clease enzyme may be one of the factors responsible for BLB susceptibility or resistance through their increased or decreased activity in rice cultivars.

REFERENCES

DAVIS, B. J. 1964. Polyacrylamide gel electrophoresis of proteins. Ann. N. Y. Acad Sci., 121 : 404-427.

GUPTA, V. K. and S. S. MALIK, 1978. Electrophoretic patterns among seed proteins from different varieties of rice. *Pantnager J. Res.*, 3(1) : 1-3.

JOHNSON, B. L., D. BERNHART and O. HALL 1967. Analysis of genome and species relationships in the polyploid wheat by proteins electrophoresis. *Amer. J. Bot.*, 54 : 1089.

JOHNSON, B. L. 1972. Protein electrophoresis profiles and the origin of the B genome of wheat. Proc. Nat. Acad. Sci., 69 : 1398-1402.

KESSLER, B. and N. ENGELBERG, 1962. Ribonuclease activity in developing leaves' *Biochem. Biophys. Acta.* 55 : 70-82.

LEE, J. W. and J. A. RONALDS 1967. Effect of environment on wheat gliadin. *Nature*. 213 : 844-846.

SCANDALIOS, J. G. 1969. Genetic control of multiple forms of enzymes in plants. *Biochem. Genet.*, 3 : 37-74.

SCANDALIOS, J. G, 1974. Isozymes in development and differentiation. *Ann. Rev. Plant Physiol.*, 24 : 225-258.

https://doi.org/10.29321/MAJ.10.A02493

Madras Agric. J. 71 (7) 424—430 July 1984.

STUDIES ON COMBINING ABILITY FOR YIELD COMPONENTS IN RICE*

SUKANYA SUBRAMANIAN[1] and M. RATHINAM

A diallel technique was employed in which ten varieties of rice were crossed among themselves in all possible combinations. A total of 90 hybrids and ten parents was studied. The analysis for combining ability was significant for all the characters which indicated the presence of both additive and non-additive gene actions. The GCA variances were higher than SCA variances which revealed the predominance of additive gene actions for all the characters. Significant gca effects for plant height, panicle length, number of grains per panicle and straw yield per plant were shown by Co.20 whereas TKM 6 showed significant effects for earbearing tillers per plant, Jaya for 100 grain weight, Dee-geo- Woo-gen (Dg Wg) for grain yield per plant and grain-straw ratio, Basmati 370 for grain length, I-geo-tze (Igt) for grain width and SLO 16 for length-width ratio of grain. No specific cross combination was found desirable for all the characters as indicated by their sca effect but the combinations involving Jaya and Dg Wg with Basmati 370 and TKM 4 were found generally good for grain yield, short stature and fine quality of grain.

* Forms a part of the Ph.D. thesis of the senior author approved by the Tamil Nadu Agricultural University, Coimbatore-641 003.

1. Associate Professor, Department of Forage Crops, Tamil Nadu Agricultural University, Coimdatore

3. Professor and Head, Forest Research Station, TNAU, Mettupalayam.

The information on the nature of combining ability in respect of parents and hybrids will facilitate the breeder to plan the breeding programme effectively for improvement of crop plants. Combining ability has been reported in many crops but has not been largely reported in rice *(Oryza sativa* L.*)*. The general combining ability (gca) and specific combining ability (sca) of ten rice lines and their all possible combinations are presented hereunder.

MATERIALS AND METHODS

Ninety hybrids along with the ten parents viz., Jaya, Taichung (Native) 1 [T(N)1] Dee-geo-Woo-gen (Dg Wg), I-geo-tze (Igt), TNAU. 13613, TKM.6, SLO.16, Basmati 370, TKM. 4 and CO 20 (P_1 to P_{10}) were tested on three seasons namely 1976 *Kar* season (June to September), 1977 *Navarai* season (January to April) and 1978 *Samba* season (August to November), at the Paddy Breeding station, Tamil Nadu Agricultural University, Coimbatore, in a randomised blocks design replicated twice. The seedlings were transplanted at a spacing of 20 x 10 cm in two rows of two meters length. Twenty plants were chosen at random in each variant from each replication to record the biometrical attributes such as plant height, earbearing tillers per plant, panicle length, number of grains per panicle besides yield of grain and straw and length and width of grain. The analysis of variance was done with the mean values for each of the three seasons as well as after pooling. Combining ability for individual season was determined by the procedure outlined by Griffing (1956 a) and for pooled data as developed by Daljit Singh (1973).

