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EXTENT OF HETEROSIS OVER SARJOO-52 IN RICE (*ORYZA SATIVA* L.) UNDER IRRIGATED CONDITION FOR YIELD AND YIELD CONTRIBUTING TRAITS

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ABSTRACT

The manifestation of heterosis for grain yield plant^{-1} is evident by significant superiority of hybrids over better parent ranging from -54.69 to 139.43 per cent and over standard variety (Sarjoo-52) ranging from 60.35 to 22.64 per cent. In general, the crosses which displayed superiority over BP and SV for GY also exhibited significant heterosis for some yield contributing traits. Besides, exhibiting exploitable level of hybrid vigour for yield, most of these hybrids except few also showed heterosis for earliness closer to the SV. Most of the hybrids possessed higher number of seed set than pollen parent and standard variety but percentage was low due to hybrid sterility as one of the parent used as CMS line. So far heterosis over standard variety was concerned, 50 per cent hybrids showed superiority for HI, EBT, TW, BY/P whereas only 40 per cent hybrids were observed better for DFF and DM. Heterosis for GY/P over Sarjoo-52 exhibited a wide range as the values varied from –60.35 to 22.64 per cent. Only five crosses showed significant increase in yield. The perusal of the data indicated that heterosis for yield of most hybrids were due to increased heterosis in G/P, FS/P, EBT, BY/P, HI and TW.

KEY WORDS
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CMS line
Heterosis
Heterobeltiosis, yield

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INTRODUCTION

Rice being the staple food for more than 70 per cent of our national population and source of livelihood for 120-150 million rural households is backbone to the Indian Agriculture. India has largest area of 44.00 million hectares, constituting 28 per cent of land under rice in the world and ranks second in production (93.20 million tones), next to China (185.49 million tones) with an average productivity of 3.12 tons per hectare (Anonymous, 2013). To meet the demand of rapidly increasing population of our country, the projection of India's rice production target for 2020 AD is 115-120 million tones, which can be achieved by increasing rice production by over 2.0 million tons per year in the coming decades. India being the second largest producer of rice but still lacks behind due to the rising demand, saturation of cultivable land and availability of quality seeds for sowing (Dhanwani *et al*., 2013).

Heterosis, a valuable expression that often results from genetic recombination, has been frequently utilized for the development and isolation of promising hybrids for further exploitation in conventional as well as heterosis breeding programmes. The F_1 hybrids in cross-fertilized as well as self-fertilized crops like rice are known to exhibit hybrid vigour. The exploitation of heterotic F_1 hybrids for developing high yielding pure-line varieties of self-fertilized crops like rice is itself a very important aspect of conventional breeding programmes (Chauhan *et al*., 2015). Therefore, attainment of more knowledge about various aspects of heterosis for yield and yield contributing traits under irrigated condition may be helpful in providing further clues for exploitation of heterosis in rice.

Therefore, studies on above aspects in rice, involving genetic stocks and environments in question, are essential for obtaining information required for planning and execution of a successful breeding programme aimed at development of superior varieties for irrigated environment. Keeping the above facts in view, the present investigation was aimed to assess the nature and magnitude of heterosis over better-parent and standard variety for different characters for development of hybrid varieties for irrigated condition.

MATERIALS AND METHODS

The investigation was conducted at Crop Research Station, Masodha, Faizabad (U.P.) during *Kharif* season. The site falls under sub tropical to semi arid region in Indo-Gangatic plains and lies between 26.47ºN latitude, 82.12ºE longitude and at an altitude of about 113 m above mean sea level.

Experimental Details

The two cytoplasmic male sterile (CMS) lines *viz*., IR-58025-A and NDMS-4-A, possessing Wild Abortive (WA) type of cytoplasm, were crossed with thirty genetically diverse pollen parents *viz*., NDRSB-96006-R, NDRSB-9730015-R, NDRSB-9830099-R, OR-1537-15-R, OR-1543-11R, OR-1547-9-1-R, OR-1564-5-R, OR-1898-17-R, CR-792-B-4-2-1-R, IR-54112-B-2–CR-1-6-2-R, BARO-5-1-B-6-3-34-1-1-1-1-R, RAU-1411-4-R, IR-31917-R, TTB-517-17-SBIR-67401-17-2-R, TTB-517-17-SBIR-70149-35-R, CN-1035-36-R, CN-1045-6-R, OR-1537-6-R, R-710-437-1-1-R, IR-70-R, IR-600-76-I-R, IR-55838-B-2-3-2-3-R, IR-21567-18-3-R, IR-10198-66-2-R, IR-65515-47-2-1-19-R, R-971-2505-2-1-R, UPRI-92-79-R, CSR-21-R, RP-2932-2528-R and JR-82-1-10-R in line x tester mating fashion. A total of 60 F_1s were produced during *Kharif* 2003. The resulting set 60 F_1's their 32 parents (30 male parents + 2 female parents) and a standard check variety *i.e*. Sarjoo-52 were evaluated in Randomized Complete Block Design with three replications.

