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Heterosis and *per se* performance of bacterial wilt resistant tomato (*Solanum lycopersicum* L.) hybrids over environments in mid Himalayas

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Abstract

Bacterial wilt resistant determinate lines (7) and indeterminate testers (4) alongwith their 28 hybrids developed as per line x tester mating design were evaluated alongwith standard check Avtar (7711)- hybrid from Nunhems Pvt. Ltd., in Randomized Block Design with three replications at the Experimental Farm of Department of Vegetable Science and Floriculture, CSK HPKV, Palampur during summer-rainy season of 2009 and 2010. Observations were recorded on incidence of bacterial wilt disease, fruit yield and component traits. The analysis of variance indicated significant differences among treatments for marketable yield and other component traits in all the environments. The hybrid BWR-5 x 16-B surpassed all the hybrids and the standard check in all the environments and recorded 2.21 kg marketable fruit yield per plant in comparison to 1.04 kg per plant in the standard check Avtar (7711).

Key Words: Heterosis, *per se* performance, bacterial wilt, tomato, *Solanum lycopersicum*.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important solanaceous fruit vegetables, which has achieved tremendous popularity during the last over a century. It is grown practically in every country of the world in outdoor fields, greenhouses and net houses. It plays an important role in the economy of the farmers of hill regions. In Himachal Pradesh, it is being grown in about 9,600 hectares (16.3% of total vegetable area in H.P.) with a production of 3,36,300 tonnes (Anonymous, 2009-10) and bulk of the produce is marketed in the plains as an off-season produce.

Tomato cultivation in most of the potential tomato growing pockets of the state has suffered a setback due to bacterial wilt disease caused by *Ralstonia solanacearum* (syn. *Pseudomonas solanacearum*). The disease results in partial to complete failure of crop and manifests at all stages of crop growth with the maximum severity during the flowering and fruiting stages. Being soil borne, its control through chemicals is neither effective nor economical. As such, genetic resistance in the cultivars is of practical significance as it reduces the cost of cultivation because the chemicals used to control diseases are costlier.

Hybrids are preferred over pure lines varieties in tomato on account of their superiority in uniformity, marketable yield and fruit quality. At present there is no bacterial wilt resistant hybrid(s) developed/ recommended for the state. Therefore, the present study was carried out with the objective to develop bacterial wilt resistant hybrid(s) comparable with the hybrids from the private seed companies especially in terms of fruit firmness.

Materials and Methods

The present investigation was carried out at the Vegetable Research Farm (32°6' N latitude, 76°3' E longitude and 1290.8 m altitude), Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, consecutively for two years (2009 and 2010). The experimental material comprising 28 F_1's (developed by crossing 7 determinate lines *viz.*, 1-2 (L_1),

CLN2116B(L_2), BL333-3(L_3), BWR-5(L_4), 17-2(L_5), 15-2(L_6), 7-2(L_7) with 4 indeterminate testers *viz.*, Palam Pride(T_1), 12-1(T_2), 16-B(T_3) and CLN1314G(T_4) alongwith parents and hybrid Avtar (7711) from Nunhems Pvt. Ltd. as standard check. The crop was transplanted in bacterial wilt sick plots in Randomized Block Design (RBD) with three replications on 7th April, 2009 and 2nd March, 2010. Each entry was grown in a single row of 3.15 m length. The plants were spaced at 75 cm row to row and 45 cm plant to plant. Two susceptible checks, Solan Gola and Roma were transplanted as every 11th row to ensure uniform presence of the inoculum of bacterial wilt disease in the experimental fields. The seeds before sowing were treated with fungicide Dithane M-45 and Bavistin as a prophylactic measure. Besides the application of Farm Yard Manure (FYM) @ 20 t/ ha, the chemical fertilizers were applied as per the recommended package of practices (150 kg N, 120 kg P_2O_5 and 60 kg K_2O). FYM was mixed at the time of transplanting alongwith 1/3rd dose of N and full dose of P_2O_5 and K_2O. Remaining 2/3rd dose of N (urea) was top dressed in two equal amounts after 30 and 45 days after transplanting (DAT). All other cultural practices and plant protection measures were followed as per recommended package of practices. The data were recorded for the characters *viz.*, bacterial wilt disease incidence, marketable yield per plant (kg), marketable fruits per plant, fruit weight (g), fruit shape index, pericarp thickness (mm) and locules per fruit. Standard statistical procedures were followed to analyze the data.

