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RESEARCH ARTICLE

GENE ACTION FOR VARIOUS MORPHO-PHYSIOLOGICAL AND BIOCHEMICAL DETERMINANTS OF DROUGHT TOLERANCE IN BREAD WHEAT (*Triticum aestivum* L.)

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ABSTRACT

The present investigation was carried out during *rabi* 2004-05 at the experimental area of Division of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Sciences and Technology -Jammu**.** Eight genetically diverse bread wheat varieties i.e five drought tolerant (PBW 175, RSP 81, PBW 500, K 9943 and HUW 576) and three drought susceptible (RSP 312, RSP 303 and WH 542) screened on the basis of drought response index were crossed in all possible combinations to produce twenty eight crosses (excluding reciprocals).Hybrids along with parents were evaluated for various morpho-physiological and biochemical determinants under normal (E_1) and moisture-stress (E_2) environments in earthen pots in a polyhouse. Both additive and dominance components of variance were significant for most of the traits under study in both E_1 and E_2. Significance of non-additive genetic component was indicated by number of tillers per plant, spike length in E_2 and proline content in both E_1 and E_2, however, the additive genetic component was predominant in all other characters. To exploit both additive and non-additive gene action, biparental mating and diallel selective mating approaches are suggested.

INTRODUCTION

A major abiotic factor limiting wheat production and productivity in India is recurrent drought. Improving drought tolerance of wheat has long been a major objective of most breeding programmes because water deficits during some part of growing season are common in most regions of the world where wheat is grown. Wheat production in rainfed areas is hampered by moisture stress of varied degree and duration during growing season (Singh, 1998). Due to erratic, spatial and temporal distribution of rainfall, it is important to have cultivars with superior yield performance under limiting and non limiting soil moisture conditions. Now a day's global warming and scarcity of water are important factors for wheat production throughout the world. The present day rice and wheat cropping system and monsoonal irregularities has compelled wheat crop to face rapidly ascending temperature coupled with moisture stress during the post anthesis stages.

Exploitation of the basic genetic principles has resulted in development of high yielding wheat varieties with a remarkable success. Genetic information concerning the nature of gene action of various morpho-physiological and biochemical characters would be a valuable tool for breeding high yielding cultivars and improvement of component characters which would lead to enhancement of yield due to correlated response to selection. In the present investigation, an attempt has been made to estimate various kinds of gene effects through standard biometrical genetic procedures and to know the relative importance of these gene effects using diallel mating approach under normal (E_1) and moisture-stress (E_2) environments.

MATERIAL AND METHODS

Materials for the present investigation comprised **of** eight genetically diverse bread wheat cultivars, among which five cultivars (PBW 175, RSP 81 PBW 500, K 9943 and HUW 576) were drought tolerant and three cultivars (RSP 312,RSP 303 and WH 542) were drought susceptible **.** These drought tolerant and susceptible genotypes were screened from among fifteen (15) genotypes (Table 1) evaluated in a pot experiment by withholding irrigation at different stages of plant growth i.e. S_1 (crown root initiation), S_2 (preanthesis) and S_3 (anthesis). In order to select the parents for hybridization, all the genotypes were evaluated for drought response index (DRI) given by Bidinger et. al.1987 on the basis of biological yield before anthesis. The lowest score 1 was given to the genotypes exhibiting the resistance, whereas the highest score 15 was given to the genotypes having susceptibility (Table-2). Out of the 15 genotypes, 5 with the lowest score and 3 with the highest score were classified as drought resistant and drought susceptible, respectively.

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These cultivars were crossed in all possible combinations excluding reciprocals to produce twenty eight crosses. All the 28 crosses along with eight parents were evaluated in randomized block design with three replications in each of the two environments viz., normal (E_1) and moisture-stress (E_2) in earthen pots in a polyhouse. The moisture stress was created by withholding irrigation at three different critical stages of the crop viz, Crown root initiation (CRI), preanthesis and anthesis The data were recorded on a set of five randomly selected plants for each genotype in both the environments for traits such as number of tillers per plant, grain yield per plant, 100-grain weight, spike length, biological yield per plant, harvest index, relative water content, drought susceptibility index and proline content. Relative water content of the 2nd leaf from top was determined and calculated by using the method of Barrs and Weatherley (1962) whereas, proline content was measured following Bates *et al*. (1973). Drought susceptibility index (DSI) for grain yield was calculated for all the eight varieties over moisture stress and non moisture- stress environments by using the formula as suggested by Fischer and Maurer (1978), DSI= $[1 - Y_D / Y_P] / D$, *where,* Y_D= grain yield under drought stress, Y_P= grain yield under unstressed conditions; D= Stress intensity

$$\textbf{Stress intensity} = 1- \left(\frac{\text{Mean } Y_D \text{ of all genotypes}}{\text{Mean } Y_P \text{ of all genotypes}}\right)$$

The DSI values are used to characterize the relative tolerance of genotypes based on minimization of yield losses compared to normal environmental conditions. Estimation of genetic parameters of traits under study was done following Hayman (1954a)

