Himachal Journal of Agricultural Research 35 (2):133-137, 2009

Variability and correlation studies involving yield and drought tolerance traits in wheat

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Abstract

Twenty five diverse wheat genotypes varying in their yield and drought tolerance were used to estimate genetic variation and heritability for some drought tolerance and yield component characters under moisture stress (E_1) and irrigated (E_2) conditions. Drought tolerance was viewed in terms of drought susceptibility index (S) and index of drought resistance (IDR). The heritability estimates ranged from 37.70 to 89.50% for harvest index under E_2 and grains per spike under drought stress (E_1) environment, respectively. The expected genetic advance varied from 8.13 for days to maturity to 38.92 for grain weight per spike under moisture stress environment, while under irrigated environment it ranged from 5.51 for days to maturity to 38.97 for biological yield. Grain yield exhibited significant positive correlation with grain weight per spike and drought susceptibility index under E_2. Harvest index showed positive association with IDR and negative with biological yield in both the environments. ELWR (Excised Leaf Water Retention) had significant negative correlation with 'S', but positive with IDR (the important indices of drought tolerance). Biological yield, grain weight per spike, harvest index and plant height each had positive direct effect on grain yield under moisture stress environment (E_1). ELWR and IDR have emerged to be the important criteria for selecting drought tolerant genotypes in wheat.Index of Drought Resistance (IDR) alongwith early seedling vigour,seminal root length and coleoptile length can be used at an early plant growth stage to screen genotypes for drought tolerence.

Key words: *Triticum aestivum* L., wheat, drought tolerance, genetic variation, selection.

Introduction

The identification of genetic variation for drought tolerance and plant productivity under stress is a long standing breeding objective in wheat, because water deficits during some part of the growing period are common to most regions of the world where wheat is produced. Development of drought tolerant genotypes seems to be the economically viable solution for increasing production and productivity of the rainfed wheat. However, during course of breeding, the knowledge of significant association between morpho-physiological characters for identifying a principal selection criterion, which could be used to screen for drought tolerant cultivars, is of paramount importance. Genetic improvement in grain yield has been demonstrated both under favorable and moisture stress conditions over a period of several decades (Blum, 1990). Therefore, the present investigation was undertaken with a view to look for genetic variability and more effective selection criteria, especially under unfavorable (drought stress) conditions.

Material and Methods

Twenty five diverse wheat genotypes varying in their yield performance and drought tolerance were chosen for the present study. The experiment was laid out in a randomized complete block design with three replications under moisture stress (E_1) and irrigated (E_2) environments. Each genotype was grown in 3 x 1.15 m plot with inter-row and inter-plant spacing of 23 cm and 5 cm, respectively. Recommended agronomic practices were followed to raise the crop under both the environments. The observations on five randomly selected plants from each genotype were recorded for different morpho-physiological characters. Drought tolerance was viewed in terms of drought susceptibility index (S) proposed by Fischer and Maurer (1978), which is a standardized ratio of drought stress to the irrigated yields 'S' is defined as follows: $(1-Y_s/Y_i)/(1-\overline{Y}_s/\overline{Y}_i)$ where, Y represents the yield of specific line and $\overline{Y}$, the mean yield for all the genotypes, and the subscripts s and i, refer to stress and irrigated environments, respectively. The experimental wheat genotypes were also evaluated for some important drought tolerance traits. Excised leaf water retention (ELWR) which has been related to drought tolerance in wheat (Schonfeld *et al.*, 1988 and Winter *et al.*, 1988) and is a rapid method of estimating water loss in field conditions (Randhawa *et al.*, 1988), was also estimated. An index of drought resistance (IDR) based on the seminal root length and leaf area was also worked

out at 2-leaf stage under glass house conditions, as suggested by Latyuk (1989).

Standard procedures were followed to record data on grain yield attributes and other morpho-physiological characters. The variance components, genotypic coefficients of variation and genetic advance were determined as suggested by Burton and De Vane (1953), and Johnson *et al.* (1955). Direct and indirect effects through path analysis were calculated as described by Dewey and Lu (1959).