Fertilizer application

The fertilizers were applied @ 120 kg nitrogen, 60 kg phosphorus and 60 kg potash/ha through urea, di-ammonium phosphate and murate of potash recommended, for the rice crop. The full dose of phosphorus, potash and half dose of nitrogen were applied as basal and rest of nitrogen was applied in two splits as top dressing at tillering and panicle initiation stage.

Experimental Methods

Raising of CMS lines and male parents

The seeds of CMS lines were treated with 0.02 per cent mercuric chloride solution followed by subsequent washing with sterilized distilled water and then placed in petridishes holding a moist towel paper for proper germination at room temperature. Seven to ten days old seedlings were transplanted in earthen pots for their normal growth while male lines were direct seeded in nursery beds on three different dates to coincide the flowering dates of CMS lines for crossing purpose (Sharma *et al*., 2013).

Production of hybrids

Each of the two cytoplasmic male sterile lines was crossed with thirty restorers, collected from diverse sources, in line x tester mating design. The seeds of F_1s obtained from these combinations were collected during wet season. Thus, a total of 93 genotypes (2 CMS lines + 30 diverse pollen parents + 60 F_1s + 1 standard check Sarjoo-52 were grown and evaluated during next year.

Observations recorded

Five randomly sampled plants entry^{-1} replication^{-1} for the non-segregating (parents and F_1s) were tagged in advance and all subsequent observations were recorded on them. Data were collected on days to 50 per cent flowering (DFF), plant height (PH), days to maturity (DM), ear bearing tiller plant^{-1} (EBT), panicle length (PL), number of spikelets panicle^{-1} (S/P), number of fertile spikelet panicle^{-1} (F/P), number of spikelet sterility panicle^{-1} (SS/P), 1000-grain weight (TW), biological yield (BY), harvest index (HI) and grain yield plant^{-1} (GY/P) following the standard procedure.

Statistical analyses

The data on 12 characters were subjected to analysis of variance for Randomized Block Design and whole set of treatments following Singh and Singh (1994). In the present study standard heterosis was calculated for various characters and environments following the procedure given by Fonseca and Patterson (1986).

Standard Heterosis (%) = [(Mean Performance of F_1) - (Mean Performance of Standard check)] x 100/ Mean Performance of Standard check. The estimates of standard heterosis were calculated by taking Sarjoo-52 as standard parent.

RESULTS

Nature and magnitude of heterosis for yield and yield contributing characters

The extent of heterosis for twelve characters *viz*. DFF, PH, DM, EBT, PL, S/P, FS/P, SS/P^{-1}, TW, GY/P, BY/P and HI over better parent and standard variety were studied. Mean values for these traits over 32 parental lines, 60 F_1 hybrids and standard check (Sarjoo-52).

Analysis of variance

The analysis of variance for design of experiment and mean squares for parent crosses and parent vs. crosses. Highly significant differences were observed among the treatments (genotypes) for all the characters. The partitioning of treatment (genotypes) variance into parents crosses and parents vs. crosses showed that mean squares due to parents and crosses were highly significant for all the characters under study. The mean squares due to parents vs. crosses were also highly significant for all the characters except DFF and EBT. The variance due to replications was significant only in case of FS/P.

Heterosis

Heterosis has been estimated as per cent increase or decrease of F_1 values over better parent (BP) and standard variety (Sarjoo-52). The nature and magnitude of heterosis is presented character wise in Table 1.

Days to 50 per cent flowering

Eighteen hybrids exhibited significant positive heterosis over better parent and eight hybrids exhibited significant positive heterosis over standard variety. Nine hybrids exhibited significant negative heterosis over better parent and thirty-eight crosses showed significant negative heterosis over standard variety. The mean heterosis over better parent and standard variety were 4.29 and –11.80 per cent, respectively. The cross IR85025 A X CN 1035-36R exhibited maximum heterosis of 25.83% and 15.67% over better parent and over standard variety, respectively. The lowest heterosis was observed in hybrid IR 58025 A X IR 21567-18-3R over better parent (-30.47%) and over standard variety (-35.10%).

