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SELECTION RESPONSES FOR GRAIN WEIGHT IN SOME MASS SELECTED AND INTERMATED POPULATIONS OF WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

Mechanical mass selection for grain size, followed by two cycles of intermating among the high grain-weight populations, was done to achieve improvement in grain yield. Forty progenies each from five mass selected, eight populations of the first and four of the second intermating cycles were evaluated for plant height, number of grains/spike, 1000-grain weight, and grain yield. Mechanical mass selection and each cycle of intermating were effective to increase 1000-grain weight, indicating the accumulation of favourable alleles in the segregates. There was slight improvement in number of grains/spike also in the progenies of the first intermated populations which pushed up grain yield. However, the second cycle of intermating was not effective in increasing grain yield due to reduction in number of grains/spike. Correlation studies also revealed the usefulness of one cycle of intermating for improving grain yield. Therefore, it is proposed to practice only one cycle of intermating to achieve optimum expression of yield components.

Key words: Wheat, grain weight, mass selection, intermating, selection response.

Grain weight and grain number are two major components of grain yield in cereals. Besides, grain weight has also been reported to be associated with various abiotic stresses caused by heat, drought and salt [1]. The inheritance of grain weight has been reported mainly through additive genes and manifestation of heterosis for this trait mainly due to dispersion of favourable alleles among the parents [2]. Consequently, mechanical mass selection for grain size has been found effective to increase grain weight as well as grain yield [3–5]. Progenies having 1000-grain weight up to 65 g have been isolated but gains in grain weight beyond 48 g have not been reflected in corresponding increase in grain yield [4]. In such situations, intermating among individuals of different populations has been advocated to break undesirable linkages as well as assemblage of favourable alleles in

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segregating populations [6]. Keeping this in view, intermating among individuals having high grain weight of heterogeneous populations was initiated to raise the selection limit of grain weight without adversely affecting grain number and ultimately grain yield.

MATERIALS AND METHODS

Five high grain weight heterogeneous populations, obtained after three cycles of mechanical mass selection through sieving for grain size in the crosses UP 368 x Shailja, WH 157 x B 1858, WL 711 x CPAN 1315, WH 157 x WH 129 and UP 368 x WC 457, were used as parental populations. The selected populations from each cross were used as parents for further crosses. In the first intermating cycle, all the 10 possible crosses were attempted between these five populations involving 20 plants from each population of a cross. The F_2 population of two crosses, namely, UP 368 – Shailja x WH 157–WH 129 and WH 157–B 1858 x UP 368–WC 457 were dropped due to the presence of necrosis. The second intermating cycle was started by involving bold grain F_2 segregates of the first intermating in the following combinations: (UP 368–Shailja x WH 157–B 1858) x (WL 711–CPAN 1315 x WH UP 368–WC 457), (UP 368–Shailja x WL 711–CPAN 1315) x (WH 157–B 1858 x WH 157–129), (UP 368–Shailja x UP 368–WC 457) x (WL 711–CPAN 1315 x WH 157–WH 129) and (WH 157–B 1858 x WL 711–CPAN 1315) x (WH 157–WH 129 x UP 368–WC 457). Forty progenies from each of the parental, first and second intermating cycles were raised in compact family block design with three replications and observations were recorded on four quantitative traits. Plot means were used for analysis. Genotypic and phenotypic coefficients of variation, correlations, heritability and genetic advance were calculated as per [7].

