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Heritability and Genetic Advance of Grain Yield and its Related Traits in Wheat

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Abstract: Studies were conducted to evaluate six genotypes of wheat and their seven segregating populations (F_2) for heritability and genetic advance of yield and its related traits. A considerable amount of variability among genotypes for the traits studied indicated the usefulness of selection for these traits in the genetic material used for future improvement in wheat. Broad-sense heritability for plant height, spikelets per spike, spike density, 1000-grain weight and grain yield per plant ranged from 75.17 to 93.61%, 46.24 to 85.09%, 55.51 to 84.65%, 85.70 to 96.37% and 58.30 to 88.24%, respectively. The respective values of genetic advance for these traits ranged from 6.78 to 18.36, 1.39 to 4.67, 0.18 to 0.52, 3.84 to 8.85 and 1.77 to 4.50. Prevalence of fairly high estimates of heritability and genetic advance for grain yield in crosses like 3 WLRG/1-8 × WL-43 and Local White × 3 WLRG/1-12, suggested the potential use of these combinations in future breeding strategies.

Key words: Wheat genotypes, variance, heritability, genetic advance, grain yield, Pakistan

INTRODUCTION

Asia produces more than the half of the total world production of wheat. The major sharer of which are South Asia (96.7 mt) and China (89 mt), (Anonymous, 2003). It is because it suits well in the cropping pattern of Asia. The reduction in production of wheat at global level (Anonymous, 2003) stresses the need to develop genotypes with consistent performance over a wider range of environments. Various polygenic attributes have been proposed which can be introduced to withstand the situation. Combination of traits in a plant, which minimize the deleterious effects and maximize the advantageous effects results in the real success of a plant. Hybridization is one of the main tools to produce genetic variability. Genetic variability is the basis of selection and further improvement in any crop species. Broader the range of heritable variation more effective will be the selection and vice versa. The practical knowledge of mechanisms of inheritance of the genetic traits involved, occupies key post in the process of progress towards desired end. The extent of heritability determines transmissibility of polygenic traits like plant height, 1000-grain weight, grain yield per plant, etc.

Study of statistical parameters like mean, variance, heritability, genetic advance, etc., is not only helpful to evaluate the genetic stability and performance of any particular genotype but it is also a measure to determine the effectiveness of selection for a particular trait in that genotype. Wider range of variability makes it convenient to select a particular trait with ease and efficacy. High heritability and genetic advance further indicate the effectiveness of selection in early segregating generations. A low heritability on the contrary indicates that the selection must be delayed till later generations.

Earlier studies pertaining to heritability and genetic advance in wheat have indicated variable results. High estimates of heritability for plant height were recorded by Korkut *et al.* (2001) and Jedynski (2001) while Gupta and Verma (2000) found medium to low and Chowdhry *et al.* (1997) found moderate to high heritability estimates for plant height in wheat. Prodanovic (1993) and Dechev (1995) observed high heritability estimates for spikelets per spike while Saleem *et al.* (2003) recorded heritability ranging from 58.38 to 79.09 and genetic advance ranging from 1.81 to 2.82 for spikelets per spike. Iqbal (1996) observed a range of 47.77 to 78.77% heritability and genetic advance ranging from 0.16 to 0.37 for spike density. Similarly, Shafiq (1996) also observed moderate to high heritability for spike density. Deswai *et al.* (1996) recorded high heritability and genetic advance for 1000-grain weight. Chowdhry *et al.* (1997) and Mehta *et al.* (1997) also observed moderate to high estimates of heritability for 1000-grain weight. Saleem *et al.* (2003) observed 63.31 to 90.86% heritability and genetic advance ranging from 7.90 to 21.51 for 1000-grain weight. High heritability and genetic advance estimates for grain yield were recorded by Chowdhry *et al.* (1997) and Ozkan *et al*, (1997). Saleem *et al.* (2003) also observed more than 90% heritability and genetic advance up to 11.61 for grain yield per plant.

In this study, six genotypes of wheat and their seven segregating populations (F_2) were evaluated for heritability and genetic advance for grain yield and some of its related components with the objective to select the most desirable genotypes and genotype combinations for the improvement of wheat.

