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Heterosis for yield and quality traits and resistance to purple blotch in onion

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ABSTRACT

The study was carried out to estimate magnitude of heterosis for bulb yield and its attributing traits in 28 crosses resulting from a Line × Tester mating design of 4 male sterile lines and 7 testers in onion. Among the 28 crosses, L_2 × T_4 was highly heterotic for purple blotch disease resistant (-42.62), plant height (7.25), neck thickness (-6.67), ten bulb weight (6.75), polar diameter (6.77), equatorial diameter (7.28), marketable bulb yield (25.95), number of rings per bulb (22.16) and per cent of sprout bulbs (-30.85) over commercial check. While the cross L_3 × T_5 exhibited significant heterosis over standard check for days to maturity (-6.67), neck thickness (-15.56), polar diameter (3.84), equatorial diameter (3.99), marketable bulb yield (28.65), rotten bulb (-25.22), number of centers per bulb (-4.55) and number of rings per bulb (6.23). Hence, these two crosses, *viz.,* L_2 × T_4 and L_3 × T_5 can be exploited commercial cultivation.

Key words: Heterosis, purple blotch disease, hybrids, yield.

INTRODUCTION

Onion (*Allium cepa*. L.) is a member of family Alliaceae, is one of the most important bulbous vegetable crop cultivated extensively in India. India ranks first in area (1.06 million ha) under onion in the world and second in total production with 15.11 million tonnes after China (Anon, 1). Even though India ranks first in area under onions in the world and second in production but its productivity is low (14.2 t/ha) as against the world productivity of 17.47 t/ha. Among several factors, diseases are one of the most important factors associated with low productivity in onion. Purple blotch disease caused by *Alternaria porri* is one among the serious fungal diseases that affects onion, causing yield loss ranging from 2.5 to 87.8% during *kharif* season (Srivastava, 10) the fungus attacks both leaves and flower stalk (Bock, 3), reducing foliar production by 62-92% (Suheri and Prince, 11). The disease can cause a yield loss of 30% (Everts and Lacy, 6) and 100% of the seed crop when the weather is favourable (Daljeet, 4; Havey, 7). At present there is no purple blotch disease resistant onion variety/ hybrid under commercial cultivation in India; hence there is need to breed a resistant variety, coupled with higher yield. Hence, the present study was under taken to know the extent of heterosis in different crosses for purple blotch disease resistance, bulb yield and quality traits in onion and their utilization in the further improvement in onion.

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MATERIALS AND METHODS

The present investigation on was carried out during 2011-12 at the Division of Vegetable Crops, IIHR, Hessaraghatta, Bengaluru. The experimental site is situated at 13° North latitude and 78° East longitude. The parents PBRMS-317 (L_1), PBRMS-318 (L_2), PBRMS-319 (L_3) and PBRMS-379 (L_4) are seven generation inbred lines resistant to purple blotch disease used as lines. Testers employed were inbreds, namely, PBRG-282 (T_1), PBRG-285 (T_2), PBRC-337 (T_3), PBRC- 338 (T_4), PBRC-339 (T_5), PBRC-340 (T_6) and PBRC-341 (T_7). The Arka Kalayan was used as the commercial check, because it is moderately resistant to purple blotch disease with good yield and quality traits. The line × tester analysis method adopted to make crosses among parental lines. The parents and crosses were evaluated in a randomised block design with three replications. The necessary package of practices required for successful cultivation of onion was followed to raise a good crop. Heterosis over commercial check was estimated based on the superiority of the particular cross for each trait. Observations on ten randomly selected plants were recorded for various traits.

RESULTS AND DISCUSSION

The results (Table 1) indicated that the mean sum of squares due to parents and crosses were significant for most of the characters except neck thickness and total soluble solids. The crosses were significant for all the characters. The per cent

Table 1. Mean sum of squares from analysis of parents and hybrids for different characters in onion.