RESULTS AND DISCUSSION

Estimates of components of genetic variance as depicted in Table 3 indicated the significance of non-additive genetic component for number of tillers per plant and spike length in E_2, however, the additive genetic component was predominant in all other characters. Almost similar results have been reported in wheat by various workers viz., Sheikh *et al.* (2000) and Rajara and Maheshwari (1996). The other yield components indicated the importance of both additive and non-additive genetic components. However, the magnitude of non-additive component was higher than the additive component. Other workers like Esmail (2002), and Singh *et al.* (1986) for grain yield per plant, Shekhawat *et al.* (2000),

Esmail (2002) for 100-grain weight, Vitkare and Akale (1996), Ismail *et al.* (2001) for spike length; Satyavart *et al.* (2001), and Singh *et al.* (1986) for biological yield per plant, Rajara and Maheshwari (1996) for harvest index also reported similar results. Average degree of dominance confirmed these results as in most of the cases over dominance was observed for number of tillers per plant, grain yield per plant, 100-grain weight, spike length in E_1, biological yield per plant, harvest index and partial dominance for relative water content, drought susceptibility index and proline content. These results are also in agreement with the results of Menon and Sharma (1997) for harvest index.

Table1. Distinguishing characters of the genotypes used for evaluation and crossing Programme

S.No	Genotypes	Source	Pedigree
1.	PBW 175	PAU, Ludhiana	HD 2160 / WG 1205
2.	PBW 500	PAU, Ludhiana	PBW 351/ W 4387
3.	RSP 303	SKUAST, Jammu	DT-35 / HD 2428
4.	RSP 81	SKUAST, Jammu	Magpie ‘s’/ Tessopeco-76
5.	RSP 312	SKUAST, Jammu	TL2676 x Sonalika
6.	HD 2815	IARI, New Delhi	BOW/C 306*2/HW 2003
7.	HD 2816	IARI, New Delhi	C 306/KITE-2
8.	HD 2830	IARI, New Delhi	KAUZ//SERI/SEP 80120
9.	PBW 343	PAU, Ludhiana	ND/VG1944/KAL//BB/3/YACO ‘S’/4 /VEE # 5 ‘S’
10.	PBW 486	PAU, Ludhiana	PBW 343/PBW 154/HD 2160
11.	HD 2780	IARI, New Delhi	DUCULA/CHAGUAL/CA 20
12.	K 9943	CSA, Kanpur	HUW 234/HD 2402
13.	WH 542	CCS HAU, Hissar	JUP / BJY // URES
14.	PBW 514	PAU, Ludhiana	PBW 282/CPAN 2005//DL 788-2
15.	HUW 576	BHU, Banaras	K 8027/HUW 478/HW 2004

Table 2. Screening of genotypes on the basis of drought response index (Biological yield per plant)

S.No.	Genotype	DRI	Rank	Remarks
1.	PBW 343	0.001	12	Intermediate
2.	HD 2816	0.056	7	Intermediate
3.	RSP 303	-0.387	14	Susceptible
4.	WH 542	-0.171	15	Susceptible
5.	RSP 312	-0.436	13	Susceptible
6.	PBW 486	0.001	11	Intermediate
7.	PBW 500	1.087	2	Resistant
8.	HD 2830	0.002	10	Intermediate
9.	HD 2780	0.003	9	Intermediate
10.	K 9943	1.303	1	Resistant
11.	HD 2815	0.697	4	Resistant
12.	RSP 81	0.548	5	Resistant
13.	PBW 175	0.832	3	Resistant
14.	HUW 576	0.112	6	Resistant
15.	PBW 514	0.010	8	Intermediate

Table 3: Estimates of components of genetic variance and ratio for various characters under normal (E_1) and moisture-stress (E_2) conditions