MATERIALS AND METHODS

Six varieties/lines of wheat (*Triticum aestivum* L.) viz., Chenab-70, WL-73, 3 WLRG/1-8, 12 WLRG/1-2, Local White and WL-43 and seven F_2 populations were evaluated for variability, heritability and genetic advance of yield and related traits during the crop season 2002-03. Seed of F_2 crosses along with their parents were space planted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan. Seeds were sown in lines of 30 cm apart in holes made with the help of a dibble keeping plant to plant distance of 15 cm. Two seeds were sown per site, which were latter thinned to one healthy seedling per site. Two hundred competitive plants from each F_2 population and 50 plants from each of the parental lines were selected randomly. Data from the selected plants were recorded for plant height, spikelets per spike, spike density, 1000-grain weight and grain yield per plant. The data were subjected to statistical analysis to calculate mean, variance, heritability and genetic advance at 10% selection intensity. Heritability in broad sense was computed following Mahmud and Kramer (1951).

RESULTS AND DISCUSSION

Plant height: The estimates of mean, variance, heritability and genetic advance for plant height are shown in Table 1. It was observed that plant height ranged from 85.47 to 127.44 cm in all genotypes. In case of parental genotypes, maximum plant height (124.41 cm) was recorded in WL-43 while 12 WLRG/1-12 had the lowest (85.47 cm) plant height. Similarly, maximum plant height (127.44 cm) in case of crosses was recorded in Local White × WL-43 cross with a standard deviation of 10.32 and the lowest (95.22 cm) plant height was observed in the cross 3 WLRG/1-8 × 12 WLRG/1-12. It was also revealed that variance estimates of the crosses were higher than their respective parental genotypes. This resulted in fairly high estimates of heritability in all the seven crosses, which were more than 75 % in all of them. The crosses showing high heritability also indicated higher values of genetic advance. Maximum values of heritability (93.61%) and genetic advance (18.36) were observed in the cross Local White × 3 WLRG/1-8 followed by Local White × WL-43 (92.31% and 16.72) and Local White × 12 WLRG/1-12 (91.03% and 15.72), respectively, while minimum heritability (75.17%) and genetic advance (6.78) was recorded in the cross Chenab-70 × WL-23. High heritability for plant height in all crosses indicated that selection for this trait would be more effective and successful in early segregating generations without going for further progeny testing.

These results are in close conformity with the findings of Chowdhry *et al.* (1997) and Korkut *et al.* (2001)

Spikelets per spike: Spikelets per spike is an important trait affecting number of grains per spike and grain yield per plant. Table 1 depicts the estimates of various statistics computed for this trait in the experimental material.

A comparison of mean values indicated that number of spikelets per spike was minimum (20.00) in 3 WLRG/1-8 while it was maximum (25.35) in Local White. It was also noted that all the crosses indicated a lower number of spikelets per spike than their respective mid parent values except the cross 3 WLRG/1-8 × WL-43 which showed an increase in spikelets per pike as compared to both of its parents. The same cross also depicted the maximum values of other parameters studied including variance, heritability and genetic advance. Heritability of the cross 3 WLRG/1-8 × WL-43 was 85.09% with a genetic advance of 4.67 followed by the cross 12 WLRG/1-12 × WL-43 (81.64% and 4.08) and Local White × 12 WLRG/1-12 (73.58% and 3.18, respectively). Heritability estimates were moderate in crosses Local White × WL-43 (66.10%) and 3 WLRG/1-8 × 12 WLRG/1-12 (63.78%) while heritability was only 46.24% in the cross Chenab-70 × WL-23. High heritability and genetic advance of crosses 3 WLRG/1-8 × WL-43, 12 WLRG/1-12 × WL-43 and Local White × 12 WLRG/1-12 indicated that spikelets per spike can be exploited easily through selection during early generations while moderate heritability estimates of crosses 3 WLRG/1-8 × 12 WLRG/1-12 and Local White × WL-43 require careful selection at early stages rather selection should be delayed till subsequent generations in these crosses.

These findings are in agreement with the findings of Prodanovic (1993) and Dechev (1995).

