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COMBINING ABILITY ANALYSIS IN *ORYZA SATIVA* L.

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A diallel cross involving four rice cultivars; Basmati 370, Basmati 385, 4048 and Basmati 198 was studied in the F_1 generation for anther length, 100-anther weight, pollen grain size and percent filled spikelets. Both general combining ability (GCA) and specific combining ability (SCA) were significant for all traits except pollen grain size. The GCA mean square magnitude was considerably higher than SCA mean square for anther length and 100-anther weight. The inverse was found for percent filled spikelets. It reveals additive gene effects for anther length, 100-anther weight and dominance gene effects for percent filled spikelets. Basmati 198 displayed positive and significant general combining ability effects for anther length and 100-anther weight. Basmati 370 was the best general combiner for percent filled spikelets. 4048 x Basmati 198, Basmati 370 x 4048 and Basmati 370 x Basmati 385 were the best specific combiners for anther length, 100-anther weight and percent filled spikelets respectively and are expected to contribute higher frequency of desirable plants than other crosses in subsequent generations.

Key words: Diallel, Anther length, Additive, Rice.

Introduction

Combining ability analysis is used to test the significance of general and specific combining ability of genotypes for different plant traits and is useful for determining potential parents for hybrid breeding programme. Very little or no information is available about the genetic behaviour of allogamic traits such as anther length, 100-anther weight and pollen grain size in rice.

Therefore the main objective of the present studies was to collect some basic information about the genetic mechanism involved in the inheritance of these floral traits. Percent filled spikelets may be expected to be associated with any of the floral characteristics. Any genetic mechanism that would improve the outcrossing potential of rice would increase the chances of success with composite breeding as well as the development of hybrids [1]. Oka and Morishima [2] reported 20 to 100% outcrossing in wild rice *Oryza perennis.* The occurrence of cytoplasmic male sterility, an essential prerequisite to hybrid development, has been reported in rice [3, 4]. The increased length of anther could improve outcrossing through its influence on stigma exertion but could also directly increase the number of pollen grains available for pollination [1]. Intervarietal and interspecific differences in anther length have also been reported in rice [4, 5]. Ali *et al.* [6] reported that anther length and pollen grain size in rice are the monogenically controlled traits. In some other studies, Ali *et al.* [7] observed that both additive and non-additive gene effects are important for anther length, 100-anther weight and percent filled spikelets in rice.

Materials and Methods

A diallel cross excluding reciprocals was developed using four rice cultivars; Basmati 370, Basmati 385, 4048 and Basmati 198. During Kharif 1992, the four cultivars and their six hybrids were planted at the Rice Research Institute, Kala Shah Kaku in a RCB design with three replications. Each plot consisted of a single row 5 m long, with 30 cm spacing between plants and rows. Data were recorded for anther length (mm), 100-anther weight (mg), pollen grain size (μ) and percent filled spikelets (%). Five observations were made on each of the ten randomly selected plants from each replicate of each of the ten genotypes. Percent filled spikelets values were obtained by dividing the number of grains per panicle by total number of spikelets per panicle, multiplying 100.

Data were analyzed using analysis of variance according to the methods of Steel and Torrie [8]. Griffing method 2, Model 2 [9] was used for the combining ability analysis and for computing standard errors for GCA and SCA effects.

Heritability (h^2) in broad sense was estimated by using the formula:

$$h^2 = VG \;/\; VP \times 100$$

Where VG = genetic variance and VP = phenotypic variance

Results and Discussion

Highly significant differences existed among rice genotypes for all the traits studied except pollen grain size (Table 1). For significant traits mean squares due to genotypes were partitioned into components attributable to general and specific combining ability. Highly significant and significant differences in GCA were only found for anther length, 100-anther weight and percent filled spikelets respectively. SCA mean squares were highly significant for all traits (Table 2). GCA effects were significant for anther length and 100-anther weight. For percent filled spikelets, GCA effects were non-significant for all the parents except for Basmati 370. The SCA effects were significant except for Basmati 370 x Basmati 198, Basmati 385 x Basmati 198(100-anther weight) and Basmati 370 x Basmati 198 and 4048 x Basmati 198 (percent filled spikelets). Highest values of general combining ability effects (0.09** and 1.11**) for anther length, anther weight and 1.99* for percent filled spikelets were exhibited by Basmati 198 and Basmati 370, respectively (Table 3). Basmati 370 appeared to be the poor general combiner for anther length and 100-anther weight. However, it was the best general combiner for percent filled spikelets. All other parents performed poorly for this trait. The cross combinations 4048 x Basmati 198 (14.71**), Basmati 370 x 4048 (1.23**) and Basmati 370 x Basmati 385 (5.53**) were the best specific combiners for anther length, 100-anther weight and percent filled spikelets respectively. The hybrid combinations Basmati 385 x Basmati 198 (–9.24**) and Basmati 385 x 4048 (–1.24**) were the poor specific combiners for percent filled spikelets and 100-anther weight, respectively. However, for anther length all cross combinations showed significant and positive specific combining ability effects. The estimates of variance components (Table 4) revealed that general combining ability variance (σ^2GCA) were larger in magnitude than those of specific combining ability variance (σ^2SCA) for all the traits except percent filled spikelets.