Weather conditions and seasonal effects

Total rainfall during the crop season was 622.3mm with evaporation being 624.5mm. The distribution of rainfall was highly erratic over the entire season. Jointing in wheat started around mid-February and heading occurred from the end of March to middle of May. The rainfed experiment suffered from drought stress in the initial critical crop growth stage i.e., crown root initiation, had intermittent rainfall at tillering and jointing stages, and post-anthesis stress was also experienced by the crop.

Results and Discussion

A wide range of variation was observed among different wheat genotypes with regard to all characters (Table1). A perusal of the phenotypic and genotypic coefficients of variation (PCV and GCV) indicated that PCV was generally higher than GCV for all the characters, but in some cases, the two values differed only slightly. Under drought stress environments, high PCV values were shown by grain yield attributes, *viz.*, grain weight per spike, grains per spike, biological yield, harvest index and tillers/m^2.

The heritability estimates ranged from 37.70 to 89.50% for harvest index under E_2 and grains per spike, under drought stress (E_1) environment, respectively. However, under irrigated environment, it ranged from 37.70 to 86.20% for harvest index and days to maturity, respectively. High heritability estimates under E_1 were observed for tillers/m^2, grains per spike, grain weight per spike, plant height and days to maturity. Interestingly, under E_2 also these traits exhibited high h^2 except tillers/m^2.

Table 1. Range, mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance of some characters in wheat under moisture stress (E_1) and irrigated (E_2) environments

Character	Env.	Range	Mean	S.E.(±)	PCV (%)	GCV (%)	Heritability	Genetics advance
Grain yield	E_1	235.33-744.33	534.20	15.77	9.97	40.00	40.00	12.99
	E_2	321.66-1286.66	845.26	88.95	16.44	13.00	62.60	21.20
Tillers/m^2	E_1	77.13-204.00	149.80	9.63	20.02	18.41	84.50	35.04
	E_2	94.00-264.00	193.09	19.73	22.19	18.32	68.32	31.17
Grains/spike	E_1	20.00-61.00	47.68	2.63	20.90	19.77	89.50	38.54
	E_2	29.00-72.00	58.94	3.60	17.64	15.98	82.00	29.81
1000-grain weight (g)	E_1	31.14-48.52	36.41	1.76	12.56	11.06	77.06	20.06
	E_2	37.51-53.89	46-06	1.96	10.57	9.19	75.60	16.48
Grain weight/spike (g)	E_1	0.69-2.21	1.73	0.12	22.34	20.55	84.70	38.92
	E_2	1.08-3.58	2.71	0.19	20.54	18.63	82.30	34.83
Plant height (cm)	E_1	55.54-82.21	71.03	2.78	11.14	10.08	81.90	18.79
	E_2	63.58-92.52	79.24	2.68	9.78	8.85	82.00	16.57
Flag leaf area	E_1	25.79-42.02	32.34	2.69	14.87	10.82	52.90	16.20
	E_2	30.08-52.06	38.61	2.56	15.23	12.88	71.50	22.45
Days to maturity	E_1	138.00-165.66	152.66	1.81	4.43	4.18	89.20	8.13
	E_2	153.00-173.00	165.57	1.55	3.10	2.88	86.20	5.51
Biological yield (g)	E_1	883.33-2403.33	1830.77	207.49	23.56	19.00	65.20	31.61
	E_2	100.00-3700.00	2414.00	345.17	29.36	23.57	64.40	38.97
Harvest index	E_1	20.03-39.90	29.73	3.09	20.30	15.82	60.70	25.39
	E_2	22.84-47.91	35.61	4.95	21.58	13.25	37.70	16.76
ELWR after 48 hr at T	E_1	5.00-15.00	10.36	0.95	17.09	14.40	71.02	25.00
IDR (%)	E_2	45.06-119.64	75.57	7.26	26.17	20.19	59.54	32.10

