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Heterosis studies for root yield and quality traits of radish (*Raphanus sativus* L.)

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Abstract

Heterosis studies were conducted in 56 hybrids developed in radish involving fourteen lines (females) and four testers (males) of Asiatic and European origin in a line x tester mating design, suggested by Kempthorne (1957) at Experimental Farm of the Department of Vegetable Science, CSK HPKV, Palampur in randomized block design with three replications for root yield and quality characters *viz.,* dry matter, total soluble solids, ascorbic acid and nitrate contents. Analysis of variance revealed significant differences among all the traits except total soluble solids exhibiting the presence of appreciable genetic diversity. Heterosis for root yield was manifested in 44, 27 and 32 crosses over better parent Japanese White (SC_1) and Chinese Pink (SC_2), the most widely grown varieties in the north western Himalayas. The hybrid Mino Early White x Pusa Himani revealed the maximum heterosis to the extent of 103.39, 59.62, and 63.11 per cent over better parent, Japanese White (SC_1) and Chinese Pink (SC_2). Significant and positive heterosis was observed for quality traits namely dry matter and ascorbic acid contents in almost all the crosses. Heterosis in negative direction is desirable for nitrate contents. Of the 56 hybrids, 20, 25 and 23 cross combinations recorded negative heterosis over better parent and commercial varieties Japanese White (SC_1) and Chinese Pink (SC_2). Selection of radish hybrids with less nitrate content is suggested. Mino Early White x Pusa-Himani, Japanese White x DPR-1 (Palam Hriday) and Chinese Pink x Nadauni were the best crosses manifesting maximum heterosis for root yield and quality characters, dry matter, ascorbic acid and low nitrate contents. Heterosis breeding could be resorted for exploitation of these traits for better advantage by developing F_1 hybrids in radish.

Key words: Radish (*Raphanus sativus* L.), heterosis, root yield, ascorbic acid and nitrate content.

Introduction

Radish (*Raphanus sativus* L.) is biennial root vegetable belonging to the family *Brassicaceae* and is traditionally important vegetable in many countries of the world. Hybrids play an important role in increasing yield and quality of vegetable crops. In India only about 10 per cent area of vegetable cultivation is under the hybrids of which 36 per cent and 30 per cent area is covered by tomato and cabbage hybrids, respectively (Kalloo, 1998), whereas in advance countries *viz.*, USA, Japan, Netherlands, Taiwan and some European countries almost all common varieties of vegetable crops being replaced by F_1 hybrids (Kalloo, 1998). Therefore, F_1 hybrids in vegetables are one of the better of options especially at this juncture of time when we have not been able to harvest full potential of F_1 hybrids in vegetables. Pal and Sikka (1956) reported that F_1 hybrids to yield 30-60 per cent more than the better parent in crosses between local variety and Chinese type of variety. Nieuwhof (1994) discussed the prospects for selecting radish cultivars with low nitrate contents. Monakhosh and Barasheba (2000) also reported heterosis for root mass in radish in a cross of eight self-incompatible inbred lines intermated in full diallel. Kutty and Sirohi (2003) observed 40.04 per cent increase in root yield over the better parent in their best performing hybrid. Therefore, the present studies were, thus, undertaken to determine the magnitude and nature of heterosis to find the type of gene effects for root yield and quality traits in radish. The parents involved were of Asiatic and European origin.

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Material and Methods

Fourteen lines (Female parents) *viz.*, Japanese White, Chinese Pink, Mino Early White, Pusa Reshmi, Hill Queen, Punjab Suffaid, Pusa Chetki, Summer Queen, Summer Long, Bombay Red, Punjab Red Long, Paprola Local, Sutton's Contai Long, Kalyanpur No. 9 and White Icicle, representing a wide genetic base were crossed in line x tester mating design suggested by Kempthorne (1957). The eighteen parents and their 56 F_1 hybrids were grown in a randomized block design with three replications at Vegetable Research Farm, CSKHPKV, Palampur (H.P.). Each experimental unit measured 3 meter long ridges per replication. The spacing between ridges and plants was kept 30 x 7.5 cm, respectively. The intercultural operations were carried out as recommended for this crop. The data were recorded from 10 randomly selected plants on root yield per plot and quality parameters *viz.*, dry matter, total soluble solids, ascorbic acid and nitrate content. The root yield was recorded at every harvesting and added to calculate total root yield per plot. Dry matter was estimated by drying 100 g of root sample in oven at 50-60^{0}C. Dried weight was recorded after complete drying and expressed in percentage. The total soluble solids were determined with the help of hand refractometer. The root samples were crushed, macerated and the juice squeezed through a double layer of fine mesh cloth into centrifuge tubes. After centrifugation for two minutes the soluble solids were determined. The ascorbic acid contents were estimated by the titrimeteric methods as described by AOAC (1970). Nitrate contents were determined by the procedure given by Tandon (1993). The heterotic effects were calculated as percentage increase or decrease of hybrids over better parent, standard check (SC_1) Japanese White and standard check (SC_2) Chinese Pink, the widely grown varieties in the region, with respect to various characters studied. The analysis of variance was done according to the methodology given by Panse and Sukhatme (1984).