RESULTS AND DISCUSSION

The progenies of five parental populations used in the present study recorded an increase in grain weight over the parents involved in the crosses. The upper limit of the range of progenies of the five crosses surpassed the grain weight of the high-grain parents involved in a particular cross (Table 1). The mechanical mass selection increased the frequency of progenies with high grain weight, pushing upward the progeny means of a particular cross [4]. Bhatt and Derera [3] and Singh et al. [5] also observed increase in grain weight of the F_3 progenies isolated from mechanically mass selected F_2 populations. The mean plant height and grain yield also increased but there was no conspicuous increase or decrease in the number of grains/spike among the progenies of different crosses. The correlation studies indicated that grain weight was positively correlated with plant height ($r = 0.61$) and grain yield ($r = 0.36$) but there was no correlation between grain weight and number of grains/spike. Thus, an increase in grain weight caused positive correlated responses for plant height and grain yield. Similar correlated responses were reported earlier [3, 4]. The magnitude of phenotypic coefficient of variability (PCV) was higher than

Table 1. Mean, range, GCV, PCV, heritability (h^2) and genetic advance (GA) among progenies of mass selected and intermated populations for four quantitative traits in wheat

Character	Mean	Range	GCV	PCV	h^2	GA
Plant height:						
UP 368–Shailja	131.42 ± 2.65	111.67–143.33	5.49	6.53	70.74	12.51
WH 157–B 1858	129.23 ± 1.76	111.67–146.67	8.47	8.80	92.55	21.66
WL 711–CPAN 1315	135.68 ± 1.94	105.67–155.00	10.26	10.56	94.37	27.86
WL 157–WH 129	111.33 ± 1.76	103.33–113.33	6.69	7.24	85.32	14.16
UP 368–WC 457	140.55 ± 2.35	132.67–152.67	2.89	4.12	49.17	5.86
UP 368–Shailja x WH 157–B 1858	123.63 ± 2.66	104.67–153.33	13.32	13.84	92.57	32.63
UP 368–Shailja x WL 711–CPAN 1315	132.36 ± 3.01	114.67–148.33	5.96	7.17	69.07	13.50
UP 368–Shailja x WH 157–WH 129	128.72 ± 2.35	105.00–150.00	9.30	9.84	89.44	23.33
UP 368–Shailja x UP 368–WC 457	128.53 ± 3.31	110.37–143.33	5.89	7.43	63.01	12.39
WH 157–B 1858 x WL 711–CPAN 1315	129.31 ± 2.87	101.67–146.67	8.04	8.93	80.99	19.28
WH 157–B 1858 x WH 157–WH 129	129.86 ± 2.66	100.00–150.67	11.18	11.74	90.63	28.46
WL 711–CPAN 1315 x WH 157–WH 129	135.09 ± 3.74	101.33–170.00	11.97	12.92	85.92	30.88
WL 711–CPAN 1315 x UP 368–WC 457	135.87 ± 4.78	116.67–150.00	5.83	8.49	47.16	11.21
WH 157–WH 129 x UP 368–WC 457	130.16 ± 5.39	110.00–155.00	7.06	10.13	48.66	13.21
(UP 368–Shailja x WH 157–B 1858) x (WL 711–CPAN 1315 x UP 368–WC 457)	128.95 ± 5.54	108.33–150.00	6.58	10.01	43.25	11.49
(UP 368–Shailja x WL 711–CPAN 1315) x (WH 157–B 1858 x WH 157–WH 129)	133.01 ± 4.25	111.67–151.67	8.15	9.89	67.84	18.39
(UP 368–Shailja x UP 368–WC 457) x (WL 711–CPAN 1315 x WH 157–WH 129)	125.60 ± 4.30	110.00–146.67	8.10	10.09	64.53	16.84
(WH 157–B 1858 x UP 711–CPAN 1315) x (WH 157–WH 129 x UP 368–WC 457)	135.69 ± 5.28	96.67–152.33	7.55	10.17	55.06	15.66
Number of grains/spike:						
UP 368–Shailja	36.32 ± 1.46	27.83–61.90	17.66	19.02	86.18	12.26
WH 157–B 1858	44.48 ± 1.20	28.83–64.83	19.53	20.10	94.41	17.39
WL 711–CPAN 1315	47.88 ± 1.03	29.50–76.00	25.04	25.32	97.78	24.42
WH 157–WH 129	44.28 ± 1.37	22.70–67.17	26.24	26.79	95.90	23.44
UP 368–WC 457	49.45 ± 1.37	28.00–75.17	26.21	26.65	96.68	26.25
UP 368–Shailja x WH 157–B 1858	44.78 ± 1.27	35.33–61.50	16.79	17.51	91.94	14.85

(Contd.)