Spike density: Spike density is the parameter of importance in relation to grain yield. It determines the denseness of wheat spike in terms of spikelets per unit length of spike. A greater number of spikelets per unit length of spike will ensure greater number of grains. However, development of grains in dense spike should also be kept in mind that may be altered.

The statistical analysis of the data for spike density (Table 1) indicated that it ranged from 1.49 spikelets/cm in WL-23 to 1.97 spikelets/cm in the cross 3 WLRG/1-8 × WL-43. It was also noted that all crosses showed sufficient increase over their mid parental values and almost all crosses except Local White × 12 WLRG/1-12, exceeded their respective better parents. Values of

Table 1: Estimates of mean ($\bar{x}$), variance (σ^2), heritability (h^2) and genetic advance (G.A) of F_2 populations for studied traits in wheat

	Plant height (cm)				Spikelets per spike				Spike density (Spikelets/cm)			
Parents/Cross	$\bar{x}$	σ^2	h^2	G.A	$\bar{x}$	σ^2	h^2	G.A	$\bar{x}$	σ^2	h^2	G.A
Chenab 70	100.61	6.19	-	-	21.60	1.62	-	-	1.57	0.01	-	-
WL-23	98.55	6.94	-	-	20.40	1.52	-	-	1.49	0.02	-	-
3WLRG/1-8	96.01	8.91	-	-	20.00	1.16	-	-	1.55	0.02	-	-
12 WLRG/1-12	85.47	10.55	-	-	21.55	1.21	-	-	1.67	0.03	-	-
Local White	103.64	7.15	-	-	25.35	2.13	-	-	1.60	0.01	-	-
WL-43	124.41	9.39	-	-	20.45	1.84	-	-	1.78	0.05	-	-
Chenab 70 × WL-23	99.75	26.39	75.17	6.78	21.41	2.92	46.24	1.39	1.58	0.03	55.51	0.18
3WLRG/1-8× 12WLRG/1-12	95.22	62.45	84.48	11.72	20.04	3.26	63.78	2.02	1.57	0.06	57.56	0.24
3WLRG/1-8 × WL-43	117.87	63.59	85.62	11.98	21.89	9.79	85.09	4.67	1.97	0.14	79.39	0.52
12WLRG/1-12 × WL-43	119.81	57.63	82.74	11.02	20.26	8.12	81.64	4.08	1.79	0.15	75.29	0.52
Local White × 3WLRG/1-8	120.33	124.95	93.61	18.36	20.25	5.17	69.61	2.78	1.61	0.07	83.20	0.38
Local White × 12WLRG/1-12	121.95	96.77	91.03	15.72	21.20	6.08	73.58	3.18	1.64	0.07	78.28	0.36
Local White × WL-43	127.44	106.53	92.31	16.72	21.43	5.84	66.10	2.80	1.87	0.12	84.65	0.51

Table 1: Continue

	1000-grain weight (g)				Grain yield per plant (g)			
Parents/Cross	$\bar{x}$	σ^2	h^2	G.A	$\bar{x}$	σ^2	h^2	G.A
Chenab 70	24.42	0.68	-	-	21.26	0.57	-	-
WL-23	32.83	1.02	-	-	22.68	1.33	-	-
3WLRG/1-8	25.83	1.47	-	-	20.15	0.96	-	-
12 WLRG/1-12	33.33	0.67	-	-	20.93	1.60	-	-
Local White	27.81	1.29	-	-	21.43	1.02	-	-
WL-43	32.47	0.64	-	-	23.25	0.68	-	-
Chenab 70 × WL-23	28.21	7.84	89.39	4.39	22.94	3.00	70.93	2.16
3WLRG/1-8× 12WLRG/1-12	34.71	27.37	96.37	8.85	21.31	2.98	58.30	1.77
3WLRG/1-8 × WL-43	32.12	9.32	89.57	4.80	23.69	6.86	88.24	4.06
12WLRG/1-12 × WL-43	30.47	10.24	93.58	5.26	24.25	6.37	83.67	3.71
Local White × 3WLRG/1-8	32.74	12.00	88.53	5.38	23.15	3.11	68.16	2.11
Local White × 12WLRG/1-12	30.03	6.51	85.70	3.84	24.84	8.95	85.74	4.50
Local White × WL-43	31.23	7.45	87.79	4.20	24.07	5.04	83.51	3.29

