Combining Ability for Physiological Traits in Wheat (*Triticum aestivum* L.)

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Combining ability analysis was conducted in 9x9 parental diallel progenies for physiological traits, namely, flag leaf area, peduncle length and grain filling period, in wheat. Peduncle length was observed to be controlled by mainly gca variance while, both gca and sca variances were important for flag leaf area and grain filling period. However, flag leaf area had higher influence of additive gene effect as compared to the non-additive gene, whereas for grain filling period both additive and non-additive genetic components of variation were equally important. The parents DL-803-3, K-8708 and HD-2160 were observed to be good general combiners for flag leaf area, K-68 and HUW-81 for peduncle length and HP-1102, WH-542, HD 2402 and K-8708 for physiological grain filling period. Mean perforamnce of the lines was observed to be related with their gca effects in most of the cases. The cross combinations which showed high sca effects were involved in majority of the crosses both poor combiners and in some cases, one being good and the other being poor combiner.

Key words: Combining Ability, Physiological Traits, Wheat

Synthesis of the physiologically efficient plant type will help to convert maximum soil and solar energy in the form of biological energy and ultimately more productivity. In dwarf and semi-dwarf wheat varieties, the internodes usually remain very short as compared to the tall varieties, while the total numbers of leaves remain more or less same. Therefore due to shorter internodes, particularly in last internode (peduncle) and more numbers of leaves in a limited culm length, the sun-light does not properly penetrate through out the plant. In this situation longer peduncle will help the plant to receive more of sun-light resulting in, increased total photosynthetic area. In addition to the longer peduncle, broader and larger flag leaf with optimum plant foliage will be extremely helpful to receive more sunlight to produce more photosynthates and to translocate them properly to the sink (Barriga, 1979; Mackey, 1982; Singh and Rai 1991).

The final yield/spike of wheat is determined by the number and the weight of the grains it contains. The weight attained by any grain depends on duration of the grain filling period, rate of supply of assimilate to the grain and the rate of incorporation of these into its structure from anthesis onwards. The yield of late sown wheat is reduced mainly due to reduced grain filling period and not due to reduced rate of supply of assimilates. To evolve a physiological efficient and high productive genotype in wheat, the knowledge of the combing ability of the physiological traits would be helpful. Information on the nature of the genetic control of these physiological traits are lacking in wheat. Keeping this in view, the present investigation was conducted to obtain information on the genetic control of flag leaf area, peduncle length and grain filling period in wheat.

Materials and Methods

Nine diverse wheat varieties belonging to different height groups (tall, single dwarf, double dwarf and triple dwarf), were taken for this study. Non reciprocal F_1 crosses in diallel fashion were attempted in 1994-95. The final experiment consisting of 36 F_1s and 9 parental lines was conducted in a randomized block design with 3 replications at the research farm of C.S. Azad University of Agriculture and Technology, Kanpur in 1995-96. Each replication was divided into 5 traits to make more homogenous and compact replication. Each plot had a single row accommodating 15 plants spaced 15cm within and 30cm between rows. Guard rows were around the whole experiment to avoid border effect. Full plant population was maintained and recommended agronomic practices were followed to raise a good crop.

Leaving the border plants, data were recorded on 10 competitive plants/plots. Flag leaf area, peduncle length, 50% physiological maturity (days) and number of days taken to heading (50%) was recorded as grain filling period (days). Plot mean of the different characters were used for statistical analysis. The combining ability analysis was performed based on method II and model I of Griffing (1956).

Results and Discussion

Mean performance: Marked differences were observed in the mean performance of the different characters in the parental lines (Table 2). The varieties namely, HUW-81, DL-803-3, HD-2160, HP-1102 and K-8708 had high flag leaf area. On the other hand, K-68 possessed low mean value for this trait. The tall variety HUW-81 had the longest peduncle length (51.89 cm) followed by single dwarf variety K-8708 (44.21cm) and tall variety K-68, which measured 43.89 cm, whereas, the variety HD-2160, a triple dwarf, recorded the shortest mean value (25.59 cm) for this attribute. As regards the grain filling period the varieties HD-2204, Hp-1102, K-8708, WH-542 and UP-115, had prolonged grain filing period while HD-2160 had a short grain filling period.

Combining ability: The estimates for the general combining ability mean squares were significant for all the characters studied, whereas these estimates, due to specific combining ability were significant only for flag leaf area and grain filling period, indicating the influence of both additive and non-additive components of variations for controlling the traits flag leaf area and grain filling period, whereas, peduncle length was mainly under the influence of additive gene action (Table 1).

In this investigation, flag leaf area was observed to be controlled by both additive and non-additive components. However, the magnitude of additive component was higher than that of the non-additive one, whereas, Dhonukshe and Rao (1979), and Ilyushechenko (1977) observed higher influence of non-additive component for flag leaf area in wheat.

Peduncle length is also reported to be predominantly under the control of additive genes (Jain and Singh 1976, Mackey 1982, Martin *et al.*, 1979. Singh and Rai 1991, Mann *et al.*, 1995 and Singh and Ravish 1997) as observed in the present investigation, Pandey *et al.*, (1983) suggested that non-additive component was more important for the control of this trait. However, Paroda and Joshi (1970), Sharma *et al.*, (1981), and Singh and Ravish (1997) observed the importance of both additive and non-additive components for peduncle length.