Components / ratio	Number of tillers/plant		Grain yield/plant		100-grain weight		Spike length		Biological yield per plant		Harvest Index		RWC	DSI	Proline content	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_2		E_1	E_2
D	0.96* ± 0.46	0.88* ± 0.39	2.72* ± 1.24*	2.28 ± 2.25	0.03* ± 0.01	0.13* ± 0.03	0.57* ± 0.12	0.54* ± 0.15	16.51 ± 12.91	14.91 ± 13.11	15.61* ± 3.79	12.21 ± 0.93	67.96* ± 3.12	0.09* ± 0.02	0.20* ± 0.03	0.52* ± 0.01
H_1	10.73* ± 1.05	6.98* ± 1.58	20.79* ± 5.16	16.70* ± 5.17	0.27* ± 0.05	0.23* ± 0.07	1.55* ± 0.27	1.73* ± 0.35	31.37* ± 9.27	34.91* ± 11.17	41.75* ± 8.71	29.51* ± 4.43	41.99* ± 7.18	0.07* ± 0.03	0.14* ± 0.06	0.11* ± 0.02
H_2	9.45* ± 0.91	5.19* ± 1.38	11.11* ± 4.49	9.17* ± 4.50	0.23* ± 0.05	0.17* ± 0.06	1.29* ± 0.24	1.16* ± 0.31	26.14* ± 8.61	29.14* ± 10.17	23.59* ± 7.58	15.55* ± 3.85	27.77* ± 6.25	0.04* ± 0.02	0.12* ± 0.05	0.10* ± 0.02
h^2	26.94* ± 0.61	9.15* ± 0.92	1.21 ± 3.01	1.61 ± 3.02	0.03 ± 0.03	0.01 ± 0.04	0.28 ± 0.16	0.11 ± 0.21	0.76 ± 3.71	0.39 ± 6.19	0.98 ± 5.08	3.03 ± 2.58	49.67* ± 4.19	-0.05 ± 0.06	0.01 ± 0.03	0.04* ± 0.01
F	1.57 ± 1.08	-0.43 ± 1.63	4.66 ± 5.30	-6.67 ± 5.31	0.02 ± 0.05	-0.12 ± 0.07	0.38 ± 0.28	0.24 ± 0.36	-9.17 ± 8.01	-13.17 ± 9.91	24.62* ±8.95	-4.45 ± 4.45	-35.70 ± 7.38	-0.05 ± 0.03	-0.10 ± 0.06	-0.10* ± 0.03
E	0.06 ± 0.15	0.05 ± 0.23	0.19 ± 0.75	0.11 ± 0.75	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.04	0.02 ± 0.05	1.37 ± 1.16	0.29 ± 1.86	1.23 ± 1.26	0.65 ± 0.64	0.40 ± 1.04	0.03 ± 0.02	0.01 ± 0.01	0.01 ± 0.01
$(H_1/D)^{0.5}$	3.35	2.82	2.78	2.71	3.17	1.35	1.64	1.79	1.37	1.53	1.64	2.41	0.79	0.88	0.82	0.45
$H_2/4H_1$	0.22	0.19	0.13	0.14	0.21	0.18	0.21	0.17	0.21	0.21	0.14	0.13	0.17	0.14	0.22	0.22
KD/kR	1.64	0.84	1.89	0.30	1.25	0.49	1.50	1.28	0.66	0.55	2.86	0.79	0.50	0.52	0.53	0.65
h^2/H_2	2.85	1.76	0.11	0.18	0.13	0.05	0.22	0.09	0.02	0.01	0.04	0.19	1.78	-1.25	0.08	0.40
Heritability (NS)	9.24	10.31	13.73	8.72	9.37	25.00	31.80	25.76	26.40	23.24	41.75	25.03	46.14	27.27	41.66	67.53
t^2	4.46	3.06	4.31	4.13	3.45	3.17	0.63	0.07	0.97	1.07	0.04	1.33	0.09	0.95	1.47	1.22
r	0.53	0.36	-0.03	0.30	0.43	0.92	-0.44	-0.04	0.41	0.83	0.16	0.20	0.85	0.32	0.62	0.84
b± S.E(b)	4.35 ± 0.12	6.25 ±0.05	-0.36 ± 0.09	8.43 ± 0.03	0.41 ±0.11	0.62 ±0.05	0.52 ±0.50	0.51 ± 0.30	0.91 ± 0.61	0.80 ± 0.69	0.33 ± 0.35	-0.17 ± 0.11	0.91 ± 0.12	0.99 ±0.81	0.64 ±0.07	0.93 ±0.04

*Significant at 5% level of significance

The ratio $H_2/4H_1$ indicated both symmetrical and asymmetrical distribution of genes. In order to have quick improvement, it is desirable to choose the parental material having genes distributed symmetrically affecting the character positively or negatively. The asymmetric distribution of genes was exhibited by all the characters in both the environment. The proportion of dominant and recessive genes among the parents, determines the extent of genetic advance that can be achieved in a particular direction. In the present study, the excess of dominant alleles among parents was shown by all the characters in both the environments except in case number of tillers per plant, grain yield per plant and 100-grain weight in E_2 spike length in E_1 biological yield per plant in E_1 and E_2 where either equal proportion of dominant and recessive alleles or more frequency of recessive alleles was observed. Besides other reasons, the genetic progress through selection will also depend upon the number of effective factors controlling a particular character. The low values of h^2/H_2 in all the environments indicated that there was at least one gene group for each trait. However, in some characters two to four number of genes or gene groups were operative in one environment or the other. The ambidirectional dominance effect and the uncorrelated distribution of genes among the parents may be one of the causes for low estimates of this ratio (Mather and Jinks, 1971). A high correlation between parental measurement and parental order of dominance indicates that most of the dominant alleles act in one direction and recessive alleles in opposite direction (Hayman, 1954a). In the present study the correlations were found to be non-significant except in case of characters grain yield per plant and biological yield per plant in E_2, positive and significant correlations were found indicating that the recessive genes had the positive effects for these characters. In general, low heritability estimates were observed for all the characters. It may be conclude that for improving wheat for drought tolerance both additive and dominant gene action have to be exploited by adopting adequate breeding strategies. For this, diallel selective mating (Jensen, 1970) and reciprocal recurrent selection (Comstock and Robinson, 1952) approaches may be adopted.

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