IDR=Index of drought resistance, ELWR=Excised leaf water retention, T=Tillering

The expected genetic advance, expressed as a percent of the mean, varied from 8.13 for days to maturity to 38.92 for grain weight per spike under moisture stress environment, while under irrigated environment it ranged from 5.51 for days to maturity to 38.97 for biological yield. Comparatively high genetic advance values were observed for tillers/m^2 and grains per spike under moisture stress environment. Grain weight per spike also exhibited high expected gain under irrigated conditions. The comparison of range of mean values under drought stress and irrigated environments revealed that range was generally higher under irrigated environment for almost all the traits, thereby indicating reduced variability under drought stress. Turner (1986), Ludlow and Muchow (1990) also reported the reduction in variability under water deficits. In this study, as in many other crops, grain yield had the lower heritability estimates with a relatively low value for genetic advance. Under drought stress environment, tillers/m^2, grains per spike and grain weight per spike showed high heritability coupled with high genetic advance, indicating effective selection for these characters under drought stress conditions. Moderate heritability and genetic advance for 1000-grain weight, biological yield, harvest index and excised leaf water retention at tillering suggested moderate expected grain by exercising selection for these characters.

The association of the above mentioned yield attributes and morpho-physiological characters as well with grain yield and the drought tolerance indices, thus assumes a special importance as the basis for selecting high yielding and drought tolerant strains.

The magnitude of correlation of different plant traits with grain yield under irrigated (E_2) environment was higher in most of the cases compared to drought stress (E_1) environment (Table 2).

Table 2. Phenotypic correlation coefficients among various characters in wheat under moisture stress (E_1) and irrigated (E_2) environments

Character	Env.	Tillers/m^2	Grains/ spike	1000-grain weight	Grain weight/ spike	Plant height	Flag leaf area	Days to maturity	Biological yield	Harvest index	ELWR	S	IDR
Grain yield (g)	E_1	0.43*	0.48*	0.38	0.24	0.08	-0.03	0.33	0.64*	0.42*	-0.24	0.39	0.09
	E_2	0.54*	0.64*	0.04	0.55*	0.23	0.24	0.18	0.78*	0.35*	-	0.77*	0.28
Tillers/m^2	E_1		0.06	-0.46*	-0.40*	-0.23	-0.08	0.12	0.40*	0.09	0.13	-0.03	-0.11
	E_2		0.15	0.31	-0.02	-0.14	0.03	0.24	0.52*	0.04	-	0.46*	-0.41
Grains/spike	E_1			0.43*	0.82*	0.32	0.09	0.27	0.26	0.40*	0.24	0.32	0.04
	E_2			0.10	0.87*	0.37	0.15	0.29	0.50*	0.45*	-	0.55*	-0.29
1000-grain weight (g)	E_1				0.44*	0.21	-0.01	0.19	0.41	0.08	0.01	0.13	0.31
	E_2				0.56*	0.39	0.26	0.02	0.02	0.02	-	0.19	0.02
Grain weight/spike (g)	E_1					0.39	-0.08	0.13	0.02	0.40*	0.21	0.22	0.10
	E_2					0.38	0.46*	0.24	0.43*	0.40*	-	0.49*	-0.21
Plant height (cm)	E_1						0.08	0.05	-0.12	0.22	-0.20	0.09	0.02
	E_2						0.04	0.06	0.21	0.00	-	0.22	0.13
Flag leaf area (cm^2)	E_1							-0.12	0.44*	-0.28	0.08	-0.25	0.01
	E_2							0.24	0.45*	-0.28	-	0.31	-0.26
Days to maturity	E_1								0.23	-0.38	-0.13	0.04	0.51*
	E_2								0.04	-0.06	-	0.32	0.31
Biological yield (g)	E_1									-0.40*	-0.30	0.42*	-0.45*
	E_2									0.27	-	0.69*	-0.53*
Harvest index (%)	E_1										0.00	0.04	0.51*
	E_2											0.32	0.31
ELWR after 48 hr at T (%)	E_1											-	0.70*-
S	E_2											0.40*	-0.53*

Significant at ≤ 0.05; IDR=Index of drought resistance; ELWR=Excised leaf water retention; S=Drought susceptibility index; T= Tillering stage

Grain yield showed positive correlation with biological yield, grains/ spike, tillers/m^2 and harvest index under both the environments. Grain yield alos exhibited significant positive correlation with grain weight/ spike and drought susceptibility index (S) under E_2.