Plant height (cm)

The dwarf stature in rice contributes towards higher resistance to lodging which promotes nitrogen responsiveness and high yield. So, in the present study dwarf parent was considered as better parent. Heterosis ranged from -26.52 (NDMS 4A X IR 70R) to 27.52 (NDMS 4A X OR 1537-6R) per cent over better parent and –22.31 (IR 58025 A X CSR 21R) to 22.29 (NDMS 4A X IR 10198-66-2R) per cent over standard variety. Mean heterosis over better parent (-10.48%) and over standard hybrid (-3.41%) were in negative direction. Among 60 crosses

Table 1: Extent of heterosis over better parent and standard variety in 60 rice hybrids for yield and yield contributing traits

Heterosis	DFF		PH (cm)		DM		EBT		PL (cm)		S/P	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
Mean heterosis (%)	4.29	-11.80	-0.63	2.59	-14.45	-10.53	-10.48	-3.41	-3.76	12.12	-6.77	-6.94
No. of hybrids with significant + ve value	18	8	13	14	12	8	13	16	25	34	12	12
No. of hybrids with significant - ve value	9	38	12	6	37	25	31	24	27	16	24	20
Range of heterosis	-30.47-25.83	-35.10-15.67	-20.36-17.17	-19.53-17.20	-40.68-34.51	-27.35-29.73	-26.52-27.52	-22.31-22.29	-43.88-30.56	-31.98-70.67	-30.94-14.62	-28.08-11.07

Heterosis	FS/P		SS/P		TW (g)		GY/P (g)		BY/P (g)		HI (%)	
	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV	BP	SV
Mean heterosis (%)	17.59	-7.63	9.23	90.40	35.59	-42.25	18.28	5.97	27.51	-88.76	0.03	30.80
No. of hybrids with significant + ve value	32	16	23	00	25	05	27	10	26	7	23	16
No. of hybrids with significant - ve value	15	19	15	60	24	43	13	17	23	48	23	20
Range of heterosis	-29.90-54.73	-28.85-11.86	-28.62-42.48	-56.31-0.00	-54.69-139.43	-60.35-22.64	-30.94-54.10	-28.08-11.07	-59.62-121.76	-62.71-19.77	-30.33-20.19	-30.13-19.29

studied, significant and positive heterosis was observed in 13 crosses over better parent and 16 crosses over standard variety. Negative and significant values were obtained for 31 crosses over better parent and 24 crosses over standard variety.

Days to maturity

The estimates of heterosis ranged from –20.36 (IR 58025 A X IR 21567-18-3R) to 17.17 (IR 58025A X CN 1035-36R) per cent over better parent and –19.53 (IR 58025 A X IR 21567-18-3R) to 17.20 (IR 58025A X CN 1035-36R) over standard variety. Mean heterosis over better parent and standard variety were -0.63 and 2.59 per cent, respectively. Twelve cross combinations exhibited significant negative heterosis and thirteen crosses showed significant positive heterosis over better parent (earlier parent). Fourteen hybrid combinations exhibited positive significant heterosis and six crosses showed significant negative heterosis over standard variety.

Ear bearing tiller plant^{-1}

Heterosis ranged from -40.68 (IR 58025A X OR 1543-11R) to 34.51 (IR 58025A X IR 54112-B_2 –CR-1-6-2R) per cent over better parent and –27.35 (NDMS 4A X BARO-5-1-B-6-3-34-1-1-1-1R) to 29.73 (IR 58025 A X NDRSB-9830099R) per cent over standard parent. Mean heterosis over better parent (-14.45%) and over standard variety (-10.53%) were in negative direction. Among 60 crosses studied, significant and positive heterosis was observed in 12 crosses over better parent and 8 crosses over standard variety. Negative and significant values were obtained for 37 crosses over better parent and 25 crosses over standard variety.

Panicle length (cm)

The mean heterosis over better parent and standard variety were -3.76 and 12.12 per cent, respectively. Out of 60 F_1s, 25 and 34 crosses displayed positive heterosis while 27 and 16 crosses expressed negative heterosis with significant values over better parent and standard variety, respectively. The extent of heterosis over better parent ranged from -43.88 (IR 58025A X UPRI 92-79R) to 30.56 (NDMS 4A X OR 1543-11R) per cent and it ranged from –31.98 (IR 58025 A X NDRSB-9830099R) to 70.67 NDMS 4A X OR 1543-11R per cent over standard variety.