Table 1. Analysis of variance of combining ability for flag leaf area, peduncle length and grain filling period in wheat

Source of variation	D.F.	Mean squares		
		Flag leaf area	Peduncle length	Grain filling period
GCA	8	43.73**	184.26*	5.71**
SCA	36	18.49**	12.56	5.59**
Error	88	2.65	9.61	0.54

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

Grain filling period was under the control of additive and non-additive components of genetic variation, equally. Similar results were also obtained by Singh *et al.*, (1982), Singh *et al.*, (1985) and Virk and Aulakh (1975) in wheat.

Combining ability effects: The positive and significant gca effects were exhibited by DL-803-3, HP-1102, K-8708 and DL-2160, whereas, negative and significant effects were found in UP-115, HD-2204 and K-68 for flag leaf area. Parents, K-68 and HUW-81, both tall cultivars, were good general combiners for long peduncle, while dwarf parents, HD-2204 and HD-2160 were poor combiners (Table 2). The good general combiners for prolonged grain filling period were HP-1102, WH-542, HD2204, and K-8708, while DL-803-3, UP-115, K-68 and HD-2160 were poor combiners.

The mean performance of parents for different characters were observed to be related to their respective gca effects in a majority of the cases. Thus the selection of the lines for a breeding programme could be based on both mean performance and combining ability test. Considering the mean performance of gca effects for all the three characters together, the variety K-8708

Table 2. General combining ability effects and mean performance of nine parents for three characters in wheat

Parent	Flag leaf area		Peduncle Length		Grain filling period	
	Mean (cm)	gca effect	Mean (cm)	gca effect	Mean (cm)	gca effect
K-68	31.43	-3.52**	43.89	5.00**	40.35	-0.74**
HUW-81	50.99	0.03	51.89	6.91**	37.00	-0.17
HP-1102	49.10	1.07*	40.82	-0.37	45.27	0.81**
K-8708	48.89	1.29**	44.21	0.09	43.51	0.49
DL-803-3	50.91	2.78**	35.84	-1.40	43.37	-0.81**
WH-542	40.38	-0.46	39.27	-0.21	40.09	0.77*
UP-115	38.45	-1.85**	41.36	0.01	43.21	-0.58**
HD-2204	42.37	-1.01**	36.42	-2.70**	45.57	0.75**
HD-2160	48.28	1.70*	26.59	-7.12*	34.23	-0.51*
SE (gi)		±0.458		±0.879		±0.221

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

(single dwarf) was found to be best followed by another single dwarf variety HP-1102, whereas, UP-115 was observed to be the poorest for these traits. The varieties DL-803-3, HP-1102, K-8708 and HD-2160 have been intensively used in the breeding programme of this centre and a number of promising lines have been isolated from these varieties.

It is not necessary that parents having high estimates of gca effects would also give high estimates of sca effects (Table 3). In most of the cases it was observed that for almost all the characters, the crosses showing significant and positive as well as high sca effects combined both negative and poor general combiners. Apparently, the parents having low gca effects and a relatively high magnitude of non-additive gene effects and thus resulted in high sca effect when crossed. For instance, the crosses UP-115xK-8708 gave the maximum significant positive sca effects for flag leaf area while, both UP-115 and K-8708 had negative gca effects for this trait. Similar cases were also observed for other traits.

In few cases, the crosses showing significantly positive sca effect combined one good and poor general combiner. In most of the cases, the best F_1s were not cross combinations that showed the maximum sca effects. This may be so as it is a comparison of an absolute and a relative value. The absolute value (performance of F_1s) being similar, the relative values (sca effects) would increase with a decrease in the performance of the base (mean of two parents). The best F_1s had involved one of the high combiners as one of their parents.

The top combiners DI-803-3 and HUW-81 for flag leaf area also showed the best F_1 for this attribute. Thus, the choice of the parents, particularly for heterosis breeding, should be based on combining ability test. The crosses showing sea effects or high F_1 performance involving one good and one poor general combiner, could produce desirable transgressive segregants, if the additive genetic system present in the good combiner and the complimentary epistatic effects in F_1 acted in the same direction to maximise the desirable plant attributes.

Table 3. Top two combiners as parents, F_1S, general combiners and specific combinations for three characters in wheat

Characters	Parents	F_1s	General Combiners	Specific combinations
Flag leaf area	HP-1102	HP-1102xHUW-81	HP-1102	UP-115xWH-542
	HUW-81	UP-115xK-8708	HD-2108	UP-115xK-8708
Peduncle length	HUW-81	HuW-81xK-68	HUW-81	HD-2204xHD-2160
	K-8708	HUW-81xWH-542	K-68	HP-1102xK-68
Grain filling period	HD-2204	HP-1102xHUW-81	HP-1102	K-68xHD-2160
	HP-1102	HP-1102xHD-2204	HD-2204	UP-115xHD-2160
		HUW-81xWH-542		
		WH-542xHD-2160		

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