Results and Discussion

Keeping in view the bulk of data, the results of findings have been discussed for pooled analysis over both years of study only. Non-significant differences were observed for incidence of bacterial wilt disease, as all the entries (F1s, parents and check) showed 100 per cent plant survival except line 1-2 (97.62 per cent). Anand *et al.* (1992) had emphasized the inclusion of both parents carrying resistant genes while developing bacterial wilt resistant hybrids in tomato. For all other traits significant differences were observed in all the environments which implies that environment/years have a definite bearing on the performance of hybrids and parents. The results are in conformity with earlier findings (Chadha 1998 and Rattan 2007).

Marketable yield per plant

It is the marketable yield which is of relevance to the farmers. Marketable yield per plant in the hybrids ranged from 0.84 (L_2 x T_1) to 2.21 kg (L_4 x T_3) in pooled environment, whereas, the standard check recorded 1.04 kg marketable yield per plant in pooled environment. As many as 23 hybrids gave significantly higher marketable yield per plant as compared to standard check (SC).

On the basis of heterosis over better parent (BP) in pooled environment, L_4 x T_3 (144.73%), L_3 x T_3 (106.65%), L_3 x T_1 (104.78%), L_2 x T_3 (101.66%) and L_4 x T_2 (90.56%) were the top ranking cross combinations, whereas cross combinations L_4 x T_3 (112.50 %), L_7 x T_4 (82.69%), L_3 x T_3 and L_5x T_4 (78.85% each) and L_4 x T_2 and L_2 x T_3 (75.00% each) were the top best in standard heterosis. The findings are in partial agreement to those Sharma *et al.* (2001) and Sharma (2003), who have also observed heterobeltiosis and standard heterosis in variable number of hybrids developed and studied by them.

Marketable fruits per plant

Number of marketable fruits is one of the direct components of marketable yield. In the hybrids, marketable fruits per plant ranged from 15.36 (L_2 x T_1) to 42.10 (L_2 x T_3) in pooled environment. The standard check recorded 17.82 marketable fruits per plant to which 22 hybrids were significantly superior. Among the top five hybrids, three (L_3 x T_3, L_7 x T_2 and L_2 x T_3) were common in both the years. The present findings are in consonance with those of Chadha (1998) and Rattan (2007), who have also observed >50 per cent of the hybrids producing marketable fruit per plant more than the standard check.

Out of 28 hybrids, 24 hybrids each exhibited significant positive heterosis over BP and SC in pooled

Table 1. Mean performance and estimation of heterosis (%) over better parent (BP) and standard check (SC) for different traits in tomato pooled over environments

