JOURNAL OF AGRICULTURE & SOCIAL SCIENCES
1813–2235/2007/03–2–59–62
http://www.fspublishers.org

Analysis of Variability and Relationship among Seedling Traits and Plant Height in Semi-Dwarf Wheat (*Triticum aestivum* L.)

SHAHID IQBAL AWAN[1], SHAHID NIAZ, MUHAMMAD FAISAL ANWAR MALIK AND SHIRAZ ALI
Barani Agricultural Research Station, Fateh Jang-Pakistan
[1]Corresponding author's e-mail: shahid1857@yahoo.com

ABSTRACT

Ten genotypes of semi dwarf wheat were sown at Barani Agricultural Research Station, Fatehjang to study the genetic variability and relationship among seedling traits and plant height. Analysis of variance showed highly significant differences among the genotypes for all the traits studied except for dry shoot weight. The estimates of genotypic variance for plant height (75.04) were found highest among the traits followed by shoot length (3.36). Heritability estimates in general were higher in magnitude for all the traits except for dry shoot weight (25%). The simple correlation coefficient for coleoptile length showed positive and significant correlation with root length. Correlation coefficient was negative and non-significant for fresh shoot weight and plant height for coleoptile length. Two components with eigen value > 1 contributed 79% of the variability amongst the genotypes studied. Genotypes, which have longer coleoptile, root and shoot lengths tended to have reduced fresh shoot weight, dry shoot weight and plant height. The genotypes were grouped into two clusters based on average linkage.

Key Words: *Triticum aestivum* L; Correlation; Variation; Seedling traits; Plant height

INTRODUCTION

Early vigour is considered an essential component of crop plant development under most environmental conditions (Ludlow & Muchow, 1990; Khan *et al.,* 2002). Crop varieties with early seedling vigour and good stand establishment tend to maximize the use of available soil water, resulting in increased dry matter accumulation and improved grain yield. Simple plant characteristics such as kernel weight, percentage germination, seedling weight and height have been identified as good indicators of seedling vigour (Regan *et al*., 1992; Awan *et al.,* 2005). As short coleoptile in dwarf and semidwarf varieties are primarily associated with poor seedling emergence under dryland farming, hence high yielding dwarf wheat varieties have not been properly exploited in the rainfed areas (Sharma *et al*., 1982). Fick and Qualset (1976) reported that culm length was closely correlated with coleoptile length and seedling emergence. They suggested that the genetic mechanism that governed culm length also influenced coleoptile length.

Plant height is a quantitative character affected considerably by aneuploid conditions, which have made it cumbersome to determine the number of dwarfing genes or the type of gene action. These genes reduced plant height by decreasing the sensitivity of reproductive and somatic tissues to endogenous gibberellins. The reduced cell elongation results in a decreased internode length, shorter plant height, shorter coleoptile length and smaller seedling leaf area (Keyes *et al*., 1989; Hoogendoorn *et al*., 1990; Beharev *et al*., 1998; Worland *et al*., 1998; Rebetzke *et al.,* 2006). In contrast, Konzak *et al*. (1969) observed that short culm length was associated with long coleoptile in a mutant of wheat variety, thus ruling out the possibility of pleiotropy between these two traits. Scarascia-Mugnozza and Porcedu (1973) also have indicated the possibility of developing variety with short culm and long coleoptile. Agrawal *et al.* (1977) screened hundred wheat varieties and found some triple dwarf varieties with longer coleoptile and good seedling vigour. Dwarf wheat lines having long coleoptile and peduncle were identified in the segregating progenies (Sharma *et al*., 1982). Determination of correlation coefficients between different parameters is important to select favorable plant types. Although direct selection for various parameters could be misleading, indirect selection via related parameters with high heritability might be more effective than direct selection (Toker & Cigirgan, 2004). Traditionally, correlation, regression and path coefficient analysis have been used in determining character interrelationships (Toker & Cagirgan, 2003). However, considering many traits simultaneously requires that the dimensionality of the data set be reduced. Factor analysis is designed to do this (Godschalk & Timothy, 1988). It has been shown that factor analysis is a multivariate statistical method that can be successfully utilized in understanding the patterned variation in a set of variables based on structural relationships among them. Factor analysis was commonly implicated in cereals (Walton, 1971, 72; Lee & Kaltsikes, 1973; Cagirgan & Yildirim, 1990).

