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GENETIC ANALYSIS OF THE ROLE OF INTERMATING IN AN INTERVARIETAL CROSS OF BREADWHEAT

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ABSTRACT

The effectiveness of population improvement methods was compared with those of the conventional approaches in a winter x spring cross of breadwheat. The biparental progenies developed through the North Carolina design I (NC I) and III (NC III), and their F_3 and parents were evaluated. Highly significant differences among generations were observed for days to heading, plant height, grains/spike, grain yield, harvest index, and grain weight. The mean performance of all BIPs exceeded that of their corresponding F_3 progenies in both designs. In NC I, significant additive genetic variance was observed for heading days, plant height and grains/spike. However, for days to heading, plant height and grains yield, the dominance variance was significant. In NC III the additive and dominance components were significant for all the characters except grains/spike. Many unfavourable correlations observed in F_3 changed to favourable in BIPs. The NC III was better than NC I for estimation of gene effects and exploitation of variability.

Key words: Breadwheat, genetic analysis, North Carolina designs.

Notwithstanding the significant success achieved in wheat breeding following the pedigree method, this procedure has the weakness of causing rapid homozygosity, low genetic variability, and poor recombination rate [1–3]. Further, negative correlations among yield components and high genotype x environment interaction prevent full exploitation of genetic variability for characters like yield. Intercrossing and recurrent selection to pool the desirable genes from the selected plants in the early segregating generations in selfpollinated crops has been suggested by [4–6]. Only a few studies have so far reported the usefulness of various intermating procedures for wheat improvement [7–11].

The present study, based on a cross between a variety of winter wheat (Atlas 66) with a high yielding dwarf spring wheat (WL 1562) aims to compare the effectiveness of intermating vis-a-vis pedigree method of breeding and study the changes in character association pattern following intermating.

MATERIALS AND METHODS

The material comprised a cross of winter x spring wheat, Atlas 66 x WL 1562. In F_2 generation of this cross, North Carolina designs I (NC I) and III (NC III) were attempted. In NC I, 11 randomly chosen plants were used as male and each crossed to four random females resulting into 44 biparental progenies (BIP). No female plant was used in more than one cross. The 55 F_2 plants were also selfed to obtain 55 F_3 families. In NC III, 43 F_2 selected plants were individually crossed to the parent lines (Atlas 66 and WL 1562). The F_2 plants were used as females and parents as males. This resulted into 86 crosses and 43 F_3 families.

The BIPs, F_3 families and parental lines were evaluated in randomized block design with two replications and 1 m long single-row plots. The row-to-row and plant-to-plant distances were 30 and 10 cm, respectively. Observations were recorded on five randomly selected competitive plants per plot for seven characters (Table 1). The plot means were used for statistical analyses. The estimates of variances were obtained using the method of [12, 13]. Simple correlation coefficients were calculated for biparental as well as selfed progenies.

RESULTS AND DISCUSSIONS

The two parent varieties used in the present investigation differed significantly in all the characters except tiller number (Table 1). In case of NC I progenies, the mean performance for tiller number, grains per spike, grain yield, harvest index and grain weight was higher than that of the F_3, but lower for days to heading and plant height. However, the difference was significant only for harvest index. For NC III progenies, the mean tiller number, grains/spike, grain yield, and grain weight was significantly better than F_3 mean. Days to heading and plant height were significantly lower in NC III than in F_3. In this design, tiller number, grains/spike, grain yield, and harvest index were even better than the superior parent. High mean yield was also accompanied by early heading and dwarf plant height, thus indicating the chances of finding early and dwarf transgressive segregants coupled with high yielding ability. For most characters this mating system proved to be superior to NC I for creating the desirable variability. The range for the biparental progenies was generally wider than in the F_3 generation. The superior mean performance of biparental families may be the result of generation of more genetic variability by breaking the undesirable linkages and accumulation of favourable alleles [7]. This makes possible the emergence of those segregants which would have been rarely obtained in the selfing series. The higher variability in the intermated population could also result from the additional opportunity for genetic recombination. These results are similar to those of [7, 11, 14].

The analysis of variance for P_1, P_2, BIPs and F_3 families indicated that these generations differed significantly from each other for all the characters except tiller number in both designs (Table 2). The nonsignificant difference for tiller number may have been caused by

Table 1. Mean performance of F_3 and BIPs for different characters in North Carolina designs I and III

Character	F_3				BIPs				CD 5%	
	range		mean		range		mean			
	NC I	NC III	NC I	NC III	NC I	NC III	NC I	NC III	NC I	NC III
Days to heading	95–117	94–122	102.4	106.4	88–113	79–136	99.6	105.4	11.2	0.25
Plant height (cm)	43–106	46–110	82.5	74.0	43–104	47–104	77.0	72.9	5.9	0.25
Tiller number	10–15	6–22	11.4	13.2	6–20	5–26	12.3	14.1	—	0.38
Grains per spike	43–67	40–81	51.8	58.4	38–83	33–86	58.8	59.5	8.0	0.72
Grain yield (g)	7–21	6.7–37.7	13.4	15.6	6.2–30.3	6.3–33.0	16.1	16.6	3.2	0.97
Harvest index (%)	20–54	21–52	34.2	39.2	31–52	24–58	39.8	42.6	2.5	—
1000-grain wt. (g)	13.2–31.4	15.8–33.6	27.0	25.6	20.2–52.4	16.0–40.2	29.4	27.6	—	0.45

the fact that while selecting F_2 plants for attempting crosses, only the profusely tillering plants were chosen so that enough tillers were available for crossing and selfing. This may have caused greater uniformity for this trait.