RESULTS AND DISCUSSION

All the characters exhibited significant GCA and SCA variances in individual seasons (Table 1) as well as in pooled analysis (Table 2) which indicated the presence of both additive and non-additive gene actions for the characters studied. Rao *et al.* (1980) also found such significant GCA and SCA variances for many triats. The variances due to GCA were higher than due to SCA which indicated the predominance of additive gene action which is in confirmation with Singh *et al*, (1979). The relative stability estimate of GCA variances was maximum in 100 grain weight and SCA variances,in grain-straw ratio. The GCA variances were more stable over seasons than SCA variance for all the characters except earbearing tillers per plant. This indicated that a single season testing could give sufficient inference for the utilisation of the additive variance available in the materials studied in a breeding programme. However, the differential behaviour of SCA variances to seasons suggested the need for evaluation of the hybrids in more than one season.

High pooled gca effects were shown by Co. 20 for plant height, panicle lenght, number of grains per panicle and straw yield per plant, TKM. 6 for earbearing tillers per plant, Jaya for 100 grain weight, DgWg for grain yield per plant and grain-straw ratio, Basmati 370 for grain length, Igt for grain width and SLO 16 for length-width ratio of grain and were adjudged to be the best general combiners (Table 3). Griffing (1956 b) expressed that general combining ability included

Table 1. Analysis of variance due to combining ability

Character	Season	GCA	SCA	GCA / SCA
Plant Height	S_1	5123.50**	75.58**	67.79
	S_2	4995.78**	84.27**	59.28
	S_3	3811.83**	79.23**	48.11
Earbearing tillers per plant	S_1	1.36**	2.03**	0.668
	S_2	2.60**	1.21	2.098
	S_3	4.25**	1.05**	4.063
Panicle length	S_1	40.70**	2.03**	20.08
	S_2	16.12**	1.79**	9.03
	S_3	25.78**	0.95**	27.28
Number of grains per panicle	S_1	313.22*	42.56**	7.36
	S_2	181.94**	13.71**	13.27
	S_3	242.17**	5.58**	43.38
100 grain weight	S_1	0.59**	0.01**	49.58
	S_2	0.57**	0.01**	47.42
	S_3	0.62**	0.01**	68.77
Grain yield per plant	S_1	91.88**	11.58**	7.93
	S_2	92.06**	7.51**	12.26
	S_3	76.57**	7.82**	9.79
Straw yield per plant	S_1	1007.46**	86.26**	11.68
	S_2	865.14**	71.71**	12.07
	S_3	1099.42**	73.61**	14.94
Grain-Straw ratio	S_1	0.23*	0.01**	19.08
	S_2	0.21**	0.01**	16.08
	S_3	0.24**	0.01**	17.36
Grain length	S_1	2.40**	0.05**	48.98
	S^3	2.38**	0.04**	64.41
	S_3	2.16**	0.04**	54.10
Grain width	S_1	0.41**	0.005**	82.40
	S_2	0.40**	0.004*	99.50
	S_3	0.42**	0.006**	70.50
Length-width ratio of grains	S_1	2.80**	0.01**	147.58
	S_2	2.66**	0.01**	221.42
	S_3	2.58**	0.02**	172.07

* Significant at 5% level ** Significant at 1% level

S_1 — 1976 Kar Season S_2 — 1977 Navarai season S_3 — 1978 Samba season

Table 2 Pooled Analysis of Variance due to Combining Ability

Variances due to	Plant Height	Earbearing tillers per plant	Panicle length	Number of grains per panicle	100 grain weight	Grain yield per plant	Straw yield per plant	Grain-Straw ratio	Grain length	Grain width	Length-width ratio of grain
General combiningability (GCA)	13844.6**	5.1**	78.7**	693.9**	1.8**	242.9**	2949.2**	0.680**	6.9**	1.227**	8.005**
Specific combining ability (SCA)	223.6**	3.6**	3.4**	41.8**	0.032**	22.9**	177.5**	0.038**	0.112**	0.011**	0.023**
GCA X Season	43.2**	1.6**	1.9**	21.8**	0.0025**	8.8**	592.8**	0.001**	0.016**	0.003**	0.019**
SCA X season	7.8**	0.3**	0.7**	10.0**	0.0013**	1.9**	27.0**	0.001**	0.007**	0.002**	0.011**
GCA/SCA	61.9*	1.4	22.9	16.6	55.6	10.6	16.6	17.9	61 7	111.5	348.0
Relative stability estimates											
a) GCA	0.99	0.76	0.98	0.97	0.99	0.96	0.83	0.99	0.99	0.99	0.99
b) SCA	0.97	0.91	0.84	0.81	0.96	0.92	0 87	0.97	0.94	0.85	0.67