Total number of spikelets panicle^{-1}

The mean heterosis over better parent and standard variety were -6.77 and -6.94 per cent, respectively. Out of 60 hybrids, 12 crosses each over better parent and over standard variety displayed significant positive heterosis while 24 crosses over better parent and 20 crosses over standard variety showed significant negative heterosis. The extent of heterosis ranged from –30.94 (IR 58025 A X RP 2932-2528R) to 14.62 (IR 58025 A X IR 600-76-1R) per cent over better parent while, it ranged from –28.08 (NDMS 4A X JR 82-1-10R) to 11.07 (IR 58025 A X R 971-2505-2-1R) per cent over standard variety.

Number of fertile spikelets panicle^{-1}

The estimates of heterosis ranged from -29.90 (NDMS 4A X RP 2932-2528R) to 54.73 per cent (IR 58025 A X OR 1543-11R) over better parent and –28.85 (NDMS 4A X RP 2932-2528R) to 11.68 per cent (IR 58025 A X IR 65515-47-2-1-19R) over standard variety. The mean heterosis over better parent and standard hybrid were 17.59 and –7.63 per cent, respectively.

Among 60 F_1's, 32 crosses over better parent and 16 crosses over standard variety showed significant positive heterosis while 15 crosses over better parent and 19 crosses over standard variety exhibited significant negative heterosis.

Number of sterile spikelets panicle^{-1}

Among 60 crosses, 27 crosses scored significant positive heterosis over better parent and 10 crosses exhibited significant positive heterosis against standard check. The significant heterosis was expressed in negative direction in 13 crosses over better parent and 17 crosses over standard variety. Mean heterosis over better parent and standard hybrid were-18.28 and 5.97 per cent, respectively. The hybrid, IR 58025 X OR 1543-11R exhibited maximum heterosis (54.10%) over better parent and IR 58025A X R 971-2505-2-1R had highest heterosis (11.07) over standard variety. The maximum negative heterosis was recorded for cross IR 58025 X RP-2932-2528 R (-30.94%) over better parent and NDMS4A X JR 82-1-10R (-28.08%) over standard check.

1000 grain weight (g)

The estimates of heterosis ranged from –28.62 (NDMS 4A X OR 1898-17R) to 42.48 (NDMS 4A X RP 2932-2528R) per cent over better parent and from -56.31 (NDMS 4A X CN 1045-6R) to –34.04 (IR 58025 A X CR-792-B_4-2-IR) per cent as none of the crosses showed positive heterosis over standard variety. Mean heterosis over better parent was 9.23 per cent while it was -90.40 per cent over standard variety. Among 60 hybrids studied, 23 hybrids expressed significant heterosis in positive direction over better parent while none of the crosses expressed significant positive heterosis over standard variety. Out of 60 hybrids, 15 crosses expressed significant negative heterosis over better parent and all 60 crosses recorded significant negative heterosis over standard variety.

Grain yield plant^{-1} (g)

The better parent heterosis ranged from -54.69 (NDMS 4A X JR 82-1-10R) to 139.43 (IR 58025A X RP 2932-2528R) per cent with the mean value of 35.59 per cent. Twenty-five crosses exhibited better parent heterosis with significant positive values, while, twenty-four hybrids showed significant and negative heterosis over their better parents. The standard parent heterosis ranged from –60.35 (NDMS 4A X IR600-76-1R) to 22.64 (IR 58025A X CR 792-B4-2-1R) per cent. Five crosses were significantly superior to the standard variety and fourty-three crosses were significantly inferior to the standard variety for standard heterosis.

Biological yield plant^{-1} (g)

Among 60 hybrids studied, 23 crosses expressed significant positive heterosis over better parent and 48 crosses had significant positive heterosis over standard variety while 26 crosses over better parent and 7 crosses over standard variety showed significant negative heterosis. The mean heterosis over better parent and standard variety were 27.51 and –88.76 per cent, respectively. The extent of heterosis ranged from -59.62 (NDMS 4A X JR 82-1-10R) to 121.76 (NDMS 4A X TTB-517-17-SBIR-67401-17-2R) per cent over better parent and from -62.71 (NDMS 4 A X IR 600-76-1R) to 19.77 (IR 58025 A X NDRSB 96006R) per cent over standard check.

Harvest index

The mean heterosis over better parent and standard check were 0.03 and 30.80 per cent, respectively. Out of 60 hybrids, 23 hybrids expressed significant positive heterosis over better parent and 16 crosses had such values over standard variety while 23 crosses over better parent and 20 crosses over standard variety showed significant negative heterosis. The maximum heterosis over better parent and standard parent was recorded for the crosses IR 58025 A X JR 82-1-10R (29.30%) and IR58025A X NDRSB 9730015R (19.29%), respectively. The minimum heterosis over better parent (-30.33%) as well as standard variety (-30.13%) was observed for the same cross, NDMS 4A X OR 1547-9-1R.

