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STUDIES ON HYBRID WHEAT SEED PRODUCTION BASED ON TRITICUM TIMOPHEEVI CYTOPLASMIC MALE STERILE LINES

P. P. SINGH AND R. K. S. RATHORE

Department of Genetics and Plant Breeding, R. B. S. College, Bichpuri Agra 283105

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ABSTRACT

A line x tester analysis of combining ability involving five male sterile (ms) lines of Indian cultivars and four exotic restorers of spring wheat revealed that σ^2 sca was higher than σ^2 gca for almost all the characters in both sets. Therefore gene action was found mainly non-additive type for these traits. In set II, σ^2 gca was higher than σ^2 sca for days to heading, duration of grain filling and plant height indicating additive gene action for these characters. Preponderance of non additive gene action was also indicated from σ^2 gca/σ^2 sca which are less than unity for most of attributes. In set I, among lines, msUP 368 and msWH 157 for duration of grain filling, tillers/plant and spikes/plant; msHD 2204 for plant height; msUP 368 for days to heading and among testers, W 8156 and 3401/478466 for duration of grain filling showed high gca effects. In set II, among lines, R_3-401 for days to heading and duration tillers/plant and spikes/plant showed high gca effects. It was observed that best general combiners were not always present in best specific cross combinations. The degree and direction of MP and BP heterosis varied greatly for different character and crosses. There was lack of definite relationship between sca effects and estimates of heterosis.

Key words: Hybrid wheat, combining ability, cytoplasmic male sterility, exotic restorer, line x tester, heterosis, *Triticum timopheevi*.

Wheat is the only crop reported to produce more than 400 million metric tonnes in a single year [1]. It is also one of the more nutritious of cereals and its contribution to the human diet puts it clearly in the first rank of plants that feed the world.

Increased yield is an important objective in most breeding programmes. While the major emphasis in wheat (*Triticum aestivum* L.) breeding is the development of improved cultivars in India, significant efforts have been made in finding economically feasible systems for production of F_1 hybrids abroad. The discovery of the biologic system comprising the cytoplasmic sterility and the restoration of pollen fertility in wheat makes the commercial production of hybrid seed possible. Kihara [2] pointed out the possibility of using male sterility by transferring the nucleus of common wheat into the cytoplasm of *Aegelops caudata*. Since that times, new sources of cytoplasmic pollen sterility were found [3–5]. Among the cytoplasm which, in an interaction with *Triticum* nucleus, bring about sterility *T. timopheevi* seems to be the most suitable one for commercial production of hybrid seed.

Expression of an adequate vigour of F_1 hybrid in important economic properties, yield and quality included is one of the fundamental preliminary condition for the successful use of hybrids in wheat. Earlier it was believed that the amount of heterosis, which can appear in wheat as a self-pollinated polyploid species, was insufficient. Briggle [6] and Milohnic [7] reviewed experimental evidence on heterosis in wheat. A number of wheat workers have approved the positive indication and most of them have reported heterosis in wheat hybrids of the magnitude found in corn and sorghum.

The genetic analysis of combining ability and estimates of heterosis assumes utmost importance as a prerequisite to embark upon a sound crop improvement programme through hybridization technique. The present investigation has been undertaken to make use of line x tester analysis for estimating combining ability effects of the parents and hybrids and identification of desirable genotypes for the production of hybrid wheat seed.

MATERIALS AND METHODS

The material for the present investigation consists of male sterile lines (A lines) of five promising Indian cultivars of wheat, viz. msHD 2204, msHD 2260, msHP 1102, msUP 368 and msWh 157. These were developed at RBS College Research Farm by repeated backcrossing to the *T. timopheevi* cytoplasm based male sterile lines of spring wheat obtained from Cargil Research Farm, USA by Jain et al. [8]. The parental selfed lines of these cultivars viz, HD 2204, HD 2260, HP 1102, UP 368 and WH 157 were used as pollinators (B lines). The four exotic restorers lines of spring wheat, viz. Wilson 8156, 3401/478466, PE/YQ/42267 and R 3- 401, which were acclimatized to the Indian conditions were used as restorer lines (R lines) for hybrid seed production.

