Indian J. Genet., **57** (3): 301–306 (1997)

GENETICS OF YIELD DETERMINING FACTORS IN SPRING WHEAT OVER ENVIRONMENTS

UMA MENON AND S. N. SHARMA*

Department of Genetics and Plant Breeding, Agricultural Research Station Durgapura, Jaipur 302018

(Received: February 8, 1996; accepted: April 9, 1996)

ABSTRACT

Genetics of yield determining factors was studied in a set of 10 x 10 half-diallel progenies (F_1 and F_2) of spring wheat over three environments. The results of components of variance analysis pooled over environments revealed that both additive (D) and nonadditive (H_1 and H_2) components of variation were involved in the expression of almost all the characters in F_1 as well as F_2 generations. However, the nonadditive components were higher than additive component except in few cases in F_1 where the additive component was preponderant. The $(H_1/D)^{1/2}$ values revealed overdominance for all the characters in both generations except for days to heading, plant height, peduncle length, spike length and spikelets per spike in F_1, where partial dominance was recorded. The values of F exhibited excess of dominant alleles for days to heading, days to maturity, spikelets per spike (F_1 and F_2) and peduncle length (F_2), and directional dominance of the decreasing genes for plant height and spike length (F_1). Biparental mating and/or diallel selective mating system could be the best breeding method for more tangible advancement in spring wheat.

Key words: Spring wheat, gene action, components of variance, dominant alleles, yield traits.

Recent reports have indicated that selection for morpho- physiological characters is a promising means of producing high yielding cultivars in wheat [1–4]. Identification of these components and their genetic control does make it possible to maximise segregation of genotypes possessing physiological complimentation required for high yield. Despite considerable genetic advance in the current plant breeding techniques, our knowledge and use of yield related morpho-physiological characters is limited. Keeping in view these facts, the present study on the genetics of some morpho-physiological characters which influence fluence grain yield in spring wheat, aims to find a suitable breeding method to attain a balance among these traits for optimum yield.

*Author for correspondence: Sector 13, House No. 998, Malviya Nagar, Jaipur, Rajasthan 302018.

MATERIALS AND METHODS

The experimental material consisted of parents, F_1 and F_2 generations of a 10 x 10 diallel set (excluding reciprocals) of spring wheat. The ten diverse parents were Moncho, Pavon, Brochis, Chiroca, HD 2204, Raj 1482, WL 711, Raj 821, Durgapura 65 and Kharchia 65. The experimental material was raised in randomized block design with three replications under three environments, which were created by planting the experimental materials at different dates of sowing: early (I week of November), normal: (III week of November), and late: (II week of December), with the usual agronomic practices for the crop. Single seeds were sown in 5 m rows at 30 x 15 spacing. The Parent varieties and F_1s were grown in single rows, and F_2s progeny of each cross in 10 rows. Ten competitive plants of the parents and F_1s and 20 plants in each F_2 progeny were randomly taken from each replication in all the three environments to record observations on grain yield and twelve morpho-physiological characters (Table 1). The pooled analysis was carried out following Singh [5]. The analysis of components of variance was done as suggested by Hayman [6].

RESULTS AND DISCUSSION

Pooled analysis of variance over the environments (Table 1) revealed highly significant differences among them. So was the case for genotype x environment interactions. The significant role of environment in the expression of yield and its component traits in wheat was also reported earlier [7–10].

Significant deviation of b from zero and nonsignificant departure of regression coefficient from unity in respect of days to heading, plant height, flag leaf area, peduncle length and spikelets per spike in F_1 as well as in F_2 indicated that the aforesaid diallel assumptions were valid for these traits in both generations. Days to maturity, tiller number, grains per spike and grain weight per spike in F_2 generation indicated their fulfillment. The remaining characters showed partial failure of the assumptions, however, the estimates for such a traits are less reliable than they would have been if all assumptions had been fulfilled. With the fulfillment of most of the assumptions of the diallel analysis, fully or partially in the present study, the conclusions drawn are to be valid and should form a guideline for improvement in the genetic material studied.