DISCUSSION

Heterosis for yield and component characters

In the present investigation the relative magnitude of heterosis over better parent and standard variety (Sarjoo-52) were studied for twelve characters. The nature and magnitude of heterosis differed for different traits in various hybrid combinations. Growth duration has special significance in crop productivity and cropping system. Keeping this fact in view, 60 hybrids studied for DFF, indicated that nine hybrids over BP and 38 hybrids exhibited significant negative heterosis over SV. Present observations are also in strong conformity with the findings of Ramesh *et al*. (2013). The overall range for heterobeltiosis and standard heterosis for plant height was observed from-26.52 to 27.52% and –22.31 to 22.29%, respectively under irrigated ecosystem. The mean heterosis over BP and SV were -10.48 and-3.41 per cent, respectively, in desired direction. Present observations are in close agreement with the finding of Dhanwani *et al*. (2013). The study suggested that parents with semi-dwarf desirable plant height should be chosen. Early maturing hybrids are highly desirable because early maturing hybrids show lodging resistance. The mean heterosis over BP and SV was –0.63 and 2.59 per cent, respectively. Twelve crosses showed significant desirable negative heterosis for days to maturity. Present observations are in close agreement with the findings of Patel *et al*. (1994).

Higher number of ear bearing tillers plant^{-1} is associated with higher productivity. In the present study, heterosis over BP was recorded for 12 crosses and 8 crosses also exhibited positive heterosis over SV. The importance of this component in influencing the yield is clear from the fact that most of the hybrids showing significant positive heterosis as well as heterobeltiosis for this trait also exhibited heterosis for grain yield. The present findings are in accordance with the finding of Singh (2000).

The hybrids with positive heterosis values are desirable for panicle length as long panicle is generally associated with higher productivity. Mean heterosis for panicle length was –3.76 per cent over BP and 12.12 per cent over SV. Twenty-five crosses over BP and 34 crosses over SV showed significant desirable heterosis. The present findings are in accordance with the earlier findings of Pandey *et al*. (1995). Heterosis for number of spikelets panicle^{-1} in general was relatively high and it was expressed in negative direction with a mean heterosis of -6.77 per cent over BP and –6.94 per cent over SV. It is one of the important components of yield and in future this character will be helpful in breaking the yield ceiling. The results revealed that 12 crosses expressed heterosis in desired direction with significant values when tested against respective BP. Virmani *et al*. (1981, 1982) concluded that heterosis in yield was primarily due to increased FS/P. Number of fertile spikelet panicle^{-1} is a complex trait. Significant and positive heterosis for this trait was recorded for 32 crosses over BP and 16 crosses over SV. Positive and negative heterosis were also reported by Patel *et al*. (1994) and Kumar (1987) confirming the present observations. The significant negative heterosis was desirable for SS/P. The significant heterosis in negative direction was observed in 13 crosses over BP and 17 crosses over SV. Lesser spikelet sterility enhances the total yield of hybrids.

Heterosis with respect to TW was expressed in positive as well as in negative directions, which is in conformity with the finding Dhanwani *et al*., (2013). The improvement in yield through heterosis of yield components may not necessarily be reflected in increased higher yield. Heterosis for GY/P over BP and SV exhibited a wide range as the values varied from –54.69 to 139.43 per cent and –60.35 to 22.64 per cent, respectively. Twenty-five crosses out yielded the better parent. In comparison to standard check (Sarjoo-52), only five crosses showed significant increase in yield. The perusal of the data indicated that heterosis for yield of most hybrids were due to increased heterosis in G/P, FS/P, EBT, BY/P, HI, and TW. Increased yield in rice due to various component traits as observed in the present investigation is in conformity to that observed by other workers (Satya *et al*., 1999; and Singh, 2000). Significant and positive heterosis for biological yield was recorded for 23 hybrids over BP and 48 hybrids over SV. The crosses which showed superior heterosis for BY/P also showed superiority for grain yield. Harvest index is a genetic trait, controlling the mechanism of distribution of photosynthates to economic and non-economic organs. However, it indirectly influences the grain yield, but surely it is an important consideration for genetic improvement. For HI, significant and positive heterosis over better parent was recorded for 23 cross combinations and 16 crosses exhibited significant positive heterosis over standard variety. The highest significant positive heterosis was observed in cross IR-58025-A X JR-82-1-10-R (29.30%) over better parent and IR-58025-A X NDRSB 9730015-R (19.29%). over standard hybrid. The results are also in conformity with that obtained by Chauhan *et al*. (2015).

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