In the light of this information present studies were initiated to investigate the genetic variability, pattern of variability and relationship among seedling traits especially of coleoptile length and plant height in some existing wheat varieties and the advanced lines developed at Barani Agricultural Research Station, Fatehjang.

MATERIALS AND METHODS

Ten genotypes of semi dwarf wheat were sown at Barani Agricultural Research Station, Fatehjang during October 2005 using triplicated randomized complete block design. Genotypes included approved varieties namely Rawal 87, Inqlab 91, Chakwal 97, Bhakkar 2002, GA 2002 and advanced lines developed at BARS, Fatehjang viz., 99FJ03, 00FJ03, 01FJ14, 02FJ01. After one week of germination ten seedlings per unit were up-rooted and washed carefully in tap water to remove soil particles. Before up-rooting the seedlings the soil was watered to avoid damage to the roots. Rest of the seedlings, were allowed to grow in the field to reach maturity. Plant and row spacing was kept 30 cm and 60 cm, respectively. All the cultural practices were uniformly applied to all the experimental units during the course of the experiment. Data on parameters like coleoptile length (cm), root length (cm), shoot length (cm), fresh root weight (g) and dry shoot weight (g) were recorded at seedling stage while that of plant height (cm) were recorded at physiological maturity. The means thus obtained were subjected to analysis of variance using computer programme MSTAT-C. Genetic components of variance were obtained as outlined by Johnson *et al.* (1956) and Mahmud and Kramer (1951). Heritability estimates were calculated as Allard (1960). Phenotypic correlation coefficients were worked out between the traits following Snedecor (1956). Simple statistics and numerical taxonomic techniques were analyzed using the procedure of cluster and principal component analysis (Sneath & Sokal, 1973) with the help of computer software 'Statistica' and 'SPSS' 12.0 for Windows. Cluster analysis was conducted on the basis of average distance of k-means and the accessions in each cluster were then analyzed for basic statistics.

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences among the genotypes for all the traits studied except for dry shoot weight, suggesting genetic differences among genotypes (Table I). Subdividing variance into its components assists in genetic resources conservation and their utilization. It enables planning for use of appropriate gene pools in crop improvement for specific plant attributes (Ghafoor *et al*., 2001). The estimates of genotypic variance for plant height (75.04) were found highest among the traits followed by shoot length (3.36), indicating the presence of greater genetic variability for these traits (Table II). Heritability estimates in general were higher in magnitude for all the traits except for dry shoot weight (25.00%). Heritability was recorded highest for root length (99.71%) followed by coleoptile length (99.48%), plant height (97.73%), shoot length (91.71%) and fresh shoot length (75.00%), which suggested that selection for these traits will be effective in future breeding programs. Most of these results are in conformity with the findings of Awan *et al.* (2005) and Khan *et al*. (2002).

Mean values of the genotypes indicated that the coleoptile length was highest for Kohistan 97 (6.28 cm) and Bhakkar 2002 (6.15 cm) followed by 00FJ03 (5.30 cm). Chakwal 97 (7.83 cm) demonstrated highest values for root length followed by Bhakkar 2002 (6.56 cm). For seedling length Kohistan 97 (18.20 cm), Bhakkar 2002 (17.94 cm) and Chakwal 97 (17.80 cm) were superior. Fresh shoot weight and dry shoot weight were recorded higher for Chakwal 97 (0.73 & 0.48 gm), Bhakkar 2002 (0.63 & 0.53 gm) and 01FJ14 (0.70 & 0.54 g). Plant height was maximum for 01FJ14 (115.63 cm) closely followed by Chakwal 97 (112.13 cm). Mean values indicated that Bhakkar-2002 was exclusive among all the genotypes for most of the seedling traits and was also one of the lowest in plant height indicating that dwarfing genes could not influence much in reducing seedling vigour. Bhakkar 2002 is expected to perform better in areas, where depleted soil surface moisture enforces the planting depth to be increased so that seed is placed in soil with proper moisture contents. Chalwal 97 exhibited some promising characters but it was among the tallest of the genotypes, which offsets its credibility as taller varieties are prone to lodging in high rainfall years. The genotypes developed at BARS, were poor in seedling vigour. Only 01FJ14 showed some promise in root length, fresh and dry shoot weight. Breeding efforts should be diverted towards the development of strains with improved seedling vigour.