Table 1 (contd.)

Character	Mean	Range	GCV	PCV	h^2	GA
UP 368–Shailja x WL 711–CPAN 1315	47.57 ± 1.83	41.33–57.17	14.61	16.09	82.39	12.99
UP 368–Shailja x WH 157–WH 129	43.26 ± 1.67	27.53–61.93	22.31	23.32	91.53	19.09
UP 368–Shailja x UP 368–WC 457	46.66 ± 1.85	32.57–80.67	19.88	21.07	89.05	18.03
WH 157–B 1858 x WL 711–CPAN 1315	41.86 ± 2.20	28.20–61.30	20.10	22.12	82.57	15.75
WH 157–B 1858 x WH 157–WH 129	44.57 ± 2.25	26.17–73.73	22.08	23.79	86.10	18.81
WL 711–CPAN 1315 x WH 157–WH 129	46.76 ± 2.47	29.60–78.97	23.28	25.05	86.31	20.83
WL 711–CPAN 1315 x UP 368–WC 457	42.44 ± 2.52	28.40–62.17	17.71	20.54	74.34	13.35
WH 157–WH 129 x UP 368–WC 457	46.69 ± 4.63	34.07–79.23	20.35	26.76	57.83	14.89
(UP 368–Shailja x WH 157–B 1858) x WL 711–CPAN 1315 x UP 368–WC 457)	37.02 ± 3.83	28.73–48.80	11.99	21.77	30.36	5.04
(UP 368–Shailja x WL 711–CPAN 1315) x (WH 157–B 1858 x WH 157–WH 129)	39.17 ± 3.26	26.33–64.50	13.04	19.59	44.30	7.00
(UP 368–Shailja x UP 368–WC 457) x (WL 711–CPAN 1315 x WH 157–WH 129)	44.16 ± 3.50	28.50–64.73	16.09	21.28	57.20	11.07
(WH 157–B 1858 x WL 711–CPAN 1315) x (WH 157–WH 129 x UP 368–WC 457)	34.48 ± 3.60	17.57–47.33	15.96	24.29	43.18	7.45
1000-grain weight:						
UP 368–Shailja	46.13 ± 1.20	39.67–51.17	5.77	7.36	61.49	4.30
WH 157–B 1858	50.70 ± 1.16	41.00–59.50	7.87	8.83	79.42	7.33
WL 711–CPAN 1315	46.36 ± 0.99	38.17–52.67	6.93	7.87	77.53	5.83
WH 157–WH 129	44.19 ± 1.37	39.83–57.67	9.45	10.91	75.03	7.45
UP 368–WC 457	46.40 ± 1.40	42.33–55.33	6.63	8.49	60.91	4.94
UP 368–Shailja x WH 157–B 1858	50.48 ± 1.11	39.17–57.50	7.66	8.58	79.72	7.11
UP 368–Shailja x WL 711–CPAN 1315	55.62 ± 1.47	52.33–58.67	1.99	5.05	15.69	0.91
UP 368–Shailja x WH 157–WH 129	50.01 ± 1.77	37.67–57.33	9.55	11.39	70.34	8.25
UP 368–Shailja x UP 368–WC 457	49.10 ± 1.67	44.00–54.17	3.60	6.96	26.80	1.89
WH 157–B 1858 x WL 711–CPAN 1315	50.54 ± 1.67	39.83–56.67	6.22	8.50	53.59	4.74
WH 157–B 1858 x WH 157–WH 129	52.36 ± 1.50	36.93–65.17	11.52	12.57	84.02	11.39
WL 711–CPAN 1315 x WH 157–WH 129	50.42 ± 1.71	39.17–55.63	7.12	9.27	58.90	5.67
WL 711–CPAN 1315 x UP 368–WC 457	49.22 ± 2.39	39.17–58.67	6.02	10.44	33.21	3.52

(Contd.)

