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HETEROSIS BREEDING IN RICE (*ORYZA SATIVA* L.) FOR QUANTITATIVE TRAITS

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Abstract

The magnitude as well as direction of heterosis over better parent and standard variety differed from character to character depending upon cross combinations. 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 ranging from 60.35 to 22.64 per cent. In general, the crosses which displayed superiority over better parent and standard variety for grain yield 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 standard variety. Therefore, these hybrids are useful as they produced more yield day^{-1} in comparison to standard variety and may fit well in multiple cropping systems. 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% hybrids showed significant superiority for harvest index, ear bearing tillers plant^{-1}, 1000 grain weight, biological yield whereas only 40% hybrids were observed better for days to 50% flowering and days to maturity.

Key words : Rice, Heterosis, Yield, Better and standard parent.

Introduction

The genetic tools (male sterile, maintainer and restorer lines) essential to develop hybrid rice are available and it is a matter of time that parental lines adapted to different rice growing conditions will be available (Virmani, 1986). Presence of exploitable heterosis and sound seed production techniques are the pre-requisites for success of hybrid rice breeding programme while these requirements have already been perfected in China, the method is yet to gain momentum to continue outside China. Prospective maintainers are to be identified from locally adapted elite breeding lines having good agronomic features, so that male sterility could be transferred to nuclear background of desired genotypes. Further, it is important to identity promising restorers and cross combinations based on per se performance and combining ability effects for ultimate use in the development of experimental hybrids (Yuan and Virmani, 1990). Strategic research is now under-way at world's leading laboratories to develop true breeding hybrids either through use of 'apomixis' or 'somatic embryogenesis' which might eventually relieve farmers of the botheration of replacement of high cost seed every year. Dihaploidy is now possible through anther culture can also be taken to advantage of in the mean time. The information available on various aspects of hybrid rice outside China, especially in tropical countries to exploit the hybrid rice technology commercially, largely lacks parental lines ideally suited to tropical environment. Recently, accelerated research efforts in India, Indonesia, Philippines and Vietnam are expected to result production of successful hybrids in near future.

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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 26.47°N latitude,

82.12°E 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 4A, possessing Wild Abortive (WA) type of cytoplasm were crossed with thirty genetically diverse pollen parents in line × 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.

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.

Production of hybrids

Each of the two cytoplasmic male sterile lines was crossed with thirty restorers, collected from diverse sources, in line × tester mating design. The seeds of F_1s obtained from these combinations were collected. 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.

Growing of F_1's and parental lines

All the crosses were attempted at Crop Research Station, Masodha, Faizabad (U.P.), India. The F_1's thus produced were evaluated along with their parents including standard check variety (Sarjoo-52) in Randomized Complete Block Design with three replications at Crop Research Station, Masodha, Faizabad. The seeds were sown in raised nursery beds. Twenty-five days old single seedling hill^{-1} were transplanted at a 20 cm inter and 15 cm intra-row spacing. Each test entry was raised in three rows of 3.0 m length. All the recommended cultural practices were followed to raise a good crop.

Heterosis analysis

The experimental data obtained on 12 characters were subjected to analysis of variance (Singh and Chaudhary, 1977). Heterosis was computed as per cent increase or decrease in the mean values of F_1 over better parent (B.P.) and standard check variety as suggested by Hayes *et al*. (1955).

Heterosis for yield and component characters

Heterosis was computed as per cent increase or decrease of F_1 over better parent (heterobeltiosis) and over the best commercial variety (standard heterosis). 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. For days to 50% flowering, negative heterosis is desirable, because this will cause the hybrids to mature earlier as compared to parents, thereby increasing their productivity day^{-1} unit area^{-1}. Nine hybrids exhibited significant negative heterosis over better parent and thirty eight hybrids exhibited significant negative heterosis over standard variety. Heterosis for days to flowering over better parent has been reported to be generally negative by Patel *et al*. (1994) and Premkumar *et al*. (2017).

Semi-dwarf plant height (80-100cm) is desirable to get high yield in rice varieties while tall varieties are usually susceptible to lodging and show low harvest index. On the other hand, very dwarf plants (less than 70cm) are related with low dry matter and low grain production. The tendency of the hybrids being taller than the parents are very obvious, but only 13 hybrids over better parent and 16 crosses over standard variety were significantly better. Among 60 F_1 crosses studied, 31 hybrids over better parent and 24 crosses over standard variety showed significant negative heterosis. Present observations are in close agreement with the findings of other workers, *viz*. Lingaraju *et al*. (1999) and Premkumar *et al*. (2017). In the present investigation, plant height of F_1 hybrids was almost equal or to some extent more than the parents as observed by Virmani *et al*. (1982). Therefore, in order to develop rice hybrid possessing semi-dwarf plant type, both parents of the hybrids should be semi-dwarf, possessing the same semi-dwarfing gene. The study thus suggested that parents with semi-dwarf desirable plant

height (80-100cm) should be chosen so that the hybrid derived form these do not become taller than 100 cm even after manifestation of heterosis for plant height under irrigated ecosystem.