In 1982 crop season sufficient seed on A lines were produced by hand pollination of each A lines with their respective B lines. The seeds of B and R lines were produced by selfing. Hybrid seed was produced by growing five A lines separately alongwith four R lines. For each ms line there were two male lines one on either side of it. Cross pollination was allowed under field conditions, this constituted set I. The four R lines were emasculated and crossed separately with each B line, this constituted set II. All fourty hybrids constituting two sets of twenty hybrids each, along with their nine parents were grown in a RBD with three replications. The observations were recorded on the basis of average of ten plants randomly selected from each replications for germination percentage, days to heading duration of grain filling, plant height, number of tillers/plant and number of spikes/plant. The experiment was conducted for two crop seasons, i.e. 1983 and 1984 crop seasons and the data was pooled over the two years. Combining ability analysis was done by the method suggested by Kempthorne [9]. Heterosis over midparent (MP) and better parent (BP) was calculated as per standard procedure.

RESULTS AND DISCUSSION

The component of combining ability obtained from the line x tester analysis and the range of heterosis and number of crosses showing desirable heterotic response for the character studied are presented in Table 1. This table reveals that σ^2 sca was higher than σ^2 gca for almost all the characters in both sets indicating preponderance of non additive gene action for these traits. However, high σ^2 gca was found higher than σ^2 sca for days to

Table 1. Components of combining ability in wheat

Component		Germination %	Days to heading	Duration of grain filling	Plant height	Tillers per plant	Spikes per plant
Set I:							
σ^2 gca		– 0.26	– 0.04	0.28	2.62	0.26	0.26
σ^2 sca		– 15.75	0.46	1.32	10.57	1.05	1.05
σ^2 gca/σ^2 sca		– 0.02	– 0.09	0.21	0.25	0.25	0.25
Set II:							
σ^2 gca		– 2.42	1.28	0.30	– 2.87	– 0.23	– 0.23
σ^2 sca		10.44	1.01	– 0.12	– 0.39	0.77	0.77
σ^2 gca/σ^2 sca		– 0.23	1.27	2.50	– 7.36	– 0.30	– 0.30
Set I:							
No. of crosses with significant economic heterosis	MP	6	9	3	1	20	20
	BP	Negative	17	2	3	20	20
Range of economic heterosis, %	MP	10.5–26.2	– 1.6–6.8	2.7–7.0	– 3.48	30.5–98.0	3.5–98.0
	BP	—	1.5–7.5	2.0–2.7	– 3.1–9.3	2.6–65.0	2.6–65.0
Set II:							
No. of crosses with significant economic heterosis	MP	2	1	Negative	Positive	14	14
	BP	2	7	Negative	Positive	7	7
Range of economic heterosis, %	MP	7.5–1.7	– 3.16	-	—	4.3–31.4	4.3–31.4
	BP	6.5–88.2	1.9–3.5	—	—	3.4–14.1	3.4–14.1

heading, duration of grain filling and plant height in set II, indicating additive type of gene action for these characters. Further, the estimates of σ^2 gca/σ^2 sca which was less the unity also indicated preponderance of nonadditive gene action in controlling most of the traits under study.

The direction and magnitude of gca-effects is presented in Table 2 and 3 for set I and set II, respectively. Considering the overall picture of gca effects it appears that among lines, msHD 2204 for plant height; msUP 368 and msWh 157 for duration of grain filling, tillers/plant and spikes/plant in Set I and R3-401 for days to heading and duration of grain filling in set II displayed favourable gca effects while for rest of the trait gca effect was unfavourable. Among testers, W 8156 and 3401/478466 for duration of grain filling in set I and HD 2204 for days to heading, tillers/plant and spikes/plant in set Ii showed high gca effects.