Source of variation	Treatment	Parent	Cross	Parent vs Cross	Line vs Tester	Error
Degree of freedom	38	10	27	1	1	76
Purple blotch (PDI)	1095.34**	2140.84**	5.09**	20055.27**	11465.06**	87.86
Plant height (cm)	51.44**	118.91**	17.94**	281.36**	374.56**	0.51
No. of leaves	1.20**	1.56**	0.59**	14.00**	5.97**	0.02
Days to maturity	40.31**	65.75**	30.71**	44.96**	181.04**	1.15
Neck thickness (cm)	0.20	0.64	0.007	1.08	0.18	0.17
Ten bulb weight (g)	5300.65**	9505.06**	3840.66**	2672.73**	11547.63**	30.57
Polar dia. (cm)	0.49**	0.55**	0.42**	1.93**	0.5**	0.009
Equatorial dia. (cm)	0.03**	0.47**	0.19**	1.57**	1.25	0.007
No. of rings per bulb	0.67**	0.31**	0.59**	6.24**	0.03**	0.024
No. of centres per bulb	0.03**	0.04**	0.03**	0.0004	0.02	0.007
Total bulb yield (t/ha)	24.87**	9.73**	29.69**	45.88**	1.10	0.32
Marketable bulb yield (t/ha)	24.70**	19.08**	57.38**	42.26**	16.80**	0.23
Unmarketable bulb yield (t/ha)	4.65**	4.46**	4.88**	0.13	8.24**	0.06
Per cent split bulbs	25.92**	14.99**	30.50**	11.51**	12.09**	0.38
Per cent rotten bulbs	19.80**	18.53**	20.66**	9.27**	91.52**	0.31
Per cent sprout bulbs	11.63**	6.90**	13.80**	0.38	24.62**	0.27
Total soluble solids (%)	3.78**	8.71**	1.05	28.12**	0.94	0.16
Bulb dry matter (%)	5.73**	13.79**	2.30**	17.66**	3.28**	0.14

heterosis worked out over better parent (BP) and commercial check (CC) Arka Kalayan are presented for different characters.

The maximum negative significant heterosis was observed in the cross $L_2 \times T_6$ (-78.44%) over better parent, which is desirable for purple blotch disease resistant and the cross $L_2 \times T_2$ (-45.90%) recorded the highest significant heterosis over commercial check. Similar results were observed (Abubakar, 2; Shashikanth Evoor, 9). Out of 28 crosses, 19 crosses over better parent showed negative and significant heterosis for plant height (Table 2a). Maximum positive significant heterosis was observed in the cross $L_4 \times T_6$ (10.21%) over better parent and $L_3 \times T_3$ (7.25%) over commercial check results are in confirmation with Shashikanth Evoor (9) and Veeregowda (13). Out of 28 crosses, 6 crosses over better parent and 4 crosses over commercial check showed positive and significant heterosis for plant height (Table 2a).

Magnitude of heterosis over better parent and commercial check was significant for number of leaves per plant. Maximum positive significant heterosis was observed in the cross $L_4 \times T_6$ (21.26%) over better parent and same cross $L_1 \times T_2$ (5.67%) over commercial check Arka Kalayan (Shashikanth Evoor, 9; Veere Gowda; 13). Out of 28 crosses, 11 crosses over better parent and only 6 crosses over commercial check showed positive and significant heterosis (Table 2a). The heterosis for days to maturity were negative significant in the cross $L_4 \times T_1$ (-10.21%) over better parent and $L_3 \times T_1$ (-8.89%) over commercial check which is desirable to get early harvesting (Divakara, 5) (Mallikarjun, 8); Out of 28 crosses, 14 crosses over commercial check showed negative and significant heterosis (Table 2a).

The maximum negative significant heterosis for bulb neck thickness was observed in the cross $L_3 \times T_2$ (-80.30%) over better parent and $L_3 \times T_5$ (-15.56%) over commercial check. Out of 28 crosses, 4 crosses over better parent and 17 cross over commercial check showed negative and significant heterosis (Table 2). Similar results were observed earlier (Shashikanth Evoor, 9; Veere Gowda, 13; Divakara, 5). The maximum positive significant heterosis for ten bulb weight was observed in the cross $L_4 \times T_5$ (8.11%) over better parent and $L_6 \times T_2$ (6.75%) over commercial check. Out of 28 crosses, 3 crosses over better parent and 3 crosses over commercial check showed positive and significant heterosis (Table 2a). These results corroborate with the findings Divakara (5), Mallikarjun (8), Shashikanth Evoor (9) and Veere Gowda (13).

Table 2a. Heterosis (%) over BP and CC for different characters in onion.

