.73	0.48	0.94	0.15	0.27	0.05	NS	0.11	0.87

findings were also reported by Khah *et al*. (2006), Gisbert *et al*. (2010), Djidonou *et al*. (2013) and Fernandez *et al*. (2013). The treatment RS4 (PI-201232) produced maximum average fruit weight (99.73 g), followed by RS5 (AVPP0205) (95.73 g/plant. All chilli rootstocks were significantly superior to control (91.88 g). The rootstock-scion interaction influences the uptake of minerals, water relations which ultimately led to increased average fruit weight of the grafted plants. The above findings are supported with the conclusions drawn by Khah *et al*. (2006), Davis *et al*. (2008), Djidonou *et al*. (2013) and Fernandez *et al*. (2013). Maximum fruit yield per plant (2.47 kg) was recorded under the rootstock RS4 (PI-201232). All five chilli rootstocks were significantly superior to control (1.17 kg) followed by RS3 (VI-37556) and RS 5 (AVPP0205). The highest yield in grafted plants may be due to resistance to soil borne diseases, water and nutrient uptake, enhancement of vigour, strong root systems, tolerance of low soil temperature and increased photosynthesis. The findings of Lee (1994), Attia *et al*. (2003), Kacjan Marsic and Osvald (2004), Davis *et al*. (2008b) and Voutsela *et al*. (2012) corroborate the above results. Data from table manifested that in case of rootstocks, the mean performance ranged from 0.51 to 9.89 kg. Maximum yield per square meter was observed in plants with rootstock PI-201232 (9.89 kg) followed by AVPP0205 (9.03 kg) and VI-37556 (8.37). All the five chilli rootstocks were found significantly superior over the control (2.50 kg/m^2). The higher marketable yield recorded with grafting was mainly due to an improvement in water and nutrient uptake. These results are in conformity with the findings of Jang *et al*. (2008), Kubota *et al*. (2008), Ballesta *et al*. (2010) and Saadoun and Allaagui (2013).

Among rootstocks AVPP0205 (RS5) was found to record 8.52 cm longer fruits followed by PI-201232 (RS4) (8.37 cm). All the chilli rootstocks were significantly superior to control (7.93 cm). Rootstocks affected fruit length and it may be due to changes in the concentration of growth regulators induced by the rootstock. Similar findings were reported by Gisbert *et al*. (2011a) and Jang *et al*. (2012). Effects of rootstocks on fruit width were found to be non-significant and these results are in line with the findings of Turkmen *et al*. (2010) and Gisbert *et al*. (2011). Harvest duration ranged from 144.6 to 161.0 days. RS4 (PI-201232) resulted in maximum days (160.99) to harvest, followed by RS 9 (Surajmukhi) (159.1 days). 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 (1994) and King *et al*. (2010) corroborate the above results.

Maximum plant height of 160.44 cm was recorded in RS4 (PI-201232) followed by RS5 (AVPP0205) (148.81 cm). All the five chilli rootstocks were found significantly superior to the control (127.77 cm). 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) also reported similar results.

Weekly record on bacterial wilt incidence showed that only non-grafted (control) plants i.e. Indra showed wilting symptoms while all the rootstocks were resistant to bacterial wilt. Therefore, less survival rate of control /non grafted plants was due to the incidence of bacterial wilt.

Therefore, from this study it may be inferred that grafting can be an effective strategy to manage bacterial wilt incidence in chillies.

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