Table 1 (contd.)

Character	Mean	Range	GCV	PCV	h^2	GA
WH 157–WH 129 x UP 368–WC 457	48.92 ± 1.82	42.63–55.40	5.77	8.71	43.91	3.85
(UP 368–Shailja x WH 157–B 1858) x (WL 711–CPAN 1315 x UP 368–WC 457)	53.82 ± 1.32	48.00–60.83	5.67	7.11	63.48	5.00
(UP 368–Shailja x WL 711–CPAN 1315) x (WH 157–B 1858 x WH 157–WH 129)	52.93 ± 1.57	47.67–58.33	3.35	6.19	29.37	1.98
(UP 368–Shailja x UP 368–WC 457) x (WL 711–CPAN 1315 x WH 157–WH 129)	51.58 ± 1.58	44.17–58.17	6.28	8.28	57.62	5.07
(WH 157–B 1858 x WL 711–CPAN 1315) x (WH 157–WH 129 x UP 368–WC 457)	53.23 ± 1.79	45.33–60.33	5.50	8.06	46.62	4.12
Grain yield:						
UP 368–Shailja	111.84 ± 1.34	79.67–142.00	16.22	16.35	98.34	37.07
WH 157–B 1858	103.34 ± 1.11	65.00–164.00	22.26	22.34	99.29	47.23
WL 711–CPAN 1315	127.53 ± 1.32	91.67–177.67	17.49	17.59	98.93	45.71
WH 157–WH 129	117.87 ± 2.10	67.00–161.67	16.19	16.49	96.42	38.60
UP 368–WC 457	100.87 ± 1.23	52.67–143.00	18.12	18.25	98.62	37.39
UP 368–Shailja x WH 157–B 1858	110.90 ± 2.42	70.33–156.33	18.21	18.61	95.78	40.72
UP 368–Shailja x WL 711–CPAN 1315	122.03 ± 2.80	61.67–210.00	28.13	28.42	97.99	70.01
UP 368–Shailja x WH 157–WH 129	107.57 ± 1.97	65.67–140.00	24.76	24.97	98.34	54.41
UP 368–Shailja x UP 368–WC 457	111.63 ± 2.34	72.33–166.00	21.77	22.14	96.68	44.80
WH 157–B 1858 x WL 711–CPAN 1315	116.93 ± 2.95	75.00–160.33	16.46	17.05	93.25	38.29
WH 157–B 1858 x WH 157–WH 129	106.62 ± 3.27	65.00–175.00	28.59	29.10	96.57	61.71
WL 711–CPAN 1315 x WH 157–WH 129	106.63 ± 3.46	81.33–156.67	15.84	16.83	88.58	32.74
WL 711–CPAN 1315 x UP 368–WC 457	119.13 ± 5.92	93.33–165.67	16.97	19.07	79.13	37.04
WH 157–WH 129 x UP 368–WC 457	97.18 ± 6.32	52.33–143.00	20.22	23.22	75.87	35.27
(UP 368–Shailja x WH 157–B 1858) x (WL 711–CPAN 1315 x UP 368–WC 457)	107.92 ± 6.74	34.33–148.33	19.62	22.27	77.68	38.45
(UP 368–Shailja x WL 711–CPAN 1315) x (WH 157–B 1858 x WH 157–WH 129)	108.82 ± 4.51	75.00–151.67	18.42	19.80	86.52	38.41
(UP 368–Shailja x UP 368–WC 457) x (WL 711–CPAN 1315 x WH 157–WH 129)	107.90 ± 8.08	65.00–163.00	17.69	22.04	64.46	31.58
(WH 157–B 1858 x WL 711–CPAN 1315) x (WH 157–WH 129 x UP 368–WC 457)	88.50 ± 6.38	42.33–129.00	23.53	26.71	77.61	37.79

the genotypic coefficient of variability (GCV) for all the four characters in all populations. The progenies of WH 157–WH 129 population exhibited the highest, while the progenies of UP 368–Shailja showed the lowest variability for grain weight. For grain yield, the progenies of WH 157–B 1858 and for grains/spike the progenies of WL 711–CPAN 1315, WH 157–WH 129, and UP 368–WC 457 showed high variability. High heritability estimates were obtained for number of grains/spike and grain yield and medium for plant height and grain weight.