Cross	Purple blotch (PDI)		Plant height		No. of leaves per plant		Days to maturity		Bulb neck thickness		Ten bulb weight	
	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC
$L_1 \times T_1$	42.16	-34.42**	-3.02**	-3.33**	2.88	-3.05**	-9.57**	-4.44**	6.45	22.22**	1.91	0.00
$L_1 \times T_2$	-69.49**	-40.98**	0.13	-0.19	12.14**	5.67**	-5.67**	-1.48	-73.89**	17.78**	-7.77**	-9.50**
$L_1 \times T_3$	-64.47	-40.98**	0.00	1.92	-1.22	-1.60	-1.17**	1.11	-18.18	0.00	-8.60**	-7.83**
$L_1 \times T_4$	-40.63**	-37.70**	1.16	0.83	11.63**	5.09**	-4.61**	-0.37	-25.00	-11.11**	-10.83**	-12.50**
$L_1 \times T_5$	-68.75**	-34.42**	3.99**	3.65**	-4.84*	-10.32**	-2.13*	2.22*	-14.84	-2.22	1.91	0.00
$L_1 \times T_6$	-78.44**	-42.62**	0.00	-0.33	7.51**	1.31	-4.26**	0.00	-20.65	-8.89**	-12.53**	-14.25**
$L_1 \times T_7$	-77.78**	-43.18**	-0.45	-0.77	3.91	-2.18*	-6.38**	-2.22*	-21.29	-8.89**	-7.86**	-9.58**
$L_2 \times T_1$	35.37	-39.34**	-4.12**	-0.13	5.7**	2.47*	-9.12**	-7.78**	-27.65	-8.89**	-3.00**	-3.00**
$L_2 \times T_2$	-72.03**	-45.90**	-3.69**	0.33	6.45**	3.20**	-5.84**	-4.44**	-79.80**	-8.89**	-1.58	-1.58
$L_2 \times T_3$	-64.47**	-40.98**	-4.92**	-0.96	-10.66**	-11.05**	-0.36	1.11	-20.59	0.00	-2.64*	-1.83
$L_2 \times T_4$	-45.31	-42.62**	2.95**	7.25**	-0.55	-3.63**	-1.46	0.00	-25.88	-6.67**	6.75**	6.75**
$L_2 \times T_5$	-69.53**	-36.06**	-7.69**	-3.85**	6.95**	3.63**	-2.55**	-1.11	-27.65	-8.89**	2.17	2.17*
$L_2 \times T_6$	-78.44**	-42.62**	-0.00	4.17**	-6.05**	-8.87**	-6.93**	-5.56**	-22.35	-2.22	-11.83**	-11.83**
$L_2 \times T_7$	-76.71**	-40.42**	-2.15**	1.92	-9.55**	-12.35**	-3.65**	-2.22*	-24.71	-4.44**	-7.92**	-7.92**
$L_3 \times T_1$	54.05	-37.70**	-12.01**	-6.10**	0.74	-1.16	-7.87**	-8.89**	-25.93	-11.11**	3.29**	2.00
$L_3 \times T_2$	-69.49**	-40.98**	-6.61**	-0.33	1.23	-0.73	-5.56**	-5.56**	-80.30**	-11.11**	1.27	0.00
$L_3 \times T_3$	-62.5**	-37.70**	-3.90**	2.56*	-7.54**	-7.99**	-2.22*	-2.22*	-9.09	11.11**	-8.51**	-7.75**
$L_3 \times T_4$	-51.56	-42.62**	-5.53**	0.83	-12.10**	-13.81**	-5.90**	-5.56**	-20.37	-4.44**	3.21**	1.75
$L_3 \times T_5$	-75.78**	-37.70**	-21.44**	-16.15**	-2.72	-4.51**	-5.97**	-6.67**	-30.25	-15.56**	3.80**	2.50*
$L_3 \times T_6$	-77.82**	-40.98**	-9.31**	-3.21**	2.22	0.29	-5.62**	-6.67**	-25.93	-11.11**	-7.85**	-9.00**
$L_3 \times T_7$	-76.71**	-40.42**	-16.82**	-11.21**	-14.07**	-15.70**	-6.37**	-7.41**	-29.01	-11.11**	-15.61**	-16.67**
$L_4 \times T_1$	38.20	-32.78**	7.39**	-2.25*	15.67**	-1.60	-10.21**	-5.56**	-29.41	-15.56**	2.92*	-11.42**
$L_4 \times T_2$	-64.41**	-31.14**	-1.18	-3.08*	20.69**	1.74	-5.63**	-0.74	-76.85**	-11.11**	-35.56**	-39.58**
$L_4 \times T_3$	-59.54**	-32.78**	-4.09**	-2.25**	-14.36**	-14.68**	-1.76	3.33**	-2.94	4.44	-15.04**	-14.33**
$L_4 \times T_4$	-40.63	-37.70**	7.54**	-2.12**	14.94**	-3.05**	-3.87**	1.11	-18.82	22.22**	-3.6**	-8.42**
$L_4 \times T_5$	-68.75**	-34.42**	7.54**	-2.12**	20.69**	1.74	-1.76	3.33**	-29.41	2.22	8.11**	0.00
$L_4 \times T_6$	-75.98**	-36.06**	10.21**	0.33	21.26**	2.18*	-7.04**	-2.22*	-20.59	-11.11**	6.85**	-2.50*
$L_4 \times T_7$	-74.79**	-35.50**	-3.39**	-8.65**	4.02	-12.35**	-4.23**	0.74	-33.53	0.00	0.91	-7.92**
CD at 5%	15.15		1.15		0.27		1.74		0.66		8.99	
CD at 1%	20.12		1.53		0.36		2.13		0.88		11.87	