variances were greater in the F_2 populations. Maximum heritability (84.65%) was recorded in the cross Local White × WL-43 followed by the crosses Local White × 3 WLRG/1-8 (83.20%), 3 WLRG/1-8 × WL-43 (79.39%), Local White × 12 WLRG/1-12 (78.28%) and 12 WLRG/1-12 × WL-43 (75.29%). Heritability estimates were moderate in 3 WLRG/1-8 × 12 WLRG/1-12 (57.56%) and Chenab-70 × WL-23 (55.51%). Range of genetic advance was maximum (0.51) in Local White × WL-43 to minimum (0.18) in Chenab-70 × WL-23. The crosses showing high heritability coupled with high genetic advance may be exploited for selection of spike density during early segregating generations.

These results are in conformity with the findings of Iqbal (1996) and Shafiq (1996).

1000-Grain weight: Thousand-grain is another useful yield related trait that affix to grain yield. Estimates of means, variance, heritability and genetic advance are presented in Table 1.

A study of Table 1 indicates that 1000-grain ranged from 24.42 g in Chenab-70 to 35.83 g in 3 WLRG/1-8. Among F_2 populations, highest 1000-grain weight (34.71 g) was observed in the cross 3 WLRG/1-8 × 12 WLRG/1-12 followed by Local White × 3 WLRG/1-8 (32.74 g), 3 WLRG/1-8 × WL-43 (32.12 g), Local White × WL-43 (31.23 g), 12 WLRG/1-12 × WL-43 (30.47 g) and Local White × 12 WLRG/1-12 (30.03 g). The cross Chenab-70 × WL-23 had the lowest (28.21 g) 1000-grain weight. The variance was much higher in the F_2 populations as compared to parental genotypes that resulted in fairly high estimates of heritability and genetic advance in all of them. Heritability was more than 85 % in all the crosses. Maximum value being 96.37 % in 3 WLRG/1-8 × 12 WLRG/1-12 cross with a maximum value (8.85) of genetic advance.

High estimates of heritability and genetic advance in all the crosses indicated that selection for 1000-grain weight in these populations would prove effective and efficient during earlier generations and the populations can be screened out for more productive strains.

Our results are in agreement with those of Dechev (1995), Chowdhry *et al.* (1997) and Mehta *et al.* (1997).

Grain yield per plant: Grain yield is the prime objective of plant breeders. High estimates of variability, heritability and genetic advance for this trait would be helpful for the breeders to select for the best combinations and to reach at the desirable level of yield potential.

Grain yield per plant among parents ranged from 20.15 g in 3 WLRG/1-8 to 23.25 g in WL-43. In case of F_2 populations it was minimum (21.31 g) in 3 WLRG/1-8 × 12 WLRG/1-12 and maximum (24.84 g) in Local White × 12 WLRG/1-12. Heritability ranged from 58.30% in 3 WLRG/1-8 × 12 WLRG/1-12 to 88.24% in 3 WLRG/1-8 × WL-43. The crosses showing high heritability also showed higher values of genetic advance which were minimum (1.77) in 3 WLRG/1-8 × 12 WLRG/1-12 and maximum (4.50) in Local White × 12 WLRG/1-12. Although selection for grain yield is difficult owing to its polygenic nature but crosses like 3 WLRG/1-8 × WL-43, Local White × 12 WLRG/1-12, 12 WLRG/1-12 × WL-43, Local White × WL-43 and Chenab-70 × WL-23 having fairly high estimates of heritability and genetic advance showed the potential of effective selection for grain yield at early stages.

These results are in close conformity with the results of Chowdhry *et al.* (1997), Ozkan *et al.* (1997) and Saleem *et al.* (2003).

The overall results of the study indicated that due to prevalence of fairly high estimates of heritability and genetic advance for grain yield, 1000-grain weight, spikelets per spike, etc., in crosses like 3 WLRG/1-8 × WL-43 and Local White × 3 WLRG/1-8, selection for these traits could be practiced more effectively at early stages and does not need to go for further progeny testing. These crosses can also be incorporated in future breeding strategies for the improvement of wheat. However, selection for polygenic traits like grain yield must be practiced with due care.

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