The estimates of components of genetic variance (Table 2) revealed that the additive component (D) was highly significant for all the characters in both generations, except for grain yield and grain weight per spike in F_1 and F_2 and 1000-grain weight in F_1. The two measures of dominance, i.e. H_1 (dominance effect) and H_2 (proportion of dominance due to positive and negative effect of genes), were nonsignificant for 1000-grain weight in both generations but in all other cases both were highly significant. It is therefore suggested that additive as well as nonadditive components were involved in the expression of almost all the characters studied. However, the values for nonadditive components (H_1 and H_2) were

Table 1. Pooled analysis of variance for yield and its morpho- physiological traits in spring wheat over three environments

Source	Generation	d.f.	Days to heading	Days to maturity	Plant height	Flag leaf area	Peduncle length	Tiller number	Spike length	Spikelets per spike	Grains per spike	Grains weight per spike	1000-grain weight	Harvest index	Grain yield
Environments (E)	F_1	2	918.4**	23905.2**	1423.8**	9939.0**	2740.7**	2618.9**	11.7**	11.5**	258.9**	3.2**	550.6**	5843.5**	8914.2**
F_2	F_2	2	345.4**	23899.0**	10089.3**	8368.9**	2475.7**	2210.4**	18.9**	27.2**	39.9**	2.1**	355.7**	3856.3**	6324.5**
Genotypes (G)	F_1	54	233.4**	38.2**	1135.7**	74.4**	165.9**	26.0**	8.0**	13.1**	321.8**	0.9**	199.9**	76.9**	161.7**
	F_2	54	188.8**	43.3**	885.2**	58.7**	105.2**	25.3**	8.5**	14.9**	310.4**	0.7**	80.2**	50.4**	119.1**
G x E	F_1	108	36.5**	13.9**	92.0**	39.2**	13.2**	18.3**	0.9**	2.7**	95.9**	0.8**	27.4**	37.3**	45.5**
	F_2	108	34.7**	14.4**	78.1**	32.9**	11.4**	15.2**	1.7**	2.9**	77.3**	0.3**	19.5**	29.2**	55.5**
Error	F_1	324	1.2	1.9	11.7	2.9	3.1	2.7	0.2	0.5	11.2	0.1	5.3	7.3	4.4
	F_2	324	1.6	2.0	11.2	4.3	2.9	2.8	0.2	0.5	9.5	0.1	7.2	9.6	35.6

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

Table 2. Components of variance and allied parameters in F_1 and F_2 generations for yield and

Component	Days to heading		Days to maturity		Plant height		Flag leaf area		Peduncle lengths		Tiller number	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
D	51.9^{**} ± 0.8	51.9^{**} ± 1.9	9.5^{**} ± 0.6	9.5^{**} ± 1.1	175.1^{**} ± 3.9	175.2^{**} ± 4.1	8.9^{**} ± 1.3	8.8^{**} ± 1.4	23.7^{**} ± 1.1	23.72^{**} ± 0.4	4.0^{**} ± 0.4	3.9^{**} ± 0.4
H_1	6.9^{**} ± 1.6	82.7^{**} ± 16.7	12.2^{**} ± 1.3	68.0^{**} ± 9.1	52.6^{**} ± 8.2	197.5^{**} ± 34.5	21.9^{**} ± 2.8	62.9^{**} ± 11.5	11.4^{**} ± 2.4	28.2^{**} ± 3.3	6.3^{**} ± 0.8	20.6^{**} ± 3.2
H_2	5.9^{**} ± 1.4	63.8^{**} ± 14.2	8.1^{**} ± 1.1	51.9^{**} ± 7.8	43.1^{**} ± 6.9	180.5^{**} ± 29.3	19.9^{**} ± 2.4	55.6^{**} ± 9.8	9.4^{**} ± 2.1	27.4^{**} ± 2.8	5.9^{**} ± 0.7	19.7^{**} ± 2.7
F	4.1^{*} ± 1.7	50.9^{**} ± 9.0	9.6^{**} ± 1.4	23.3^{**} ± 4.9	-56.0^{**} ± 8.9	11.7 ± 18.7	4.9 ± 3.1	8.8 ± 6.2	–5.1 ± 2.6	9.6^{**} ± 1.8	1.7 ± 0.9	2.5 ± 1.7
E	0.1 ± 0.2	0.2 ± 0.6	0.2 ± 0.2	0.2 ± 0.3	1.3 ± 1.2	1.2 ± 1.2	0.3 ± 0.4	0.5 ± 0.4	0.4 ± 0.3	0.3 ± 0.1	0.3^{*} ± 0.1	0.3 ± 0.1
$(H_1/D^{1/2}$	0.4	1.3	1.1	2.7	0.6	1.1	1.6	2.7	0.7	1.1	1.3	2.3
(b-0/sb)	9.0^{**}	4.7^{**}	4.2^{**}	2.3^{*}	21.4^{**}	8.5^{**}	3.0^{**}	2.5^{*}	7.6^{**}	14.4^{**}	2.6	3.3^{*}
(1-b/sb)	0.1	0.5	2.5^{*}	0.5	–1.4	–0.2	0.0	2.1	0.8	–0.1	1.4	2.0