MP = Mid parent, BP = Better parent, SC = Standard check, *,**Significant at 5 & 1% levels

Heterosis for polar bulb diameter was positive significant observed in the cross $L_1 \times T_5$ (15.20%) over better parent and $L_1 \times T_5$ (8.35%) over commercial check; Out of 28 crosses, 16 crosses over better parent and 11 crosses over commercial check showed positive and significant heterosis (Table 2b). Similar results were also reported by (Shashikanth Evoor, 9; Sundari, 12). The magnitude of heterosis over better parent and commercial check for equatorial bulb diameter was significant. Maximum positive significant heterosis was observed in the cross $L_2 \times T_4$ (8.73%) over better parent and $L_3 \times T_6$ (9.62%) over commercial check. Out of 28 crosses, 9 crosses over better parent and 11 crosses over commercial check showed positive and significant heterosis (Table 2).

The magnitude of heterosis over better parent and commercial check was significant for number of rings per plant. Maximum positive significant heterosis was observed in the cross $L_3 \times T_4$ (30.22%) over better parent and $L_3 \times T_2$ (23.63%) over commercial check (Shashikanth Evoor, 9). Out of 28 crosses, 14 crosses over better parent and 15 crosses over commercial check showed positive and significant heterosis (Table 2b). Maximum negative significant heterosis was observed in the cross $L_1 \times T_2$ (-13.60%) over better parent and $L_4 \times T_4$ (-7.27%) over commercial check for number of centers per bulb (Veere Gowda, 13). Out of 28 crosses, 3 crosses over better parent and 2 cross over commercial check showed negative and significant heterosis for number of centers per bulb (Table 2b).

Table 2b. Heterosis (%) over BP and CC for different characters in onion.

