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RESEARCH PAPER

Study of heritability and gene action using CMS line in hybrid rice (*Oryza sativa* L.)

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The low heritability (h^2_{ns}) estimate was observed with grain yield plant^{-1} and test weight indicating a preponderance of non-additive gene action to govern these traits. Combining ability revealed higher specific combining ability variance than their respective general combining ability variances indicating the predominance of non-additive gene effects indicated the relevance of heterosis breeding for improving the yield and yield contributing attributes.

Key words : Heterosis, Combining ability, Line x tester, Rice hybrids

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INTRODUCTION

Rice contributes around 45 per cent of India's cereal production and is the main staple food for over 60 per cent of the population in the country. Despite the age old human concerns about balancing population and food supplies, the world population is expected to continue to grow, possibly reaching 9-11 billion sometimes during 2030-2050. With the current trends of population growth and agricultural production, the demand for food in most parts of the world will be double by the year 2025 and nearly triple by 2050.

The knowledge of genetic variability present in a given crop species for the character under improvement is of paramount importance to the success of any plant breeding programme, Heritability and genetic advance is important selection parameters. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone.

RESEARCH METHODOLOGY

Plant materials :

The experimental material for this investigation comprised of 2 CMS lines *viz*., IR 68897 A and IR 58025 A possessing "wild abortive" (WA) cytoplasm as lines (females), 20 diverse rice varieties/genotypes as testers (males) and 40 crosses obtained through crossing in a "line × tester" mating design (Kempthorne, 1957). These diverse elite strains were selected from the collection of genetic stock available in Rice Section of the Department of Genetics and Plant Breeding, N.D. University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad. The resulting set of 60 F_1's along with their 23 parents were evaluated in a Randomized Complete Block Design with three replications during *Kharif*, 2010. All the recommended cultural practices were followed to raise a good crop. The experimental data collected on thirteen characters *i.e.* days to 50 per cent flowering, flag leaf area, plant height, panicle bearing tillers plant^{-1}, panicle length, spikelets panicle^{-1}, grain yield plant^{-1}, test weight, biological yield plant^{-1} and harvest index.

Statistical analysis :

Data were recorded on five randomly selected plants from parents and F_1 s plant samples. Heritability in the narrow sense (h^2n) was calculated as suggested by Kempthorne (1957).

RESEARCH FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Analysis of variance :

The analysis of variance (Table 1) revealed that the variation among CMS lines (females) for all characters and testers (males) except number of leaves seedling^{-1}, test weight and grain yield plant^{-1} indicating the prevalence of additive variance for rest of the traits. The significance of mean square due to line × tester for all traits provides a direct test indicating that (i) non-additive variance and (ii) combining ability contributed heavily to the expression

Table 1 : Analysis of variance for line x tester for 10 characters in rice

Source of variation	Replications	Tester (t)	Lines (l)	Crosses	L X T effect	Error
DF	2	19	2	59	38	118
Days to 50 per cent flowering	7.439	52.165	241.072*	59.925**	54.271**	9.301
Flag leaf area (cm^2)	4.438*	92.817**	485.142**	67.101**	32.241**	1.131
Plant height (cm)	5.295**	282.055*	4978.882**	345.034**	132.6375**	0.845
Panicle bearing tillers per plant	5.650**	49.957**	49.245**	21.996**	6.581**	0.608
Panicle length (cm)	6.049**	30.044**	107.760**	20.652**	11.370**	1.023
Spikelets per panicle	363.491	2918.248	7222.535*	2534.953**	2096.590**	245.698
Test weight (g)	2.154**	27.208	6.349	27.794**	29.215**	0.317
Biological yield per plant (g)	11.963	5245.676	35838.850**	5889.423**	4635.010**	40.715
Harvest-index (%)	97.332**	297.888	1047.005*	299.558**	261.054**	7.834
Grain yield per plant (g)	157.004**	1609.642	41.872	1089.803**	885.038**	20.152

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2: Estimates of heritability broad (h^2_{bs}) and narrow sense (h^2_{ns}), additive (σ^2_A) and dominance (σ^2_D) genetic components of variance, genetic advance (GA) and genetic advance as % of mean (GM%) for 13 characters in rice

