Indian J. Genet., **48**(1): 43–48 (1988)

COMBINING ABILITY IN A FEW VARIETIES OF *T. AESTIVUM*, *T. COMPACTUM* AND *T. SPHAEROCOCCUM*

P. K. MAJUMDAR* AND J. G. BHOWAL

Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012

(Received: August 16, 1985; accepted: July 14, 1987)

ABSTRACT

Combining ability studies were undertaken for ten quantitative characters in a diallel set involving nine parents from three groups of hexaploid wheats *T. aestivum*, *T. compactum* and *T. sphaerococcum*. The gca and sca variances indicated that additive gene action was of greater importance for spike length, spike density, grain wt. per spike, 100-grain weight, and yield/plant; while for days to first flowering, plant height, number of tillers/plant, spikelets/spike, and grains/spike nonadditive component was more important. Dwarf or semidwarf parents, in general, were not good combiners for yield and also for the important yield components that emphatically indicated the consideration of height along with yield components in the selection criteria. Use of the hitherto unexploited semidwarfs like *T. compactum* and *T. sphaerococcum* as the source of semidwarfing stiff straw gene(s) has been suggested. The per se performance of the parent is an adequate measure of gca for most characters except days to first flowering, tillers/plants, spikelets/spike, and grains/spike. It is also suggested that the crosses with at least one parent with superior gca effect will hasten genetic recombination and also help in overcoming the genetic barriers, if present.

Key words: *Triticum* species, combining ability, plant height.

Combining ability analyses in wheat have been reported by several workers, but these are limited to either breadwheat (*Triticum aestivum*) for macaroni wheat (*T. durum*). No attempt seems to have been made to evaluate varieties of *T. sphaerococcum* and *T. compactum* in combination with varieties of *T. aestivum*. *T. compactum* and *T. sphaerococcum* have some semidwarf varieties with stiff erect straw and hemispherical to almost round grain. The present study explores the possibility of using *compactum* and *sphaerococcum* varieties as alternate sources of dwarfing and analyse the combining ability, in a diallel cross, of a few varieties from these three hexaploid wheats, viz., *T. compactum* *T. sphaerococcum* and *T. aestivum*.

MATERIALS AND METHODS

A diallel cross involving nine parents of three hexaploid wheat species, *Triticum compactum* Host., *Triticum sphaerococcum* Perc., *Triticum aestivum* L. varieties Chinese Spring, Sonora 64, Kalyan Sona, NP 846, NP 890, C 306 and C 591 were used in this investigation. The material was selected mainly based on height, tall and dwarf, and geographic diversity. Parents and 36 F_1 (without reciprocals) were grown in randomised block design with three replications. Each treatment in a

---

*Present Address: Department of Genetics, Rajendra Agric. Univ., Pusa, Samastipur 848125.

replication was raised in a single-row plot of 2 m length with 45 cm × 10 cm spacing. The data on individual plant were recorded on ten quantitative characters (Table 1). Plot means were used for statistical analysis. Combining ability analysis was carried out using Method 2, Model I of Griffing [1].

RESULTS AND DISCUSSION

Difference among entries, parents and crosses, were highly significant for all the ten characters, except tillers plant in case of parents. The tall plant types generally surpassed dwarfs for most characters. The wide variability among parents as well as between groups suggests that they would be useful in future breeding work. The gca and sca variances were significant for all the characters (Table 1). The significance of gca as well as sca exhibits the importance of both additive and nonadditive gene actions in the present material. Some workers identified high gca, while others sca or both, for the same character. Somayajulu et al. [2] could not detect gca variance for grains per ear, whereas several workers [3–5], observed both gca and sca components of variance for this character. Thus, combining ability may differ depending on the material studied, and its handling would depend on the information available.

Table 1. ANOVA for combining ability

Source	d.f.	Mean squares									
		days to first flowering	plant height	tillers per plant	spike length	spikelets per spike	spike density	grains per spike	grain wt. per spike	100-grain wt.	yield per plant
gca	8	46.77**	591.3**	39.3**	12.02**	3.54**	0.72**	78.8**	0.80**	2.64**	394.8**
sca	36	22.01**	149.2**	17.0**	0.93**	2.33**	0.10**	56.0**	0.08**	0.24**	60.4**
Error	88	3.48	12.3	10.3	0.11	0.19	0.002	6.2	0.016	0.023	22.6
$\frac{2\hat{\sigma}^2g}{2\hat{\sigma}^2g+\sigma^2s}$		0.30	0.4	0.4	0.73	0.22	0.57	0.21	0.70	0.69	0.6

*, ** Significant at 5% and 1% levels, respectively.