Simple correlation coefficient for coleoptile length showed positive and significant correlation with root length, whereas it was positively and highly significantly correlated with shoot length (Table III). Correlation coefficient was negative and non-significant for fresh shoot weight and plant height for coleoptile length. Root length showed positive and highly significant correlation for almost all the traits. Shoot length showed positive but non-significant correlation with fresh shoot weight and plant height; but it was positively and significantly correlated with dry shoot weight. Fresh shoot weight exhibited highly significant and positive correlation with dry shoot weight and plant height. Dry shoot weight also showed highly significant and positive correlation with plant height.

Two components with eigen value > 1 were extracted. They contributed 79% of the variability amongst the genotypes studied (Table IV). PC I and II explained 50.23% and 29.28%, respectively of total variance explained. The first PC was more related to root length, fresh shoot weight and dry shoot weight. All the characters contributed negatively to PC I. The characters with the greatest negative weight on this factor were root length, fresh shoot weight and dry shoot weight. The parameters with greatest positive weight on PC II were coleoptile length and seedling length. Root length also contributed positively to this component. Whereas, fresh shoot weight, dry shoot weight and plant height had negative weight. These finding suggest that those

Table I. Analysis of variance of seedling traits studied in wheat genotypes

SOV	df	CL	RL	SL	FSW	DSW	PH
Blocks	2	6.99**	1.86**	1.86**	0.11**	0.06**	7.69**
Genotypes	9	1.74**	3.11**	10.38**	0.05**	0.01^{NS}	226.87**
Error	18	0.003	0.003	0.304	0.005	0.005	1.74

** Significant at p<0.01
^{NS} Non-significant
Where as, CL = Coleoptile length, RL = Root length, SL = Seedling length, FSW = Fresh shoot weight, DSW = Dry shoot weight and PH = Plant height.

Table II. Means (x), genotypic variance (δg), phenotypic variance (δp) environmental variance (δe) and broad sense heritability (h^2) of seedling traits in wheat genotypes

	CL	RL	SL	FSW	DSW	PH
Rawal 87	4.94	6.08	15.64	0.57	0.41	103.65
Inqlab 91	4.86	5.96	14.70	0.50	0.44	100.65
Chakwal 97	5.53	7.83	17.84	0.73	0.48	112.13
Kohistan 97	6.28	5.09	18.20	0.30	0.36	99.13
Bhakkar 2002	6.15	6.56	17.94	0.63	0.53	94.91
GA 2002	4.18	4.24	12.45	0.40	0.39	103.78
99 FJ 03	4.76	4.88	13.89	0.57	0.40	99.63
00FJ 03	5.30	5.06	16.08	0.60	0.42	100.57
01 FJ 14	4.28	6.24	15.51	0.70	0.54	115.63
02 FJ 01	4.22	5.68	15.17	0.47	0.41	84.07
Means (x)	5.05	5.76	15.74	0.55	0.44	101.42
δg	0.58	1.04	3.36	0.02	0.00	75.04
δp	0.57	1.03	3.66	0.01	0.01	76.78
δe	0.003	0.003	0.304	0.005	0.005	1.74
h^2 (bs)%	99.48	99.71	91.70	75.00	25.00	97.73

Table III. Simple correlation coefficients of seedling traits studied in wheat genotypes

Traits	CL	RL	SL	FSW	DSW
RL	0.299*				
SL	0.850**	0.619**			
FSW	-0.032^{NS}	0.707**	0.222^{NS}		
DSW	0.045^{NS}	0.669**	0.304*	0.785**	
PH	-0.054^{NS}	0.324*	0.035^{NS}	0.499**	0.377**