* Significant at 5% level ** Significant at 1% level

Table 3. GCA Effects of Parents (Pooled)

	Parents	Plant height	Earbearing tillers per plant	Panicle length	Number of grains per plant	100 grain weight	Grain yield per plant	Straw yield per plant	Grain-Straw ratio	Grain length	Grain width	Length-width ratio of grain
P_1	Jaya	-14.59**	-0.31**	-1.29**	-1.71**	0.27**	0.90**	-3.94**	0.10**	0.12**	0.09**	-0.12**
P_2	Taichung (Native) 1	-10.60**	-0.02	-0.80**	-2.15**	-0.74**	-6.83**	-6.83**	0.08**	0.30**	0.15**	-0.36**
P_3	Dee-geo-Woo-gen	-9.42**	0.19**	0.01	-1.24**	0.20**	2.04**	-4.18**	0.13**	-0.09**	0.09**	-0.21**
P_4	I-geo-tze	-14.53**	0.11	-0.74**	2.70**	0.10**	1.49**	-5.16**	0.11**	-0.43**	0.22**	-0.52**
P_5	TNAU13613	-15.54**	-0.03	-1.40**	-1.92**	-0.03**	-0.71**	-4.37**	0.05**	-0.55**	0.07**	-0.40**
P_6	TMK 6	17.54**	0.56**	1.001**	3.98**	-0.16**	1.54**	5.38**	-0.05**	-0.005	-0.09**	0.13**
P_7	SLO 16	-2.15**	-0.39**	-0.61**	-4.43**	-0.29**	-4.42**	-6.78**	-0.04**	0.19**	-0.19**	0.44**
P_8	Basmati 370	12.86**	-0.15**	-0.91**	-3.49**	-0.10**	-1.11**	6.15**	-0.13**	0.49**	0.14**	0.44**
P_9	TKM 4	12.51**	-0.21**	0.96**	3.12**	-0.09**	-1.00**	7.68**	-0.14**	0.27**	-0.07**	0.23**
P_{10}	Co.20	23.97**	0.28**	1.96**	5.15**	-0.01**	-1.99**	12.05**	-0.12**	0.29**	-0.13**	0.35**
	S.E.	0.15	0.07	0.07	0.16	0.0007	0.06	0.11	0.007	0.009	0.005	0.005

both additive effects as well as additive x additive interaction.

In addition, DgWg and Igt were found to be good general combiners for grain yield, number of tillers, 100 grain weight and grain-straw ratio. Besides, Igt was also a good combiner for number of grains per panicle. Jaya and T(N)1 were good combiners for 100 grain weight and short stature. Except for short stature, TNAU 13613 was not a good combiner for any other character. TKM 6 and Co. 20 were good general combiners for grain yield, tiller number panicle length, number of grains per panicle and fine quality of grain. SLO 16, Basmati 370 and TKM 4 were good general combiners for fine quality of grain, besides the latter two parents being good for panicle length.