Cross	Polar bulb dia.		Equatorial bulb dia.		No. of rings per bulb		No. of centres per bulb		Total bulb yield		Marketable bulb yield	
	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC	BP	CC
$L_1 \times T_1$	4.00*	-2.26*	6.40**	3.99**	12.89**	1.10	-3.45	27.27**	19.26**	-0.14	-1.05	-13.68**
$L_1 \times T_2$	-0.00	-4.51**	0.00	-2.11*	3.53	3.85**	-13.60*	-1.82	7.72**	-10.23**	6.95**	-8.49**
$L_1 \times T_3$	3.08	0.90	3.17	1.64	6.20**	5.68**	1.60	15.45**	-7.75**	-7.77**	-6.02**	-7.19**
$L_1 \times T_4$	4.58*	3.16**	-2.40	-4.46**	11.68**	-0.18	5.60	20.00**	-10.39**	-17.07**	-8.44**	-19.84**
$L_1 \times T_5$	15.20**	8.35**	4.80**	2.58*	-3.86	0.37	-10.40	1.82	17.05**	10.70**	24.24**	10.81**
$L_1 \times T_6$	1.60	-4.51**	6.40**	3.99**	20.82**	8.42**	-1.57	13.64**	-16.79**	-29.30**	-18.32**	-30.11**
$L_1 \times T_7$	4.0*	-2.26*	5.60**	3.29**	11.21**	0.00	-6.67	6.36*	15.19**	-3.58**	14.32**	-2.16
$L_2 \times T_1$	-9.06**	-13.09**	-11.11**	-12.44**	-0.00	-7.51**	-6.90	22.73**	23.41**	5.44**	1.03	-11.73**
$L_2 \times T_2$	4.72*	0.00	7.94**	6.34**	6.27**	6.59**	-2.61	1.82	1.09	-13.63**	2.47	-10.43**
$L_2 \times T_3$	3.08	0.90	3.17	1.64	3.31	2.75*	-5.98	0.00	-7.75**	-7.77**	-6.57**	-7.73**
$L_2 \times T_4$	8.40**	6.77**	8.73**	7.28**	32.01**	22.16**	-1.82	-1.82	32.33**	22.47**	43.83**	25.95**
$L_2 \times T_5$	11.02**	6.09**	6.35**	4.93**	5.09*	9.71**	-4.55	-4.55	18.85**	12.42**	10.30**	-1.62
$L_2 \times T_6$	-1.57	-5.87**	-10.32**	-11.50**	5.94*	-2.01	-13.39*	0.00	27.40**	8.84**	30.31**	13.89**
$L_2 \times T_7$	5.51**	0.90	-1.59	-3.05**	11.88**	3.48**	2.27	9.09**	24.68**	6.51**	26.60**	10.65**
$L_3 \times T_1$	10.08**	6.77**	-9.70**	-5.40**	11.86**	3.11**	-8.89	20.00**	3.39	-0.60	-19.64**	-18.92**
$L_3 \times T_2$	7.75**	4.51**	1.49	6.34**	23.33**	23.63**	4.35	9.09**	-8.87**	-12.42**	-13.21**	-12.43**
$L_3 \times T_3$	2.31	0.00	-6.72**	-2.11*	11.11**	10.44**	-1.71	4.55*	-18.60**	-18.60**	-19.64**	-18.92**
$L_3 \times T_4$	4.58*	3.16**	-12.69**	-8.45**	30.22**	19.96**	-0.00	-1.82	9.68**	5.44**	1.79	2.70*
$L_3 \times T_5$	6.98**	3.84**	-0.75	3.99**	1.75	6.23**	-2.78	-4.55*	32.58**	27.44**	27.50**	28.65**
$L_3 \times T_6$	-10.85**	-13.54**	4.48**	9.62**	9.94**	1.28	-5.51	9.09**	-19.35**	-22.47**	-26.79**	-26.11**
$L_3 \times T_7$	-3.10	-5.87**	0.75	5.63**	13.05**	2.38*	1.70	8.18*	-10.48**	-13.95**	-12.68**	-11.89**
$L_4 \times T_1$	-12.60**	-16.48**	4.07*	0.23	-5.36*	-4.21**	-10.34*	18.18**	-9.30**	-19.86**	-15.87**	-30.27**
$L_4 \times T_2$	-26.77**	-30.02**	-6.50**	-10.09**	-4.16	-2.93*	-6.09	-1.82	-18.25**	-27.77**	-16.42**	-28.49**
$L_4 \times T_3$	-6.15**	-8.13**	-5.56**	-6.81**	-0.54	0.73	-1.71	4.55	-26.20**	-26.19**	-30.84**	-31.73**
$L_4 \times T_4$	6.11**	4.51**	-0.81	-4.46**	0.12	1.47	-7.27	-7.27*	-11.22**	-17.81**	-10.91**	-22.00**
$L_4 \times T_5$	7.87**	3.16**	0.81	-3.05**	-1.75	2.56*	-1.82	-1.82	-4.92*	-10.09**	-1.01	-11.73**
$L_4 \times T_6$	10.24**	5.42**	0.00	-3.76**	-12.30**	-11.17**	-7.09	7.27*	1.75	-10.09**	12.61**	-6.65**
$L_4 \times T_7$	5.51**	0.90	2.44	-1.41	-8.68**	-7.51**	2.27	9.09**	7.89**	-4.65**	17.83**	-2.32**
CD @ 5%	0.15		0.14		0.25		0.14		0.92		0.78	
CD @ 1%	0.20		0.18		0.33		0.18		1.22		1.04	

MP = Mid parent, BP = Better parent, SC = Standard check, *,**Significant at 5 & 1% levels

Magnitude of heterosis over better parent and commercial check was highly significant for total bulb yield per hectare. Maximum positive significant heterosis was observed in the cross $L_3 \times T_5$ (32.58%) over better parent and $L_3 \times T_5$ (27.44%) over commercial check (Mallikarjun, 8; Shashikanth Evoor, 9; Sundari, 12). Out of 28 crosses, 12 crosses over better parent and 7 crosses over commercial check showed positive and significant heterosis for total bulb yield per hectare (Table 2b). Maximum positive significant heterosis was observed in the cross $L_2 \times T_4$ (43.83%) over better parent and $L_3 \times T_5$ (28.65%) over commercial check for marketable bulb yield per hectare (Divakara, 5; Shashikanth Evoor, 9). Out of 28 crosses, 9 crosses over better parent and 6 crosses over commercial check showed positive and significant heterosis (Table 2b).

Thus, above results give us a clear indication that it would be useful to utilize the promising male sterile lines in respect of higher yield, earliness and for other quality traits to exploit heterosis. From the above discussion it may be concluded that among the twenty eight hybrids the hybrid $L_2 \times T_4$ and $L_3 \times T_5$ was identified as superior hybrid, it recorded significant and positive standard heterosis for total bulb yield per hectare, marketable bulb yield per hectare and other quality attributes over commercial check and could be exploited for commercial cultivation.

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