* Significant at P<0.05
** Significant at p<0.01
^{NS} Non-significant

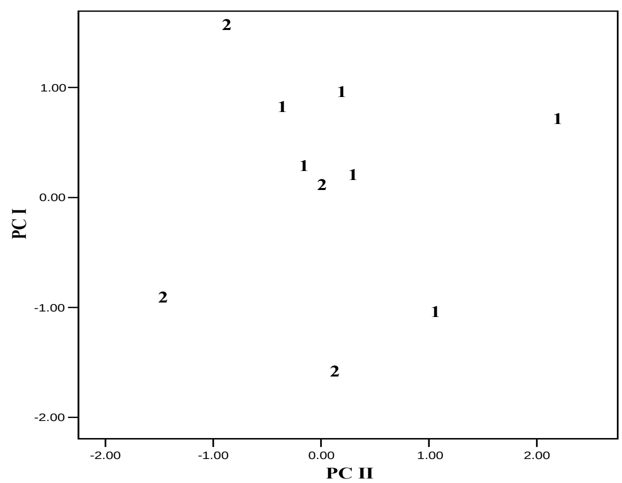
Table IV. Principal Components (PCs) for seedling traits in wheat genotypes

Traits	PC I		PC II	
Eigen value	3.01		1.76	
Total Variance (%)	50.23		29.28	
Cum. Eigen value	3.01		4.77	
Cumulative %	50.23		79.51	
	Communalities		Factor Loadings	
	PC I	PC II	PC I	PC II
CL	0.162	0.896	-0.402	0.857
RL	0.814	0.815	-0.902	0.038
SL	0.442	0.957	-0.665	0.717
FSW	0.682	0.869	-0.826	-0.432
DSW	0.662	0.770	-0.814	-0.329
PH	0.252	0.464	-0.502	-0.460

Table V. Means, standard deviations and variances for clusters based on seedling traits

Characters	Cluster I		Cluster II	
	Mean ± SD	Variance	Mean ± SD	Variance
CL	5.26 ± 0.82	0.67	4.73 ± 0.63	0.40
RL	5.54 ± 0.65	0.42	6.10 ± 1.47	2.16
SL	16.00 ± 1.76	3.09	15.36 ± 2.22	4.91
FSW	0.51 ± 0.12	0.01	0.60 ± 0.15	0.02
DSW	0.43 ± 0.06	0.00	0.45 ± 0.07	0.00
PH	96.49 ± 6.44	41.53	108.80 ± 6.04	36.52

Fig. 1. Scatter plot of wheat genotypes for two PCs
The digits 1 and 2 represent the cluster numbers



genotypes, which have longer coleoptile, root and shoot lengths tend to have reduced fresh shoot weight, dry shoot weight and plant height. While those having shorter lengths of coleoptile, root and shoot tend to have larger plant height and more fresh and dry shoot weight. Hence the strong correlation between seedling vigour especially of coleoptile length and plant height was found to be missing. These results are in close agreement with the findings of Konzak *et al*. (1969), Scarascia-Mugnozza and Procedu (1973), Agrawal *et al*. (1977) and Sharma *et al*. (1982).

The genotypes were grouped into two clusters based on average linkage. Mean values along with standard deviations (SD) for each cluster (Table V) revealed that the genotypes included in cluster I had longer coleoptiles and shoots but reduced in plant height. While those included in cluster II were having larger root length, dry and fresh shoot lengths and plant height. Plant height and seedling length showed highest values for variance in both the clusters, indicating greater magnitude of variability among genotypes for both the traits. The two principle components were plotted to observe relationship between the clusters (Fig. 1). Scatter plot diagram indicated that the two clusters displayed clear separation from each other. Cluster II was not clearly separated, which might be due to mixture of accessions with different traits, especially plant height as all the accessions with higher plant height were grouped in this cluster.

REFERENCES

Agrawal, R., K.R. Sharma, G.S. Sharma, R.B. Singh and R. Nandan, 1977. Variability and association of coleoptile length and other traits in wheat. *Indian J. Agric. Sci*., 47: 234–6

Allard, R.M., 1960. *Principles of Plant Breeding*. John Willey and Sons, Inc., USA

Awan, S.I., M.F.A. Malik and M. Siddique, 2005. Study on seedling traits for drought tolerance in wheat under moisture stress conditions. SAARC. *J. Agric*., 3: 247–54