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

relatively higher for most of the traits in both generations, expect for days to heading, plant height, peduncle length, spike length and spikelets per spike in F_1 generation, in which case the additive gene effects were preponderant. These results further showed that nonadditive gene effects were responsible for determining grain yield. This is in accordance with the earlier reports in wheat [11–13]. However, the importance of both additive and nonadditive gene effects has also been emphasized for yield and yield components [14, 15].

The estimates of F value, which indicated the relative proportion of the dominant and recessive alleles in parents, were positive and highly significant for days to heading, days to maturity and spikelets per spike in both generations, and for peduncle length in F_2, indicating excess of dominant alleles. However, the F value was significant and negative for plant height and spike length in F_1, which indicates the directional dominance of the decreasing genes. Positive but nonsignificant F value for most of the remaining traits indicates of the excess of dominant alleles in the parent varieties. The environmental component (E) was significant for tiller number (F_1 and F_2), spikelets per spike (F_1), harvest index, and grain yield (F_2).

The proportion $(H_1/D)^{1/2}$ representing the degree of dominance was more than unity for days to maturity, flag leaf area, tiller number, grains per spike, grain weight per spike, 1000-grain weight, harvest index and grain yield in both generations, and for days to

other morpho-physiological characters in spring wheat over environments

Spike length		Spikelets per spike		Grains per spike		Grains weight per spike		1000-grain weight		Harvest index		Grain yield	
F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
1.3**	1.4**	3.4**	3.4**	46.2**	46.4**	0.1	0.1**	15.6	15.4**	5.6*	5.4**	5.0	1.5
±0.0	±0.1	±0.1	±0.2	±4.2	±2.8	±0.0	±0.0	±10.6	±1.6	±2.2	±1.6	±3.6	±4.1
0.4**	4.0**	0.9**	5.7**	55.3**	148.7**	0.3**	0.8**	42.0**	49.2**	27.3**	67.5**	61.6**	12.9**
±0.1	±0.9	±0.2	±1.5	±9.0	±2.8	±0.1	±0.1	±22.5	±13.6	±4.7	±13.2	±7.7	±34.8
0.3**	3.5**	0.6**	4.7**	49.5**	90.6**	0.3**	0.6**	36.9	46.0**	21.3**	49.4**	57.8**	137.6**
±0.1	±0.8	±0.2	±1.3	±7.7	±20.2	±0.1	±0.1	±19.8	±11.6	±4.0	±11.2	±6.5	±29.6
–0.2**	–0.1	1.2**	2.1*	6.5	4.2	0.0	0.0	–9.0	10.1	7.9	10.5	6.0	13.0
0.1	±0.5	±0.2	±0.8	±9.8	±12.9	±0.1	±0.1	±24.2	±7.4	±5.1	±7.2	±8.3	±18.8
0.0	0.0	0.1*	0.9	1.2	1.1	0.0	0.0	0.6	0.8	0.8	1.1*	0.5	3.9**
±0.0	±0.0	±0.0	±0.1	±1.3	±0.9	±0.0	±0.0	±3.2	±0.5	±0.7	±0.5	±1.1	±1.2
0.6	1.8	0.5	1.3	1.1	1.8	2.2	3.7	1.6	1.8	2.2	3.6	3.5	9.2
14.4**	4.7**	8.5**	2.9*	3.4**	3.1*	0.3	2.9*	8.3**	1.7	2.4*	1.9	2.2	2.4*
5.6**	2.4*	–0.9	0.9	2.9*	1.7	0.8	1.6	25.0**	2.2	3.8**	3.2*	4.5**	7.6**