In the first intermating cycle, the mean grain weight improved in the progenies of all the eight populations (Table 1) but the mean number of grains/spike and grain yield were within the range of the parental populations involved in a particular cross. However, some progenies in the crosses UP 368–Shailja x WL 711–CPAN 1315, UP 368–Shailja x UP 368–WC 457, and WH 157–B 1858 x WH 157–WH 129 surpassed the upper limits of the range of parents involved in these crosses. The grain yield in the progenies of these crosses increased due to improvement in the lower or upper limits of the range, or both, in respect of grains/spike and grain weight. This indicates that there was accumulation of favourable alleles for grain weight and grain yield, resulting in the better performance of the progenies with respect to these traits. Balyan and Verma [8], Srivastava et al. [9] and Pawar et al. [10] obtained improvement in the progenies selected from the intermated populations for grain yield and its components.

The magnitude of correlation (r = 0.60) between gràin weight and grain yield was almost doubled in the progenies of the cross WH 157–B 1858 x UP 368–Shailja in comparison to the parental populations. The association between plant height and grain weight was almost of the same magnitude (r = 0.41) as in the parental population (Table 2). The coefficient of variability increased in the progenies of two crosses (WH 157–B 1858 x WH 157–WH 129 and WL 711–CPAN 1315 x UP 368–WC 457) for grain weight; in four crosses (UP 368–Shailja x WL 711–CPAN 1315, UP 368–Shailja x UP 368–WC 457, WH 157–B 1858 x WH 157–WH 129, and WH 157–WH 129 x UP 368–WC 457) for grain yield; and in five crosses (UP 368–Shailja x WH 157–B 1858, UP 368–Shailja x UP 358–WC 457, WH 157–B 1858 x WH 157–WH 129, WL 711–CPAN 1315 x WH 157–WH 129, and WH 157–WH 129 x UP 368–WC 457) for plant height. However, variability decreased in the progenies of all the eight populations for number of grains/spike in comparison with the parental populations involved in different crosses, which indicates that number of grains/spike had opposite trend. Grain yield and number of grains/spike were highly heritable in the progenies of all the populations except those of WL 711–CPAN 1315 x UP 368–WC 457 and WH 157–WH 129 x UP 368–WC 457 (Table 1). However, unlike parental progenies, a uniform pattern of heritability estimates was not observed for plant height and grain weight in all the crosses and low to high heritability estimates among the progenies of different crosses were observed. Contrary to the findings of Yunus and Paroda [11], the heritability estimates did

Table 2. Range of genotypic correlation (above diagonal) and significant phenotypic correlation coefficients (below diagonal) among parental and intermated progenies of different populations for four quantitative traits in wheat

Character	Population	Plant height	Grains/spike	1000-grain wt.	Grain yield
Plant height	Parental	—	- 0.31–0.08	0.001–0.74	0.05–0.20
	I intermating	—	- 0.16–0.29	- 0.05–0.61	- 0.09–0.42
	II intermating	—	- 0.35–0.29	- 0.01–0.41	- 0.12–0.24
Grains/spike	Parental	- 0.30*	—	- 0.25–0.05	- 0.03–0.43
	I intermating	—	—	- 0.56–0.19	0.01–0.42
	II intermating	—	—	- 0.54–0.30	0.09–0.61
1000-grain wt.	Parental	0.61**/0.29*	—	—	- 0.14–0.41
	I intermating	0.41**/0.31*	—	—	- 0.29–0.67
	II intermating	0.31*	- 0.41**	—	- 0.20–0.47
Grain yield	Parental	—	0.42**	0.36*	—
	I intermating	0.36*/0.30*	0.39**/0.31*/0.29*	0.60**	—
	II intermating	—	0.36*/0.35*	0.28*	—