Results and Discussion

The analysis of variance revealed significant differences among parents, hybrids and parents vs. hybrids for all the characters studied except total soluble solids in case of hybrids (Table-1). The estimates of heterosis over BP, SC_1, and SC_2 expressed in percentage for the selected crosses with respect to root yield, dry matter, ascorbic acid and nitrate contents are given in Table 2. The heterosis for root yield was manifested in most of the cross combinations over BP, SC_1 and SC_2. The magnitude of heterosis was in the range of 14.47 to 103.39 per cent, -24.46 to 59.62 per cent and –22.52 to 63.11 per cent over BP, SC_1 and SC_2, respectively. The hybrid Mino Early White x Pusa Himani exhibited the maximum heterosis to the extent of 103.39, 59.62 and 63.11 over BP, SC_1, and SC_2 followed by Japanese White x DPR-1 (Palam Hriday) to the extent of 98.25, 56.27 and 60.29 per cent, respectively.

Table 1. Analysis of variance for root yield and quality characters of parents and hybrids in radish (*Raphanus sativus*)

Source	d.f.	Root yield (kg)	TSS (%)	Dry matter (%)	Ascorbic acid (mg/100g)	Nitrate content (mg/100g)
Replications	2	18.66*	0.63	0.17	0.20	84.90*
Parents	17	19.65*	2.64*	4.46*	18.73*	1496.78*
Hybrids	55	34.91*	1.24	4.61*	8.61*	14756.63*
Parents vs hybrids	1	1328.90*	7.48*	8.52*	20.20*	9721.00*
Error	146	2.66	0.81	0.10	0.34	11.85

*Significant at 5 % level of significance

The heterosis for root yield in radish has also been reported by Pandey *et al.* (1978), Ahmed *et al.* (1993), Monakhos and Barasheba (2000) and Kutty and Sirohi (2003). Dry matter is an important constituent, which contribute toward yield and better quality. Of 56 hybrids, 15, 28, 35 cross combinations exhibited positive heterosis over BP, SC_1 and SC_2 for dry matter content, respectively. The hybrid Punjab Suffaid x Nadauni showed the highest heterosis over

better parent (56.38%), SC_1 (60.43%) and SC_2 (69.13%) followed by Summer Queen x Nadauni to extent of 27.61, 31.00, 38.10% over BP, SC_1 and SC_2, respectively. Heterosis for dry root weight in radish from 2.07 to 24.90 per cent over the parents was also reported by Bokhari and Yaqub (1963). Heterosis for dry matter content has also been reported by Rattan and Singh (1984) in radish, Parkash *et al.* (1991) and Chandel *et al.* (1996) in carrot.

Table 2. Heterosis over BP, SC_1 and SC_2 expressed in percentage for root yield and quality characters of selected crosses in radish (*Raphanus sativus*)

Sr. No.	Crosses	Root yield			Dry matter		
		BP	SC_1	SC_2	BP	SC_1	SC_2
1.	Mino Early White x Pusa Himani	103.39*	59.62*	63.11*	15.60*	26.00*	32.31*
2.	Japanese White x DPR-1 (Palam Hriday)	98.25*	56.27*	60.29*	9.55*	48.57*	56.62*
3.	Chinese Pink x Nadauni	93.62*	55.59*	59.66*	18.38*	21.43*	28.12*
4.	Bombay Red x White Icicle	85.75*	29.17*	32.49*	1.82*	6.28	12.48*
5.	Hill Queen x White Icicle	70.77*	51.07*	54.96*	8.35*	13.14*	19.23*
6.	Sutton's Contai Long x DPR-1 (Palam Hriday)	63.32*	39.74*	42.72*	11.52*	20.00*	26.51*
7.	Pusa Reshmi x White Icicle	52.05*	31.50*	34.88*	7.05	22.86*	29.52*
8.	Summer Queen x Nadauni	40.61*	25.99*	29.23*	27.61*	31.00*	38.10*
9.	Summer Long x White Icicle	37.39*	15.90*	4.20	0.88	9.57*	15.51*
10.	Hill Queen x Nadauni	36.03*	28.38*	31.68*	2.51*	1.43*	6.11*
11.	Punjab Suffaid x Nadauni	28.94*	15.53	18.51*	56.38*	60.43*	69.13*
12.	Pusa Chetki x DPR-1 (Palam Hriday)	27.46*	15.53	18.50*	4.99	28.86*	35.84*
13.	Punjab Suffaid x Pusa Himani	18.56	10.15	7.84	11.67*	5.28	10.99*
14.	Pusa Cheki x Pusa Himani	17.68	6.67	9.41	0.35	9.45*	15.36*
15.	Pusa Reshmi x Nadauni	14.47	2.57	5.21	8.88*	25.00*	31.78*
	CD (P= 0.05)	2.61	2.61	2.61	0.51	0.51	0.51