heading, plant height, peduncle length, spike length and spikelets per spike in F_2, indicating the existence of overdominance for these characters. Partial dominance was recorded for the remaining traits in F_1 generation as the degree of dominance was lower than unity. The inconsistency observed for degree of dominance in F_1 and F_2 generations may be attributed to sampling error.

The study demonstrates that both additive (fixable) and nonadditive (nonfixable) components of genetic variances were involved in governing the inheritance of almost all the quantitative traits although nonadditive genetic variance was predominant. Therefore, biparental mating and/or diallel selective mating which may allow intermating of the selects in the different cycles and exploit both additive and nonadditive gene effect should be useful in the genetic improvement of the characters of spring wheat.

REFERENCES

1. P. D. Walton. 1969. The inheritance of morphological character associated with yield in spring wheat. Can. J. Pl. Sci., **47**: 359–365.
2. P. Hsu and P. D. Walton. 1970. The inheritance of morphological and agronomic characters in spring wheat. Euphytica, **19**: 54–60.

3. P. G. Thombre, K. S. Gill and G. S. Nanda. 1979. Genetic analysis of morpho-physiological characters in wheat. I. The harvest index. Crop. Improv., **6**: 120–125.

4. G. S. Dhindsa. 1982. Genetics of Physiological and Morphological Yield Determining Factors in Wheat. Ph.D. Thesis. Punjab Agricultural University, Ludhiana.

5. D. Singh. 1973. Diallel analysis for combining ability over several environments. II. Indian J. Genet., **33**: 469–481.

6. B. I. Hayman. 1954. The theory and analysis of diallel crosses. Genetics, **39**: 105–114.

7. S. K. Sharma and R. K. Singh. 1982. Diallel analysis for combining ability over environments in wheat. HAU J. Res., **12**: 675–678.

8. G. S. Nanda, P. S. Virk and K. S. Gill. 1983. Diallel analysis over environments in wheat yield and its components. Indian J. Genet., **36**(2): 184–196.

9. S. K. Sharma, I. Singh and K. P. Singh. 1986. Heterosis and combining ability in wheat. Crop Improv., **13**: 60–65.

10. T. Dasgupta and A. B. Mondal. 1988. Diallel analysis in wheat. Indian J. Genet., **48**(2): 167–170.

11. S. K. Sharma and R. K. Singh. 1983. Combining ability for harvest index and its components in wheat. Indian J. Genet., **43**(2): 229–231.

12. R. A. Sharma. 1992. Genetic Analysis of Grain Yield and Its Components in Wheat under Salinity and Normal Conditions. Ph.D. Thesis. Rajasthan Agricultural University, Bikaner.

13. Y. S. Solanki, A. S. Redhu, I. Singh, R. B. Srivastava and R. A. S. Lamba. 1993. Combining ability analysis in diallel crosses in wheat. Abstr. Natl. Symp. Plant Breeding Strategies for India 2000 A.D. and Beyond. Marathwada Agricultural University, Parbhani. Aurangabad, December 25–27, 1993: 57–58.

14. D. S. Jatasara and R. S. Paroda. 1980. Genetics of yield and yield components in bread wheat. Indian J. agric. Sci., **40**: 379–382.

15. I. Singh, A. S. Redhu, S. C. Sharma, Y. S. Solanki and R. P. Singh. 1993. Genetics of yield and yield component characters in spring wheat. Abstr. Natl. Symp. Plant Breeding Strategies for India 2000 A.D. and Beyond. Marathwada Agricultural University, Parbhani. Aurangabad, December 25–27, 1993: 64–65.