This suggests a preponderance of both additive and non-additive gene action for the inheritance of anther length, 100-anther weight and non-additive gene action for percent filled spikelets, respectively. The estimates of general combining ability variance (σ^2GCA) and additive variance (σ^2A) were negative in direction for percent filled spikelets so the most appropriate values for such estimates are zero. The additive variances (σ^2A) and broad sense heritability (h^2) estimates were high for anther length and 100-anther weight thus indicating the possibility of better phenotypic selection for these traits in early segregating generations. Ali *et al.* [7] observed

Table 1. Mean Squares from the Analysis of Variance for Allogamic Traits in A4x4 Diallel Cross Experiment. (Excluding Reciprocals).

Source of variation	D.F.	Anther length (mm)	100-anther weight (mg)	Pollen grain size (micron)	Percent filled spikelets
		Traits			
Replications	2	$0.022^{N.S.}$	$0.301^{N.S.}$	$2.589^{N.S.}$	$7.0028^{N.S.}$
Genotypes	9	0.069^{**}	10.856^{**}	$4.356^{N.S.}$	115.4843^{**}
Error	18	0.004	0.569	2.136	16.0814
Total	29	–	–	–	–

N.S. = Non significant. ** = Significant at 1% probability level.

Table 2. Analysis of Combining Ability Variance for Anther Length, 100-Anther Weight and Percent Flled Spikelets.

Source of variation	D.F	Anther length	100-anther weight	Percent filled spikelets
GCA	3	0.0594^{**}	8.9697^{**}	18.1127^{*}
SCA	6	0.0083^{**}	0.8461^{**}	48.7358^{**}
Error	20	0.0014	0.1707	4.8244
$Total_{(N-1)}$	29	—	—	—

*,** = Significant at 5 and 1% probability levels respectively. GCA = General combining ability. SCA = Specific combining ability.

Table 4. Estimation of Variance Components for Anther Length, Anther Weight and Percent Filled Spikelets in Rice Genotypes.

Variance	Anther length (mm)	100-anther weight (mg)	Percent filled spikelets
σ^{2GCA}	0.0085	1.3539	–5.1039
σ^{2SCA}	0.0083	0.8461	48.7358
σ^{2g}	0.0253	3.5390	38.5280
σ^{2p}	0.2670	3.7246	43.3524
σ^{2e}	0.0014	0.1707	4.8244
σ^{2A}	0.0170	2.7078	–10.2078
σ^{2D}	0.0083	0.8461	48.7358
$h^{2B.S.}$	94.76	95.4200	88.8700

σ^{2GCA} = General combining ability variance. σ^{2SCA} = Specific combining ability variance. σ^{2g} = Genetic variance. σ^{2p} = Phenotypic variance. σ^{2e} = Environmental variance. σ^{2A} = Additive variance. σ^{2D} = Dominance variance. $h^{2B.S.}$ = heritability in broad sense.

Table 3. General Combining Ability Effects (Diagonal) and Specific Combining Ability Effects (Off-Diagonal) for Allogamic Traits in a 4 x 4 Diallel Cross Experiment.

Parents	Anther length (mm)				100-Anther weight (mg)				Percent filled spikelets			
	Bas. 370	Bas. 385	4048	Bas. 198	Bas. 370	Bas. 385	4048	Bas. 198	Bas. 370	Bas. 385	4048	Bas. 198
Bas. 370	-0.11^{**}	14.63^{**}	14.5^{**}	14.62^{**}	-1.23^{**}	0.71^{*}	1.23^{**}	$0.40^{n.s.}$	1.99^{*}	5.53^{**}	-7.21^{**}	$0.15^{n.s.}$
Bas. 385		0.08^{**}	14.59^{**}	14.63^{**}		-0.87^{*}	-1.24^{**}	$0.11^{n.s.}$		$0.82^{n.s.}$	-2.73^{*}	-9.24^{**}
4048			-0.06^{**}	14.71^{**}			0.99^{**}	0.61^{*}			$-0.94^{n.s.}$	$-2.59^{n.s.}$
Bas. 198				0.09^{**}				1.11^{**}				$-1.88^{n.s.}$

*,** = Significant at 5 and 1% probability levels respectively. Bas. = Basmati. n.s. = Non-significant.

similar results in rice for combining ability of anther length and 100-anther weight. Virmani and Athwal [1] also reported that in rice increased anther length could improve outcrossing not only through its influence on stigma exertion but could also directly increase the number of pollen grains available for pollination.

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