Treatments	Marketable yield/plant (kg)			Marketable fruits/plant			Fruit Weight (g)			Fruit Shape Index		
	Mean value	Heterosis Over		Mean value	Heterosis Over		Mean value	Heterosis Over		Mean value	Heterosis Over	
		BP	SC		BP	SC		BP	SC		BP	SC
$L_1 \times T_1$	1.09	15.47*	4.81	19.25	11.24	8.02	56.87	-3.01	-3.40	0.97	-17.28*	3.19
$\times T_2$	1.19	25.17*	14.42*	25.95	19.07*	45.62*	50.42	-14.01*	-14.35*	1.04	-11.47*	10.64*
$L_1 \times T_3$	1.51	58.88*	45.19*	30.86	19.92*	73.18*	49.45	-15.65*	-16.00*	1.08	-8.64*	14.89*
$L_1 \times T_4$	1.39	46.92*	33.65*	20.83	20.35*	16.89*	67.50	-20.12*	14.66*	0.86	-27.20*	-8.51*
$L_2 \times T_1$	0.84	60.51*	-19.23*	15.36	32.17*	-13.80	55.44	13.23*	-5.83	0.90	-16.80*	-4.26
$L_2 \times T_2$	1.75	83.22*	68.27*	37.41	71.65*	109.93*	47.51	9.21	-19.30*	1.01	-6.93*	7.45*
$L_2 \times T_3$	1.82	101.66*	75.00*	42.10	63.61*	136.25*	42.62	0.87	-27.60*	0.99	-8.63*	5.32
$L_2 \times T_4$	1.54	74.39*	48.08*	23.21	99.78*	30.25*	67.28	-20.37*	14.29*	0.84	-22.03*	-10.64*
$L_3 \times T_1$	1.43	104.78*	37.50*	23.87	78.26*	33.95*	59.68	18.54*	1.38	0.84	-19.20*	-10.64*
$L_3 \times T_2$	1.34	40.03*	28.85*	28.03	28.57*	57.30*	47.59	-5.48	-19.16*	0.95	-8.63*	1.06
$L_3 \times T_3$	1.86	106.65*	78.85*	41.98	63.13*	135.58*	44.75	-11.12	-23.99*	1.00	-4.32	6.38*
$L_3 \times T_4$	1.56	76.84*	50.00*	24.72	84.57*	38.72*	62.69	-25.80*	6.49	0.82	-21.44*	-12.77*
$L_4 \times T_1$	1.55	90.16*	49.04*	20.35	27.38*	14.20	75.55	48.54*	28.33*	0.86	0.00	-8.51*
$L_4 \times T_2$	1.82	90.56*	75.00*	29.09	33.48*	63.24*	63.11	24.09*	7.20	0.90	-13.90*	-4.26
$L_4 \times T_3$	2.21	144.73*	112.50*	38.86	51.02*	118.07*	56.31	10.70	-4.35	0.97	-6.59*	3.19
$L_4 \times T_4$	1.60	81.17*	53.85*	20.48	28.19*	14.93	77.17	-8.67*	31.09*	0.81	-3.94	-13.83*
$L_5 \times T_1$	1.44	16.02*	38.46*	20.80	30.20*	16.72*	69.96	-9.22*	18.84*	0.97	-25.79*	-3.19
$L_5 \times T_2$	1.54	24.36*	48.08*	29.60	35.79*	63.24*	52.15	-32.34*	-11.41*	1.04	-20.46*	10.63*
$L_5 \times T_3$	1.46	17.90*	40.38*	30.76	19.53*	72.62*	47.52	-38.34*	-19.28*	1.04	-20.97*	10.63*
$L_5 \times T_4$	1.86	50.61*	78.85*	23.32	45.96*	30.86*	79.86	-5.48	35.65*	0.90	-31.51*	-4.26
$L_6 \times T_1$	1.07	36.02*	2.88	27.07	6.13	51.91*	39.53	-19.27*	-32.85*	0.91	-11.59*	-3.19
$L_6 \times T_2$	1.22	27.97*	17.31*	29.72	16.49*	66.78*	41.93	-3.62	-28.78*	0.97	-7.03*	3.19

Contd.

$L_6 \times T_3$	1.43	58.60*	37.50*	32.88	27.79*	84.51*	42.12	-1.37	-28.45	1.00	-3.70	6.38*
$L_6 \times T_4$	1.44	63.09*	38.46*	26.76	4.92	50.17*	52.88	-37.41*	-10.17	0.82	-20.45*	-12.77*
$L_7 \times T_1$	1.72	45.21*	65.38*	38.63	51.79*	116.78*	44.70	-8.71	-24.07*	0.87	-18.00*	-7.45*
$L_7 \times T_2$	1.73	46.20*	66.35*	39.60	55.61*	122.22*	39.85	-8.39	-32.34*	0.96	-9.86*	2.13
$L_7 \times T_3$	1.47	24.23*	41.35*	38.70	50.40*	117.17*	38.39	-11.04	-34.79*	1.05	-1.25	11.70*
$L_7 \times T_4$	1.90	60.14*	82.69*	28.01	10.08	57.18*	73.61	-12.88*	25.04*	0.85	-20.19*	-9.57*
L_1	0.95	-	-	17.31	-	-	58.63	-	-	1.18	-	-
L_2	0.52	-	-	11.62	-	-	42.25	-	-	1.08	-	-
L_3	0.70	-	-	13.39	-	-	50.35	-	-	1.04	-	-
L_4	0.81	-	-	15.97	-	-	50.86	-	-	0.85	-	-
L_5	1.24	-	-	15.97	-	-	77.07	-	-	1.31	-	-
L_6	0.79	-	-	25.51	-	-	42.71	-	-	1.03	-	-
L_7	1.18	-	-	25.45	-	-	43.15	-	-	1.06	-	-
T_1	0.42	-	-	8.44	-	-	48.96	-	-	0.86	-	-
T_2	0.95	-	-	21.81	-	-	43.50	-	-	1.04	-	-
T_3	0.90	-	-	25.73	-	-	38.08	-	-	1.04	-	-
T_4	0.88	-	-	10.37	-	-	84.50	-	-	0.84	-	-
SC(Avtar)	1.04	-	-	17.82	-	-	58.87	-	-	0.94	-	-
CD (P=0.05)	0.21	-	-	4.12	-	-	8.90	-	-	0.09	-	-