The relative values of gca and sca, as judged by the proportion of estimated gca variance to the total genetic variance ($2\hat{\sigma}^2g/2\hat{\sigma}^2g+\hat{\sigma}^2s$), indicated greater importance of the gca (additive) component of genetic variance for spike length, spike density, grain weight/spike, 100-grain weight, and yield/plant, while sca (nonadditive) variance was more important for the remaining characters,. viz., days to first flowering, plant height, tillers/plant, and spikelets and grains spike.

The per se performance of the parents showed more or less parallel trend with the gca effects for plant height, spike length, spike density, grain weight/spike, 100-grain weight, and yield/plant. This association was also evident from the correlation coefficients between mean value and gca of the parents (Table 2). It appears that

Table 2. Character means and estimates of gca effects of parents

Parent	Parameter	Days to first flowering	Plant height	Tillers per plant	Spike length	Spikelets per spike	Spike density	Grains per spike	Grain wt. per spike	100-grain wt.	Yield per plant
T. compactum	Mean	96.1	91.9	24.0	7.7	21.4	2.8	53.6	1.69	3.14	21.23
	gca	0.8	−7.5*	0.3	−0.8*	−0.1*	0.2*	−1.5*	−0.32*	−0.49*	−5.75*
T. sphaerococcum	Mean	103.9	109.8	21.8	5.5	20.6	3.7	37.5	1.05	2.81	12.78
	gca	1.3*	−4.1*	−0.7	−1.6*	0.4*	0.4*	−3.4*	−0.15*	0.07	−3.77*
Chinese Spring	Mean	105.9	121.8	25.8	7.7	23.1	3.0	64.7	1.31	2.01	17.30
	gca	4.2*	2.7*	1.3	−1.2*	0.65*	0.3*	−2.0*	−0.35*	−0.48*	−6.45*
Sonora 64	Mean	79.9	81.8	16.5	11.2	19.8	1.8	55.0	1.50	2.72	14.79
	gca	−0.9	−2.8	−0.4	−0.0	1.0*	0.05*	4.3*	−0.16*	−0.58*	−3.37*
Kalyan Sona	Mean	97.7	82.0	20.4	12.9	21.3	1.6	69.1	1.73	2.49	21.48
	gca	−1.9*	12.8	−3.5*	0.7*	−0.5*	−0.2*	4.3*	−0.06	−0.30*	−3.65*
NP 846	Mean	98.6	121.6	31.0	12.5	20.9	1.7	46.9	2.00	4.27	39.66
	gca	−1.3*	2.2*	1.7	1.4*	−0.1	−0.286*	−0.4*	0.26*	0.48*	6.85*
NP 890	Mean	92.3	116.8	20.5	11.5	20.3	1.8	56.9	2.10	3.68	23.86
	gca	−2.44*	6.0*	2.8*	1.2*	−0.2	−0.3*	−0.6	0.39*	0.73*	10.51*
C 306	Mean	97.90	132.6	24.1	11.3	19.9	1.7	55.7	2.20	3.95	30.74
	gca	−0.9	7.2*	0.1	0.4*	−0.7*	−0.2*	−1.06	0.19*	0.41*	2.53
C 591	Mean	100.5	138.1	23.7	10.4	21.3	2.1	58.5	2.23	3.82	32.13
	gca	1.1*	9.2*	−1.6	−0.04	−0.4*	−0.1*	0.4	0.21*	0.31*	3.10*
CD(gi) 5%		1.1	2.0	1.8	0.19	0.246	0.03	1.4	0.07	0.08	2.68
CD(gi-gj) 5%		1.6	3.0	2.7	0.28	0.370	0.04	2.1	0.11	0.13	4.02
Mean-gca correlation		0.58	0.84**	0.36	0.92	0.13	0.92**	0.54	0.80*	0.83**	0.68*

*, **Significant at 5% and 1% levels, respectively.

parents for breeding to improve the above characters may be selected largely on the basis of their per se performance, and also suggests the presence of considerable additive effects. On the other hand, per se performance of the parents for characters like days to first flowering, tillers/plant, spikelets and grains/spike did not correspond to that for gca effects. The correlation coefficients between mean value and gca effects for these characters were also not significant. For improvement of such characters, therefore, the choice should be based on their gca effects.