Table 2. Analysis of variance (mean squares) for different characters in North Carolina designs I and III

Source of variation	d.f.	Design	Days to heading	Plant height	Tiller number	Grains per spike	Grain yield	Harvest index	1000-grain weight
Replications	1	NC I	15.81	7.88	0.35	2.06	0.011	0.002*	0.01
		NC III	0.69	5.93	3.62	33.64*	4.29	0.01*	0.55
Generations	3	NC I	139.84*	1037.63**	2.08	141.38*	21.38*	0.01**	8.00*
		NC III	185.49**	175.78**	3.31	238.49**	24.26	0.01**	4.84
Error	3	NC I	13.15	3.41	4.52	6.33	1.00	0.0001	0.89
		NC III	0.097	0.89	5.35	1.25	1.33	0.0006	0.87

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

The choice of breeding procedure for genetic improvement of a crop depends the relative magnitude of the various genetic parameters. In NC I, additive variance (σ^2A) was significant for days to heading, plant height and grains/spike (Table 3). The dominance component (σ^2D) was significant for days to heading, plant height and grain yield. The estimate of dominance component for days to heading and plant height was negative, indicating the predominance of decreasing number of alleles for these characters. Similar observations have been made earlier for the mean performance where BIP had lower height and reduced number of days to heading. In this design, the magnitude of additive component was higher for all the characters except grains/spike. The relative magnitude

Table 3. Estimates of genetic components (mean squares) for different characters in North Carolina designs I and III

Sources of variation	Days to heading	Plant height	Tiller number	Grains per spike	Grains yield	Harvest index	Grain weight
			North Carolina design I				
σA^2	30.9**	24.59**	—	62.88*	-3.48	—	—
σD^2	-1.06**	-27.94**	—	-88.02	-31.73*	—	—
			North Carolina design III				
σA^2	33.76**	296.92**	9.49**	—	12.88*	0.004**	9.81**
σD^2	-4.57**	30.33**	-1.52*	—	9.01*	0.002**	3.51**

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

of additive component was higher than that of dominance component for all the characters studied. NC III was relatively superior to NC I, as the magnitudes of genetic parameters were higher in this design. The advantage of NC III is that it enables D and H to be tested and estimated independently of each other. Under NC I, one gets biased estimates of the genetic parameters.

Table 4. Correlation coefficients among different characters in BIPs and F_3 families in North Carolina design I

Character	Generation	Days to heading	Plant height	Tiller number	Grains per spike	Grain yield	Harvest index	Grain weight
Days to heading	BIPs	—	-0.09	-0.20	0.46**	-0.14	-0.45**	-0.31
	F_3		0.21	0.08	0.09	-0.24	-0.25	-0.28*
Plant height	BIPs		—	-0.24	-0.01	0.41**	-0.10	0.44**
	F_3			-0.26	0.26	0.41**	-0.29*	0.48**
Tiller number	BIPs			—	0.06	0.60**	-0.63**	-0.14
	F_3				0.09	-0.39**	0.04	-0.12
Grains per spike	BIPs				—	0.15	-0.27	-0.12
	F_3					0.25	-0.30*	0.32*
Grain yield	BIPs					—	0.47**	0.47**
	F_3						-0.33*	0.36**
Harvest index	BIPs						—	0.17
	F_3							0.31**
Grain weight	BIPs							—
	F_3							

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

Table 5. Correlation coefficients among different characters in BIPs and F3 families in North Carolina design III

Characters		Days to heading	Plant height	Tiller number	Grains per spike	Grain yield	Harvest index	Grain weight
Days to heading	BIPs	—	–0.08	0.40**	–0.20	–0.09	–0.22	–0.61**
	F3		0.11	0.04	–0.07	–0.23*	–0.14	–0.02
Plant height	BIPs		—	–0.16	–0.16	0.19	–0.19	0.28*
	F3			0.46**	0.09	0.10	–0.16	0.002
Tiller number	BIPs			—	0.07	0.43**	–0.21	–0.49**
	F3				0.12	–0.43**	–0.33**	–0.04
Grains per spike	BIPs				—	0.25	0.29*	0.23
	F3					0.26*	0.04	0.01
Grain yield	BIPs					—	0.09	0.18
	F3						0.24*	0.01
Harvest index	BIPs						—	0.42*
	F3							0.005
Grain weight	BIPs							—
	F3							

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

A comparison of correlation coefficients in the BIPs and F3 revealed that as many as nine correlations changed in NC I (Table 4) and twelve in NC III (Table 5). Some of the important changes observed were grain yield, showing negative association with tiller number and harvest index in F3 turned out to be positive in NC I. Similarly, in this design negative association of harvest index and grains/spike turned out to be nonsignificant. The association of harvest index with days to heading became negative in BIPs. In NC III, the negative correlation between grain yield and tiller number became positive. Similarly, the associations of harvest index with tillers and grains/spike, heading days with grain weight, and plant height with tiller number changed to the favourable direction. A comparison of correlation coefficients in BIP and F3 generations revealed that number of correlations changed to favourable direction in both the designs. The increase in the correlation coefficient would be expected if linkages were in predominantly repulsion phase. Intermating reduces the genetic drift and unfavourable correlated responses by maintaining genetic variability in the population. Similar observations were also reported earlier [7, 9, 15].

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