* Significant at 5% level of significance

Lines: L_1: 1-2, L_2: CLN2116B, L_3: BL333-3, L_4: BWR-5, L_5: 17-2, L_6: 15-2, L_7: 7-2;

Testers: T_1: Palam Pride, T_2: 12-1, T_3: 16-B T_4: CLN1314G

over environments. A perusal of pooled data revealed that the cross combination exhibiting the maximum heterobeltiosis may or may not fall in top ranking order of standard heterosis. L_2 x T_4 (99.78%), L_3 x T_4 (84.57%), L_3 x T_1 (78.26%), L_2 x T_2 (71.65%) and L_2 x T_3 (63.61%) were the top five cross combinations which exhibited the maximum heterobeltiosis, whereas L_2 x T_3 (136.25%), L_3 x T_3 (135.58%), L_7 x T_2 (122.22%), L_4 x T_3 (118.07%) and L_7 x T_3 (117.17%) recorded significantly higher standard heterosis. Heterobeltiosis for marketable fruits per plant has also been observed by Vidyasagar *et al.* (1997), Sharma (2003), Sharma and Thakur (2007) in tomato.

Average fruit weight (g)

Fruit weight is also one of the direct components of marketable yield. In the hybrids, this ranged from 38.39 (L_7 x T_3) to 79.86 g (L_5 x T_4) in pooled environment. The standard check recorded fruit weight 58.87 g. Five hybrids recorded significantly more fruit weight compared to the standard check Avtar.

In general, consumers prefer medium sized (60-80g) fruits particularly in the off-season when prices are invariably higher. Since fruit weight and number of fruits per plant are negatively correlated (Nandpuri *et al.* 1973), the breeders will have to keep a balance keeping in view the agro-climatic conditions of the production areas and consumer's preference.

Positive and significant heterosis over BP and SC was observed in 4 and 7 hybrids, respectively. Two of the hybrids (L_4 x T_1 and L_4 x T_2) revealed heterobeltiosis in all the environments, whereas, the only hybrid to express hybrid vigour over the standard check was L_5 x T_4. (Individual year's data not shown). The results are in close proximity to the findings of Sharma (2003), Tiwari and Lal (2004), Asati *et al.* (2007) and Singh *et al.* (2007), who have also reported hybrid vigour in a few cross combinations studied by them. However, Fageria *et al.* (2001) could record negative heterobeltiosis only.

Fruit shape index

Fruit shape index gives an idea about fruit shape which has a practical relevance to consumer's preference, transportation and shelf life of tomato fruits (Roy and Choudhury 1972). Fruit shape index in the hybrids ranged from 0.81 (L_4 x T_4) to 1.08 (L_1 x T_3) in pooled analysis. The standard check had 0.94 fruit shape index value.

The heterosis for this character ranged from -31.51 (L_5 x T_4) to 0.00 per cent (L_4 x T_1) and -13.83 (L_4 x T_4) to 14.89 per cent (L_1 x T_3) in pooled environment over BP and SC, respectively. L_1 x T_3 (14.89%), L_7 x T_3 (11.70%), L_1 x T_2 (10.64%) and L_5 x T_2 and L_5 x T_3 (10.63% each) were the top ranking cross combinations on the basis of standard heterosis for fruit shape index in pooled environment. No hybrid could surpass respective BP. On comparison with SC, 8 hybrids revealed economic heterosis. The results are in accordance with the observations of Powers (1941), Quinones (1957) and Raijadhav and Kale (1985), who have recorded decrease in fruit size of the hybrids.

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