Grain weight per spike exhibited positive correlation with harvest index in E_1, while under E_2, this trait showed positive correlation with flag leaf area, harvest index, biological yield and 'S'. Biological yield appears to be an important character, as it had positive association with the traits namely, grain yield, tillers/m^2, flag leaf area and drought susceptibility index (S) under both the environments. In addition, biological yield showed positive association with 1000-grain weight, but negative with harvest index under drought stress. Moreover, under both the environments, biological yield had significant negative correlation with index of drought resistance. Harvest index showed positive association with index of drought resistance and negative with biological yield under moisture stress conditions.

Excised leaf water retention (ELWR) had poor association with grain yield, its components and other morpho-physiological traits. However, Ashraf *et al.* (1996) and Ashok and Sharma (2006) have reported positive association of relative water content, a drought tolerance trait with grain yield under drought stress environments. As referred to in the earlier section, ELWR had negative correlation with 'S', but positive with IDR (the two important indices of drought tolerance). Drought susceptibility index was negatively correlated with IDR. Positive correlation of grain yield with tillers/m', grains per spike, yield and harvest index under both the environments indicated that selection for these traits under irrigated environment will result in correlated yield improvement under drought stress conditions also. Further, significant positive correlation of harvest index with grains per spike, grain weight per spike and IDR, suggested harvest index to be amenable for yield improvement under drought stress conditions. Grain weight per spike exhibited negative correlation with tillers/m^2 indicating that high tillering genotypes suffer reduced grain weight under stress conditions.

Table 3. Direct and indirect genetic effects via various paths of yield related attributes on grain yield under drought stress (E_1) and irrigated (E_2) environments

Character	Env.	Tillers/m^2	Grains/ spike	1000-grain weight	Grain weight/ spike	Plant height	Flag leaf area	Days to maturity	Harvest index	Biological yield	Correlation coefficient with grain yield
Tillers/m^2	E_1	0.06	0.36	0.05	-0.13	-0.04	0.01	-0.01	0.03	0.35	0.54*
	E_2	0.11	-0.12	0.22	-0.05	-0.03	0.00	-0.01	0.14	0.41	0.67*
Grains/spike	E_1	0.00	-0.27	0.01	0.31	0.09	0.06	-0.70	0.01	0.23	0.72*
	E_2	0.02	-0.78	0.12	0.89	0.04	0.01	0.01	0.13	0.51	0.72*
1000 -grain weight (g)	E_1	-0.03	0.04	-0.10	0.15	0.04	0.03	0.01	0.04	-0.54	0.45*
	E_2	0.00	-0.13	-0.51	0.60	0.04	0.01	0.00	-0.05	0.03	0.06
Grain weight/spike (g)	E_1	-0.02	-0.23	0.04	0.38	0.11	0.09	-0.09	0.10	-0.07	0.29
	E_2	-0.01	-0.70	-0.36	1.01	0.05	0.02	-0.01	0.12	0.42	0.60*
Plant height (cm)	E_1	-0.02	-0.22	-0.03	0.25	0.16	0.01	0.00	0.07	-0.13	0.16
	E_2	-0.03	-0.34	-0.25	0.57	0.08	0.01	-0.02	0.05	0.10	0.22
Flag leaf area	E_1	-0.02	0.03	0.05	-0.06	-0.01	-0.39	0.01	-0.01	0.23	-0.14
	E_2	0.01	-0.17	-0.14	0.32	0.00	0.19	0.01	-0.23	0.47	0.26
Days to maturity	E_1	-0.03	0.26	0.04	-0.30	-0.01	0.17	0.03	-0.36	0.04	-0.40*
	E_2	0.01	-0.07	0.04	0.04	0.01	0.08	0.04	-0.02	0.23	0.25
Harvest index	E_1	0.01	-0.12	-0.02	0.19	53.00	0.22	0.00	0.22	-0.21	0.48*
	E_2	0.04	-0.29	-0.07	-0.34	0.02	-0.03	-0.02	0.37	0.12	0.57*
Biological yield (g)	E_1	0.02	-0.08	0.06	-0.03	-0.02	-0.14	-0.01	-0.09	0.83	0.71 *
	E_2	0.06	-0.51	-0.02	0.55	0.01	0.03	0.00	0.05	0.75	0.89*