Characters	Heritability (%)		Genetic components of variance		GA	GM (%)
	h^2_{bs}	h^2_{ns}	$\pm^2_A$	$\pm^2_D$		
Days to 50 per cent flowering	66.69	22.84	5.354	15.051	7.188	7.10
Flag leaf area (cm^2)	93.19	58.70	14.883	10.285	8.655	25.98
Plant height (cm)	98.02	76.69	144.802	43.470	21.388	21.48
Panicle bearing tillers per plant	91.55	53.20	2.494	1.886	6.233	46.12
Panicle length (cm)	85.91	46.81	3.335	3.424	4.946	19.56
Spikelets per panicle	83.48	19.79	172.394	624.227	63.321	32.23
Test weight (g)	96.04	@	-0.721	9.619	5.952	26.40
Biological yield per plant (g)	98.46	37.38	922.160	1534.241	92.747	74.98
Harvest-index (%)	91.17	21.57	23.849	84.025	18.934	55.66
Grain yield per plant (g)	94.68	@	-3.437	288.757	36.621	89.07

@ Negative estimates

of these traits.

Heritability in narrow sense:

The concept of heritability (narrow sense) plays a vital role in the formulation of aselection strategy for plant improvement. Hanson (1963) while reviewing the importance of heritability in plants pointed out that this parameter is influenced by the method of estimation, generation of hybrid, the experimental material used and the environment. It measures the genetic relationship between parent and progenies. It is widely used in determining the degree to which a character may be transmitted from parent to off springs.

Heterosis breeding can improve these traits in F_1. Days to 50 per cent flowering$^{-1,}$ spikelets panicle^{-1}, harvest index showed moderate heritability whereas seedling height, flag leaf area, plant height, panicle bearing tillers plant^{-1}, panicle length and biological yield plant^{-1} shown high heritability indicating that improvement can be done with phenotypic selection (Table 2). Above findings were also confirmed from the estimates of variance due to anadditive genetic component in the present study.

Heritability in broad sense :

Heritability of a character is important to the breeder since it indicates the possibility and extent to which improvement is possible through selection (Robinson *et al.*,1949). It also indicates towards selection pressure applied for a trait during selection because it measures the genetic relationship between parent and their progeny hence widely used in determining the degree to which a character may be transmitted from parent to offspring.

The genetic advance is yet another important selection parameter because it measures the difference between the mean genotypic value of the selected lines and the mean genotypic value of the original population from which these were selected. Panse (1957) viewed that if a character is governed by non-additive gene action it may give high heritability but low genetic advance whereas if it is governed by additive gene action both heritability and genetic advance would be high. High estimates of heritability along with high genetic advance provide good scope for further improvement in advance generations of these characters if subjected to the mass progeny or family and clonal selection. The population expressing higher variability for the character (s) can give the desirable plant type more frequently but in the case of the low amount of variability a large population will be required, if the effective selection is to be made.

In the present study, the high heritability (h^2_b) coupled with high genetic advance was recorded (Table 2) for biological yield plant^{-1}, followed by spikelets panicle^{-1}, hence, these traits were predominantly under the control of additive gene action. High heritability and the low genetic advance were recorded for grain yield plant^{-1}, spikelet fertility, plant height, harvest index, seedling height, flag leaf area, panicle bearing tillers plant^{-1}, test weight and panicle length suggesting a predominance of non-additive gene action in the inheritance of these traits. Days to 50 per cent flowering and number of leaves seedling^{-1} had low heritability and low genetic advance suggesting character is highly influenced (Rajput *et al.*, 2014; Ketan and Sarkar, 2014 and Allam *et al.*, 2015).

Genetic components of variance and gene action :

The relative magnitude of variance (Table 2) components revealed that SCA variance was greater than the GCA variance for all the character except flag leaf area, plant height, panicle bearing tillers plant^{-1}. The degree of dominance was higher than unity (>1) except flag leaf area, plant height, panicle bearing tillers plant^{-1} and predictability ratio was low (<1) for all the characters. Dominance variance was greater than additive variance for each character except flag leaf area, plant height, panicle bearing tillers plant^{-1}. These findings showed that dominance gene action had agreater role in the inheritance of these traits and fully supported by Mahmood *et al.* (2002) and Singh *et al.* (2005) studied under salinity and also found yield traits was governed by non-additive gene action.

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