The best general combiner for tiller number was NP 890. NP 846 and NP 890 were good general combiners for spike length. Sonora 64 mainly influenced number of spikelets/spike. For grains/spike, Kalyan Sona was the best general combiner. NP 890 and NP 846, in that order, were the best general combiners for both grain weight/spike and 100-grain weight. C 591 and C 306 also had superior gca effects for these two characters. NP 890, NP 846 and C 591 were good combiners for yield. These parents were also the best combiners for two or more yield components, thereby suggesting that combining ability for yield was associated with combining ability for its components. Kalyan Sona and Sonora 64, which were good combiners for grains/spike, failed to show significant positive general combining ability for yield.

Considering the overall picture of gca effects it appears that the semidwarf parents, Kalyan Sona and Sonora 64 of *T.aestivum*, are similar to *T. compactum* and *T. sphaerococcum* in that they displayed favourable gca effect for height, and unfavourable gca effect for yield and important yield components. But they differ with regard to number of spikelets/spike and spike density. *T. sphaerococcum* and Sonora 64 were good combiners for number of spikelets/spike. *T. compactum* was a medium and Kalyan Sona a poor combiner for this character. For spike density, *T. sphaerococcum, T. compactum* and Sonora 64 were good combiners, whereas Kalyan Sona was reckoned as a poor combiner. The parents showing favourable gca effects for individual characters can be utilized for improving the character of some otherwise good varieties. The gca effects in this study indicated the importance of height along with yield components as selection criteria. From the segregating materials, plants of intermediate height should be selected so that their extreme dwarfness does not have unfavourable effects on yield, and extreme tallness does not make them prone to lodging. The stiff straw genes from the unexploited semidwarfs like *T. compactum* and *T. sphaerococcum* can likewise be introduced in the tail Indian varieties, viz., NP 846, NP 890, C 306 and C 591 of *T. aestivum,* which have good combining ability for yield and its components. Successful utilization of these species will not only enable the full exploitation of the high yield potential of the tall varieties of breadwheat but also broaden the base of the present breeding material.

Table 3. Ranking of desirable crosses on sca effects for different characters

Days to first flowering	Plant height	Tillers per plant	Spike length	Spikelets per spike	Spike density	Grains per spike	Grain wt. per spike	100-grain weight	Yield per plant
$P_1\times P_4^*$	$P_3\times P_4^*$	$P_5\times P_6^*$	$P_1\times P_5^*$	$P_4\times P_7^*$	$P_1\times P_2^*$	$P_4\times P_5^*$	$P_4\times P_5^*$	$P_5\times P_6^*$	$P_5\times P_6^*$
$P_2\times P_4^*$	$P_1\times P_4^*$	$P_4\times P_7^*$	$P_1\times P_4^*$	$P_2\times P_3^*$	$P_4\times P_9^*$	$P_2\times P_3^*$	$P_5\times P_6^*$	$P_2\times P_6^*$	$P_1\times P_6^*$
$P_3\times P_4^*$	$P_1\times P_5^*$	$P_3\times P_7^*$	$P_1\times P_8^*$	$P_4\times P_8^*$	$P_1\times P_3^*$	$P_1\times P_3^*$	$P_2\times P_5^*$	$P_3\times P_6^*$	
$P_8\times P_9^*$	$P_6\times P_7^*$	$P_1\times P_6^*$	$P_4\times P_6^*$	$P_4\times P_5^*$	$P_4\times P_8^*$	$P_6\times P_8^*$	$P_4\times P_7^*$	$P_1\times P_6^*$	
$P_5\times P_7^*$	$P_4\times P_6^*$		$P_3\times P_4^*$	$P_1\times P_3^*$	$P_4\times P_5^*$	$P_1\times P_5^*$	$P_2\times P_6^*$	$P_5\times P_7^*$	
$P_5\times P_8^*$	$P_2\times P_4^*$		$P_7\times P_9^*$	$P_6\times P_8^*$	$P_2\times P_3^*$	$P_2\times P_5^*$	$P_1\times P_9^*$	$P_8\times P_9^*$	
	$P_2\times P_7^*$		$P_8\times P_9^*$	$P_4\times P_9^*$	$P_4\times P_7^*$	$P_6\times P_7^*$		$P_7\times P_9^*$	
	$P_6\times P_8^*$				$P_6\times P_8^*$	$P_4\times P_7^*$		$P_2\times P_9^*$	
	$P_6\times P_9^*$				$P_2\times P_6^*$	$P_6\times P_9^*$		$P_1\times P_8^*$	
	$P_5\times P_9^*$				$P_6\times P_7^*$				
	$P_8\times P_9^*$				$P_5\times P_7^*$				
	$P_2\times P_8^*$								

P_1—*T. compactum*, P_2—*T. sphaerococcum*, P_3—Chinese Spring, P_4—Sonora 64, P_5—Kalyan Sona, P_6—NP 846, P_7—NP 890, P_8—C 306, and P_9—C 591.