Early maturing hybrids are highly desirable because early maturing hybrids show lodging resistance. The heterosis for days to maturity ranged from –20.36 (IR 58025A × IR 21567-18-3R) to 17-17 (IR 58025A × CN 1035-36R) over better parent and from –19.53 (IR 58025A × IR 21567-18-3R) to 17.20 (IR 58025A × CN 1035-36R) over standard variety. The mean heterosis over better parent and standard variety 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) and Premkumar *et al*. (2017).

Higher number of ear bearing tillers plant^{-1} is associated with higher productivity. In the present study, heterosis for ear bearing tillers plant^{-1} over better parent and standard variety exhibited a wide range, but overall it was expressed in negative direction with mean heterosis of –14.45 and 10.53%, respectively. Significant positive heterosis over better parent was recorded for 12 crosses and 8 crosses also exhibited positive heterosis over standard variety. 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 findings of Satya *et al.* (1999), Singh (2000), Devi *et al*. (2017) and Thorat *et al*. (2017).

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 better parent and 12.12 per cent over standard variety. Twenty-five crosses over better parent and thirty-four crosses over standard variety showed significant desirable heterosis. The present findings are in accordance with the earlier findings of Patel *et al*. (1994), Pandey *et al*. (1995), Das *et al*. (2017), Devi *et al*. (2017) and Thorat *et al*. (2017).

The hybrids with positive heterosis values are desirable for total number of spikelets panicle^{-1}. Higher number of spikelets is generally associated with higher productivity. 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 better parent and –6.94 per cent over standard variety. Number of spikelets panicle^{-1} is one of the important components of yield and probably in future this character will be helpful in breaking the yield ceiling thus, the hybrids with positive heterosis are desirable for this trait. The results revealed that 12 crosses expressed heterosis in desired direction with significant values when tested against respective better parents. So far as the standard heterosis was concerned, 12 crosses expressed significant values in positive direction. The work of Pandey *et al*. (1995), Devi *et al*. (2017) and Das *et al*. (2017) also reported similar expression.

Number of fertile spikelet panicle^{-1} is a complex trait. Significant and positive heterosis for this trait was recorded for 32 crosses over better parent and 16 crosses over standard variety. It has also been observed that the hybrids which had higher fertility of more than 80% exhibited generally non-significant value in either positive or negative direction because the standard variety and better parent also exhibited spikelet fertility of more than 80 per cent. Positive and negative heterosis were also reported by Das *et al*. (2017), Devi *et al*. (2017) and Thorat *et al*. (2017) confirming the present observations.

The significant negative heterosis was desirable for number of sterile spikelets panicle^{-1}. The significant heterosis in negative direction was observed in 13 crosses over better parent and 17 crosses over standard variety. Lesser spikelet sterility enhances the total yield of hybrids. The findings are in close conformity with the Das *et al*. (2017) and Devi *et al*. (2017).

Heterosis with respect to 1000-grain weight was expressed in positive as well as in negative directions, which is in conformity with the findings of Rahimi *et al.*, 2010 and Devi *et al*. (2017).

Grain yield plant^{-1} is a complex trait. It is multiplicative end product of several component traits of yield (Grafius, 1959). The improvement in yield through heterosis of yield components may not necessarily be reflected in increased higher yield. Contrarily the increased grain yield is definitely because of either increase in one or more than one yield components. In the present study, heterosis for grain yield plant^{-1} over better parent and standard variety 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 number of grains panicle^{-1}, number of fertile spikelets panicle^{-1}, panicle bearing tillers plant^{-1}, biological yield, harvest index and test weight. Increased yield in rice due to various

Table 1 : Extent of heterosis over better parent and standard variety in 60 rice hybrids for different characters.

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

Contd…..

Crosses	FS/P		SS/P		TW (g)		GY/P (g)		BY (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
Hybrids with significant (+) 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

component traits as observed in the present investigation is in conformity to that observed by other workers (Singh, 2000; Rahimi *et al.,* 2010; Devi *et al*., 2017; Das *et al*., 2017 and Premkumar *et al*., 2017).

Biological yield is a complex trait. Significant and positive heterosis for this trait was recorded for 23 hybrids over better parent and 48 hybrids over standard variety. Twenty-six and seven hybrids exhibited negative and significant heterosis over better parent and standard variety, respectively. The crosses which showed superior heterosis for biological yield also showed superiority for grain yield. These results are also in conformity with those obtained by Das *et al*. (2017), Devi *et al*. (2017), Premkumar *et al*. (2017) and Thorat *et al*. (2017).

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 harvest index, 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 58025A × JR 82-1-10R (29.30%) over better parent and IR 58025A × NDRSB 9730015R (19.29%) over standard hybrid. The results are also in conformity with that obtained by Das *et al*. (2017), Devi *et al*. (2017), Premkumar *et al*. (2017) and Saravanan *et al*. (2018). On the basis of results obtained in the present investigation, it was concluded that heterotic hybrids can be developed from the CMS and restorers lines possessing semi-dwarf plant height and high performance for spikelet fertility percentage, ear bearing tillers plant^{-1}, yield plant^{-1}, biological yield, harvest index and test weight. These traits are also major yield contributing traits and are often associated with each other. Therefore, these traits should be taken in to consideration either simultaneously or alone for selecting the high yielding genotypes of rice.

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