Three combinations expressing the highest pooled Sca effects in each of the traits are given in the table 3. The pooled specific combining ability effects for plant height were high and positively significant in four combinations P_1 x P_{10}, P_1 x P_5, P_3 x P_8, and P_3 x P_{10} and negatively significant in three combinations, P_6 x P_{10}, P_7 x P_{10}, and P_8 xP_{10}. None of the hybrids were good for earbearing tillers per plant and panicle length. However, combinations P_3 x P , and P_3 x P_8, recorded the highest significant positive sca effects for tiller number and panicle length respectively. For number of grains per panicle the combinations, P_4 x P_6 and P_1 x P_4 were markedly superior to others. Significant positive sca effects were observed for 100 grain weight in the combinations P_1 x P_9 and P_5 x P_9. Three combinations P_4 x P_5, P_1 x P_8 and P_5 x P_9 showed high positive sca effects for grain yield per plant. Eighteen combinations exhibited significant negative (desirable) sca effects for straw yield per plant, the highest being recorded by the combination P_1 x P_8. For grain-straw ratio, high positive significant sca effects were recorded by the combinations P_3 x P_4, P_1 x P_4 and P_1 x P_{10}. The combinations P_3xP_{10} and P_3 x P_8 exhibited high positive sca effects for grain length while P_1 x P_3 exhibited high negative sca effect (desirable) for grain width. The highest positive sca effects were observed for lenth-width ratio of grain in the combinations P_6 x P_8 and P_6 x P_{10}. Sprague and Federer (1952) studied combining ability over years and found that specific combining ability not only included dominance and epistasis, but a considerable amount of genotype x environment interaction also.

Thus in the cross combinations, none of the hybrids were good for all the characters. In general, the combinations involving the semi-dwarf varieties, Jaya, T (N)1. DgWg, Igt and TNAU 13613 with tall varieties, SLO 16, Basmati 370 and TKM 4 exhibited significant sca effect for short stature, Of these, the combinations of the semi-dwarf varieties Jaya and DgWg with the tall varieties Basmati 370 and TKM 4 appeared to be promising for better tillering habit, more number of grains per panicle, greater 100 grain weight, shorter stature, higher grain yield and fine quality of grain. These may be utilised in hybridisation programme for realising the most disirable recombinants.

Table 4. Mean sca effects of best three F_1 hybrids

Characters	Combinations	sca effect
1. Plant height	$P_1 \times P_{10}$	9.65
	$P_1 \times P_6$	9.43
	$P_8 \times P_9$	9.16
2. Earbearing tillers per plant	$P_8 \times P_9$	1.09
	$P_7 \times P_9$	0.94
	$P_3 \times P_8$	0.86
3. Panicle length	$P_3 \times P_6$	1.74
	$P_7 \times P_8$	0.99
	$P_3 \times P_9$	0.99
4. Number of grains per panicle	$P_4 \times P_6$	4.87
	$P_1 \times P_4$	4.51
	$P_8 \times P_{10}$	3.30
5. 100 grain weight	$P_1 \times P_9$	0.18
	$P_6 \times P_9$	0.15
	$P_6 \times P_8$	0.11
6. Grain yield per plant	$P_4 \times P_6$	3.33
	$P_1 \times P_8$	3.04
	$P_5 \times P_9$	3.00
7. Straw yield per plant	$P_1 \times P_6$	−8.63
	$P_1 \times P_6$	−6.68
	$P_7 \times P_8$	−6.58
8. Grain-straw ratio	$P_3 \times P_6$	0.14
	$P_1 \times P_4$	0.12
	$P_1 \times P_{10}$	0.10
9. Grain length	$P_3 \times P_{10}$	0.21
	$P_3 \times P_8$	0.21
	$P_5 \times P_8$	0.18
10. Grain width	$P_1 \times P_9$	−0.14
	$P_6 \times P_8$	−0.07
	$P_1 \times P_8$	−0.06
11. Length-width ratio of Grain	$P_6 \times P_8$	0.14
	$P_6 \times P_{10}$	0.10
	$P_3 \times P_8$	0.10

REFERENCES

DALJIT SINGH, 1973. Diallel analysis over different environments. *Indian J. Genet.*, 33 : 127-36.

GRIFFING, B. 1956 a. Concept of general and specific combining ability in relation to diallel crossing systems. *Aust. J. Biol. Sci.*, *9* : 463-93.

GRIFFING, B. 1956 b. A generalised treatment of the diallel cross in quantitative inheritance. *Heredity*, *10* : 31-50.

RAO, A. V., T. SAIKISHNA and A.S.R. PRASAD 1980. Combining ability analysis in rice. *Indian J. Agric. Sci.* *50* : 193-97.

SINGH, R P., R. R SINGH, S. P. SINGH and R. V. SINGH, 1979. Combining ability for yield components in rice. *Oryza*. *16*: 115-18.

SPRAGUE, G. F. and W. T. FEDERER, 1952. A comparison of variance components in corn yield trials. II. Error, year x variety, location x variety and variety components. *Agron J* *44* : 535-44.