Table 2. Gca effects of Set I (A x R) in wheat crosses

Parent	Germi-nation %	Days to heading	Duration of grain filling	Plant height	Tillers per plant	Spikes per plant
Lines:						
msHD 2204	– 3.39	– 0.63	0.19	– 2.39**	– 1.39**	– 1.39**
msHD 2260	3.32	– 0.05	0.06	– 0.54	– 0.66	– 0.66
msHP 1102	– 0.30	0.04	– 1.31**	– 0.96	– 0.19	– 0.19
msUP 368	– 2.18	0.87*	0.69**	0.04	0.98**	0.98**
msWH 157	1.03	– 0.13	0.40*	3.84**	1.24**	1.24**
SE	2.54	0.35	0.18	0.73	0.33	0.33
CD (0.05)	5.13	0.71	0.36	1.48	0.67	0.67
CD (0.01)	6.87	0.95	0.49	1.97	0.89	0.89
Testers:						
W 8156	– 1.08	– 0.02	0.59**	3.50**	– 0.07	– 0.07
3401/478466	– 0.61	– 0.09	0.49**	– 1.28	– 0.26	– 0.26
PE/YQ	0.85	0.48	0.05	– 0.97	0.38	0.38
R3-401	0.82	– 0.29	– 1.11**	– 1.25	– 0.07	– 0.07
SE	2.28	0.31	0.16	0.65	0.29	0.29
CD (0.05)	4.61	0.63	0.32	1.31	0.59	0.59
CD (0.01)	6.17	0.84	0.43	1.76	0.78	0.78

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

Table 3. Gca effects of Set II (R x B) in wheat crosses

Parent	Germination %	Days to heading	Duration of grain filling	Plant height	Tillers per plant	Spikes per plant
Lines:						
W 8156	1.56	0.43	- 0.31	- 0.02	0.07	0.07
3401/478466	0.22	- 0.10	- 0.38	0.47	0.21	0.21
PE/YQ	- 1.64	0.46	- 0.48	- 0.69	0.52	0.52
R3-401	- 0.14	- 0.77*	1.16**	0.26	- 0.79**	- 0.79**
SE	1.17	0.35	0.31	1.23	0.27	0.27
CD (0.05)	2.37	0.71	0.63	2.49	0.55	0.55
CD (0.01)	3.16	0.95	0.84	3.33	0.73	0.73
Testers:						
HD 2204	1.26	- 2.15**	- 0.11	2.09	0.61*	0.61*
HD 2260	- 1.41	- 0.10	- 0.44	0.60	- 0.19	- 0.19
HD 1102	0.47	- 0.53	- 0.07	0.57	- 0.03	- 0.03
UP 368	0.26	2.85**	0.43	- 1.50	- 0.33	- 0.33
WH 157	- 0.58	- 0.24	0.18	- 1.73	- 0.04	- 0.04
SE	1.31	0.39	0.35	1.38	0.30	0.30
CD (0.05)	2.65	0.79	0.71	2.79	0.61	0.61
CD (0.01)	3.54	1.05	0.95	3.73	0.81	0.81

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

The nature and magnitude of heterosis showed wide range of variation for different traits over the crosses. Heterosis for different characters were worked out over midparent (MP) and better parent (BP). However, BP heterosis has been discussed in view of practical utility. Out of twenty crosses that showed significant economic heterosis were 0, 17, 2, 3, 20 and 20 in set I and 2, 7, 0, 0, 7 and 7 in set II for germination %, days to heading, duration of grain filling, plant height, tillers/plant and spikes/plant, respectively. The reason for the high incidence of negative heterosis for germination % and duration of grain filling may be due to the adverse effect of *timopheevi* cytoplasm [10–12]. The incidence of high positive heterosis in this experiment for plant height was a deficiency. When the parents differ in height, the hybrids are always taller than mid parent, and frequency also taller than the tall parent. As plant height is often connected with poorer resistance to lodging, heterosis is not desirable in this character of F_1 hybrids.