@ Negative sca effects were considered for days to first flowering and plant height, and positive sca effects for the remaining characters.

*Significant at 5% level.

The crosses showing significant and desirable sca effects for the different characters are listed in descending order of magnitude in Table 3. The cross combinations with high sca effects for yield/plant were Kalyan Sona × NP 846 and *T. compactum* NP 846. The gca status of parents in both crosses was low × high. A high–low method of crop improvement [6, 7] may be followed by crossing low and high combiners in order to have desirable transgressive segregants. The cross Kalyan Sona × NP 846 also had significant sca effect for tillers/plant, grain weight/spike, and 100-grain weight, suggesting their importance in determining high sca effect for yield. Similarly, high sca effect for yield was in cross *T. compactum* × NP 846 associated with spike length and 100-grain weight.

For earliness, 7 hybrids showed high sca effects. Hybrids involving Sonora 64, a medium combiner for earliness with and *T. sphaerococcum*, showed higher desirable sca effects, and the first two crosses were Chinese Spring×Sonora 64 and *T. compactum*×Sonora 64. These crosses may help in bringing about improvement in these characters.

64. These crosses may help in bringing about improvement in these characters.

In case of two important yield components, namely, grain weight/spike and 100-grain weight, some of the crosses with high sca effects were combinations of high × low general combiners. In addition to high–low breeding method, another way of exploiting such crosses would be diallel selective mating [8, 9]. This procedure will increase genetic recombination and also assist in breaking unfavourable repulsion phase linkage blocks. In the present material, the crosses showing desirable sca effects for various characters with low × low general combiners are difficult to exploit as low × low combinations reflect nonadditive gene action. The most interesting crosses were those in which both parents displayed high desirable sca as well as sca effects. The major part of such variance would be fixable in later generations. Such crosses were Kalyan Sona × NP 890 for earliness, × *T. compactum* × Sonora 64 × for dwarfness, *T. sphaerococcum* × Chinese Spring for number of spikelets, *T. compactum*×*T. sphaerococcum* for spike density, and Sonora 64 × Kalyan Sona for grains/spike. Recombination breeding through multiple crosses involving these hybrids would be useful to breed genotypes exhibiting improvement in these characters. Involving genetically diverse parents like *T. aestivum* in crosses with *T. compactum* or *T. sphaerococcum*, or *T. compactum* with *T. sphaerococcum* would be beneficial as it would provide an opportunity to bring together gene constellations of different origin.

ACKNOWLEDGEMENTS

The first author is thankful to Rajendra Agricultural University, Bihar, for providing financial assistance as I.D.A. fellowship during the course of this investigation.

REFERENCES

1. B. Griffing. 1956. Concept of general and specific combining ability in relation to diallel crossing system. Aus. J. Biol. Sci., 9: 463–493.

2. P. L. N. Somayajulu, A. B. Joshi and B. R. Murty. 1970. Combining ability in wheat. Indian J. Genet., **30:** 134–141.

3. K. S. Gill, S. S. Dillon and K. S. Bains 1972. Combining ability and inheritance of yield components in crosses involving Indian and exotic wheat germplasm Indian J. Genet., **32:** 421–430.

4. G. S. Nanda, K. S. Gill and S. K. Sharma. 1974. Combining ability in wheat. Genet. Agrar., **28:** 307–316.

5. S. C. Mani and M. V. Rao. 1977. Combining ability and heterosis in wheat (*T. aestivum* L.). Genetics and Wheat Improvement (ed. A. K. Gupta). Oxford and IBH Publishing Co., New Delhi: 23–30.

6. D. G. Lamgham. 1961. The high–low method of improvement. Crop Sci., **1:** 376–373.

7. G. S. Smith. 1966. Transgressive segregation of spring wheat. Crop Sci., **6:** 310–312.

8. N. F. Jensen. 1970. A diallel selective mating system for cereal breeding. Crop Sci., **10:** 629–635.

9. R. J. Redden and N. F. Jensen. 1974. Mass selection and mating systems in cereals. Crop Sci., **14:** 345–350.