Residual effect: $E_1 = 0.2352$; $E_2 = 0.2986$

Interestingly, ELWR had significant negative correlation with drought susceptibility index and positive with IDR, indicating that genotypes with high ELWR at tillering stage would be more drought tolerant. Significant negative correlation of 'S' and IDR indicated that IDR can be used as a simple reliable criterion for assessing drought tolerance at seedling stage.

A perusal of the direct and indirect effects (Table 3) delineate that under drought stress (E_1) environment, biological yield exhibited highest positive direct effect on grain yield, followed by grain weight per spike, harvest index and plant height, whereas, flag leaf area and grains per spike exhibited high negative direct effects. However, under irrigated (E_2) environment, grain weight per spike had the highest positive direct effect on grain yield followed by biological yield, harvest index and tillers/m^2. The high positive direct effect of grain weight per spike was counter-balanced by its negative indirect effect via grains per spike. Significant positive correlation of harvest index with grain yield under drought stress environment was mainly due to its positive direct effect and indirect effects via flag leaf area and grain weight per spike.

Conclusively, biological yield, grain weight per spike and harvest index due to their high direct and indirect effects via other traits appear to be the characters of importance worth considering while selecting for grain yield under such environments. Besides these, excised leaf water retention and IDR have emerged to be the important criteria for selection of drought tolerant genotypes in wheat. Index of Drought Resistance can be used to screen germplasm at an early growth stage.

References

Ashok Kumar and Sharma SC 2006. Selection criteria for drought tolerance in bread wheat. Him. J. Agric. Res.**32** (1):27-30.

Ashraf MY, Naqvi MH and Khan AH 1996. Evaluation of four screening techniques of drought tolerance in wheat.(*Triticum aestivum* L.). Acta Agronomica Hungarica **44**:213-20.

Blum A 1989. Breeding for drought resistance. In: *Plants under stress eds* Jones HG, Flower TF and Jones MB ,Cambridge Univ Press, Cambridge.

Burton GW and De Vane EH 1953 .Estimating heritability in tall fescue (*Festuca arundinacea* L.) from replicated clonal material. Agron J. **45**:478-81.

Dewey DR and Lu KH 1959. A correlation and path coefficient analysis of components of crested wheatgrass seed production. Agron J. **51**:515-18.

Fischer RA and Maurer R 1978. Drought resistance in spring wheat cultivars: Grain yield responses. .Aust. J. Agric. Res. **29**:897-912.

Johnson HW, Robinson HF and Comstock RE 1955. Estimates of genetic and environmental variability in soybean. Agron. J. **47**:314-18.

Latyuk GI 1989. Drought resistance of winter wheat varieties during germination period In:Inpol'zovanie iskustvennogo – Klimata V selektsionn-geneticheskikh issledovaniyakh. Odessa Ukrainian SSR 29-33 From Referativynyi Zhurnal **2**:65-86.

Ludlow M and Muchow RC 1990. A critical evaluation of traits for improving crop yields in water limited environments. Adv. Agron. **43**:107-53.

Randhawa AS, Sharma SK and Dhaliwal HS 1988. Screening for drought tolerance in wheat. Crop Improv. **15** (l):61-64.

Schonfield MA, Johnson RC, Carver BF and Mornhinweg DW 1988. Water relation in winter wheat as drought resistance indicators. Crop Sci. **28**:526-31.

Turner NC 1986. Crop water deficits: A decade of progress Adv. Agron. **39**:1-51.

Winter SR, Musick JT and Porter KB 1988. Evaluation of screening techniques for breeding drought resistant winter wheat. Crop Sci. **28** (3):512-16.