Table 4. Best five crosses selected for each character on the basis of heterosis and sca effects of both sets along with gca effects of the parents involved (in parentheses)

Character	Heterosis		Sca effects	
	I	II	I	II
Germination %	Nonsignificant positive	3401/478466 x UP368 (A x A) R3-401 x HD 2204 (L x A)	Nonsignificant	PE/YQ x HP1102 (L x A)
Days to heading	msUP368 x 3401/478466 (L x A) msHD 2260 x 3401/478466 (A x A) msWH157 x R3-401 (L x A) msHP1102 x PE/YQ (L x L) msHP1102 x 3401/478466 (L x A)	3401/48466 x HD 2260 (A x A) 3401/478466 x HD2204 (A x H) R3-401 x HD2260 (H x A) W8157 x HD2260 (L x A) PE/YQ x HD2260 (L x A0	msHD2204 x W8156 (A x A) 3401/478466 x UP368 (A x L)	PE/YQ x HD 2204 (L x H)
Duration of grain filling	msUP368 x PE/YQ (H x A)* msUP368 x R3-401 (H x L)	Nonsignificant positive	msHP1102 x W 8156 (L x H) msUP368 x PE/YQ (H x A)* msWH157 x 3401/478466 (H x H)	Nonsignificant
Plant height	msHD2204 x R3-401 (H x A)* msHD2204 x PE/YQ (H x A) msUP368 x R3-401 (L x A)	Nonsignificant negative	msHD2260 x*W81156 (A x L) msHD2204 x R3-401 (H x A) msHP1102 x W8156 (A x L) msWH157 x 3401/478466 (L x A)	R3-401 x HP1102 (L x L)
Tillers/plant	msHP1102 x PE/YQ (L x A)* msWH157 x PE/YQ (H x A) msUP368 x PE/YQ (H x A) msHD2260 x PE/YQ (L x A) msWH157 x R3-401 (H x L)	3401/478466 x HD2204 (A x H)* PE/YQ x HD2260 (A x L)* 3401/478466 x HP1102 (A x L)* PE/YQ x UP368 (L x L) W8156 x HP1102 (A x L)*	msHP1102 x PE/YQ (L x A)* msHD2260 x R3-401 (L x L)	3401/478466 x HP1102 (A x L)* 3401/478466 x HD2204 (A x H)* PE/YQ x HD2260 (A x L)* W8156 x HP1102 (A x L)*
Spikes/plant	msHP1102 x PE/YQ (L x A)* msWH157 x PE/YQ (H x A) msUP368 x PE/YQ (H x A) msHD2260 x PE/YQ (L x A) msWH157 x R3-401 (H x L)	3401/478466 x HD2204 (A x H)* PE/YQ x HD2260 (A x L)* 3401/478466 x HP1102 (A x L)* PE/YQ x UP368 (L x L) W8156 x HP1102 (A x L)	msHP1102 x PE/YQ (L x A)* msHD2260 x R3-401 (L x L)	3401/478466 x HP1102 (A x L)* 3401/478466 x HD2204 (A x H)* PE/YQ x HD2260 (A x L)* W8156 x HP1102 (A x L)*

H—high, A—average and L—low general combiner. *Common cross in both comparisons.

The performance of the crosses was compared on the basis of heterotic response and sca effects. The five best crosses selected on the basis of heterotic response and sca effects for different attributes are presented in Table 4. A perusal of the table shows that only one cross was common in both comparisons in set I, for duration of grain filling, tillers/plant and spikes/plant. This indicates that ranking on the basis of heterotic response and sca effect was different, though high sca effect denotes heterotic response. Also with the same amount of heterosis the sca effect may be less where the per se performance of parents is higher. This means that selection of the crosses based on heterosis response would be more realistic than on the basis of sca effects. The crosses showing high sca effect were found to be derived from A x A, AL x A, H x A and L x L general combiners. Therefore, no relationship was observed between sca effect of the crosses and gca effect of their parents. This indicated the involvement of dominance or non allelic interaction. In set II, four crosses were common in both comparisons for tillers/plant and spikes/plant, indicating the association of high sca with heterotic response. Heterosis is expressed in some characters more and in some character less. Depending on the cross heterosis can be observed either in single component of yield, but also in more components. It is important to find out the more promising combinations for crossing and to select the lines with higher heterotic effect. The undesirable effect of *timopheevi* cytoplasm might be reduced by the use of specific nucleoplasmic interactions [13–15].

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