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

not improve in the progenies of the intermated populations for all the traits. The genetic gains improved over the parental populations in two crosses (UP 368–Shailja x WH 157–B 1858 and WH 157–B 1858 x WH 1 57–WH 129) for grain weight; in two crosses (UP 368–Shailja x WL 711–CPAN 1315 and WH 157–B 1858 x WH 157–WH 129) for grain yield; and in three crosses (UP 368–Shailja x WH 157–B 1858, WH 157–B 1858 x WH 157–WH 129 and WL 711–CPAN 1315 x WH 157–WH 129) for plant height. The high genetic gains for grain yield were associated with high gains for grains/spike. The gains for grain weight were relatively poor in most crosses.

The mean performance of the progenies of various populations from the second intermating cycle decreased for plant height, number of grains/spike, and grain yield in comparison to the parental and first intermated populations (Table 1). However, for grain weight, an improvement in the mean performance was obtained in all the four populations, which was due to a rise in the lower limit of the range. Thus, the increase in grain weight after the second cycle of intermating was not reflected in increased grain yield. This was mainly attributed to reduction in the number of grains/spike. The correlation coefficient (r = 0.28) between grain weight and grain yield in the progenies of second intermating decreased as compared to that of first intermating, while correlations of grain yield and number of grains/spike were of the similar magnitude after the first and second cycles of intermating. The negative association between number of grains/spike and grain weight (r = – 0.41) among the progenies of second intermating was of higher magnitude than in the progenies of the first intermating cycle. Thus, due to antagonistic relationship between number of grains/spike and grain weight, the second intermating cycle was not effective in increasing the grain yield. In general, the coefficient of variability for all the four traits decreased as compared to the parental and the first intermated population. The estimates of heritability and genetic advance for all the traits were poorer in the second intermated populations than in the parental and first intermated populations.

It is obvious from these results that mechanical mass selection in the parental populations was effective in increasing the grain weight and there was corresponding increase in grain yield but mechanical mass selection had no effect on the number of grains/spike. The correlation studies also revealed that grain weight and grain yield were positively correlated in the parental populations but there was no relationship between number of grains/spike and grain weight. The improved mean performance of the progenies of the first intermated populations for grain weight, number of grains/spike and grain yield was due to accumulation of desirable alleles for grain weight along with some improvement in number of grains/spike through intermating of the individual plants from the high grain-weight populations. The mean performance of the progenies obtained after the second intermating cycle showed slight improvement in grain weight but no improvement in number of grains/spike and grain yield. The correlation studies also indicated that association of grain weight and grain yield was strengthened in the first intermating cycle but was brought down to the parental level after the second intermating cycle. Negative correlation between grain weight and number of grains/spike appeared only in the progenies of second intermating which was probably due to the disruption of the blocks of desirable genes for grain weight and number of grains/spike, resulting in reduced grain yield. Thus, increase in grain weight without decreasing number of grains/spike was responsible for an increase in grain yield. Correlations of similar magnitudes among other traits in the parental as well as intermated populations indicated that mechanical mass selection for grain weight has not altered the nature of genetic correlations of grain number with grain yield, and plant height with grain weight. However, the negative correlations of plant height with number of grains/spike were eliminated, while the correlations of plant height with grain yield strengthened through intermating. It was also observed that with increase in grain weight, there was reduction in tillering potential (data not presented). Moreover, the maximum release of variability for grain weight and grain yield in the first intermating cycle resulted in high gains in grain weight and grain yield. The release of variability in second intermating cycle for number of grains/spike, grain weight and grain yield was considerably reduced. Thus, mechanical mass selection for grain size should be practised for improvement of grain yield and only one cycle of intermating between high grain-weight segregates would be desirable to improve grain yield and its components. Two populations, namely, UP 368–Shailja x WL 711–CPAN 1315 and WH 157–B 1858 x WH 157–WH 129 of the first intermating cycle may be exploited for isolating productive progenies.

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