Contd...

Sr. No.	Crosses	Ascorbic Acid			Nitrate contents		
		BP	SC_1	SC_2	BP	SC_1	SC_2
1.	Mino Early White x Pusa Himani	16.21*	24.30*	30.28*	-1.23*	-5.83*	-7.83*
2.	Japanese White x DPR-1 (Palam Hriday)	14.79*	20.06*	25.83*	-8.57*	-12.71*	-14.84*
3.	Chinese Pink x Nadauni	0.64	9.23*	14.49*	-0.33	-2.50	-0.33
4.	Bombay Red x White Icicle	0.12	7.25*	12.41*	-6.22*	-9.50*	-11.42*
5.	Hill Queen x White Icicle	3.30	3.57	8.55*	-6.22*	-2.50	-0.33
6.	Sutton's Contai Long x DPR-1 (Palam Hriday)	3.63	8.38*	13.60*	-5.25*	9.83*	-11.74*
7.	Pusa Reshmi x White Icicle	0.35	7.36*	12.65*	-6.04*	-9.33*	-11.26*
8.	Summer Queen x Nadauni	0.16	6.85*	11.99	-13.33*	-9.00*	-10.92*
9.	Summer Long x White Icicle	7.63*	6.03*	1.99*	-6.72*	-7.56*	-9.46*
10.	Hill Queen x Nadauni	1.88	5.32*	10.39*	-20.67*	-9.16*	-11.09*
11.	Punjab Suffaid x Nadauni	21.17*	25.27*	31.29*	-11.95*	0.50	-2.61
12.	Pusa Chetki x DPR-1 (Palam Hriday)	5.58*	10.42*	15.74*	-5.60*	10.16*	-12.07*
13.	Punjab Suffaid x Pusa Himani	0.62	7.65*	12.83*	-2.08	-5.66*	-7.66*
14.	Pusa Cheki x Pusa Himani	8.74*	2.38	2.31	-17.12*	-6.83*	-8.80*
15.	Pusa Reshmi x Nadauni	1.35	4.75	9.92*	-5.97*	-7.66*	-5.38*
	CD (P=0.05)	0.94	0.94	0.94	5.51	5.51	5.51

*Significant at 5% level of significance

Ascorbic acid content is also an important quality attribute in radish. As many as 5, 23 and 30 hybrids exhibited hybrid vigour for ascorbic acid content over BP, SC_1 and SC_2, respectively, suggesting that heterosis breeding can be of much use for improving the ascorbic acid contents. The hybrids Punjab Suffaid x Nadauni and Mino Early White x Pusa Himani manifested the highest positive heterosis to the tune of 31.29 and 30.28 % over SC_2. 25.27 and 24.30% over SC_1, 21.17 and 16.21% over BP. These results corroborate with the findings of Rattan and Singh (1984) who have reported that most of the hybrids manifested positive heterosis over better parent in radish. Parkash *et al.* (1991) and Chandel *et al.* (1996) also advocated heterosis for ascorbic acid content in carrot.

Heterosis in negative direction is desirable for nitrate contents, because of its carcinogenic nature. Of the 56 hybrids, 20, 25 and 25 cross combination manifested negative heterosis over BP, SC_1 and SC_2, respectively. Nieuwhof (1991) also reported negative heterosis in breeding lines of radish and suggested that it is possible to select hybrid cultivars in radish with low nitrate content. Since the superiority of F_1 to better parent, SC_1 and SC_2 for the root yield and quality parameters was exhibited by the cross combinations namely Mino Early White x Pusa Himani, Japanese White x DPR-1 (Palam Hriday) and Chinese Pink x Nadauni for root yield and quality characters, dry matter, ascorbic acid and low nitrate content. Therefore, it may be effective and advantageous to use these cross combinations for the commercial exploitation of the hybrid vigour in radish. On the basis of results obtained, it may be concluded that it would be useful to adopt heterosis breeding for improving root yield and quality characters in radish.

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