Beharev, A., A. Cahaner and M.J. Pinthus, 1998. Genetic correlations between culm length, grain yield and seedling elongation within tall (*rht1*) and semi-dwarf (*Rht1*) spring wheat (*Triticum aestivum* L.). *European J. Agron*., 9: 35–40

Cagirgan, M.I. and M.B. Yildirim, 1990. An application of factor analysis to data from control and macro mutant populations of 'Quantum' barley. *J. Faculty Agric. Akdeniz University*, 4: 125–38

Fick, G.N. and C.O. Qualset, 1976. Seedling emergence, coleoptile length and plant height relationship in crosses of dwarf and standard height wheats. *Euphytica*, 25: 679–84

Ghafoor, A., A. Sharif, Z. Ahmad, M.A. Zahid and M.A. Rabbani, 2001. Genetic diversity in blackgram (*Vigna mungo* L. Hepper). *Field Crops Res*., 69: 183–90

Godschalk, E.B. and D.H. Timothy, 1988. Factor and principal component analysis as alternative to index selection. *Theor. Appl. Genet*., 76: 352–60

Hoogendoorn, J., J.M. Rickson and M.D. Gale, 1990. Differences in leaf and stem anatomy related to plant height of tall and dwarf wheat. *J. Pl. Physiol*., 136: 72–7

Johnson, H.W., H.F. Rodinson and R.E. Cronstrock, 1956. Estimation of genetic and environment variability in soybeans. *Agron. J*., 47: 314–8

Keyes, G.J., D.J. Paolillo and M.E. Sorrells, 1989. The effects of dwarfing genes *Rht1* and *Rht2* on cellular dimensions and rate of leaf elongation in wheat. *Annl. Bot*., 64: 683–90

Khan, M.Q., S. Anwar and M.I. Khan, 2002. Genetic variability for seedling traits in wheat (*Triticum aestivum* L.) under moisture stress conditions. *Asian J. Pl. Sci*., 5: 588–90

Konzak, C.F., S.C. Woo and J. Dickey, 1969. An induced dominant semidwarf plant height mutation in spring wheat. *Wheat Info. Ser*., 28: 10

Lee, J. and P.J. Kaltsikes, 1973. Multivariate statistical analysis of grain yield and agronomic characters in durum wheat. *Theor. Appl. Genet*., 43: 226–31

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

Mahmud, I. and H.H. Kramer, 1951. Segregation for yield, height and maturity following a soybean cross. *Agron. J*., 43: 605–9

Rebetzke, G.J., R.A. Richards, V.M. Fischer and B.J. Mickelson, 2006. A breeding solution to improve seedling establishment of wheat. *Proceedings of 13th Australian Agronomy Conference, 10-15 September.* Perth, WA

Regan, K.L., K.H.M. Siddique, N.C. Turner and B.R. Whan, 1992. Potential for increasing early vigor and total biomass in spring wheat. 2. Characteristics associated with early vigor. *Australian J. Agric. Res*., 43: 541–53

Scarascia-Mugnozza, G.T. and E. Porcedu, 1973. Genetic studies of coleoptile length in T. durum. *Proceedings 4th International Wheat Genetics Symptoms*, pp: 301–8

Sharma, G.S., R. Paliwal and R.B. Singh, 1982. Interrelationship between coleoptile length, seedling height, culm length, yield and their traits in wheat. *Indian J. Genet*., 42: 172–5

Sneath, P.H.A. and R.R. Sokal, 1973. *Numerical Taxonomy: The Principles and Practices of Numerical Classification,* p: 573. W.F. Free-man and Co., San Francisco

Snedecor, G.W., 1956. *Statistical Methods*. 5th edition. Iowa State University Press, Ames, Iowa, U.S.A

Toker, C. and M.I. Cagirgan, 2003. Selection criteria in chickpea (*Cicer arietinum*). *Acta Agric. Scandinavia (Sect. B, Soil Pl. Sci.)*, 53: 42–5

Toker, C. and M.I. Cigirgan, 2004. The use of phenotypic correlation and factor analysis in determining characters for grain yield selection in chickpea (*Cicer arietinum* L.). *Heriditas*, 140: 226–8

Walton, P.D., 1971. The use of factor analysis in determining characters for yield selection in wheat. *Euphytica*, 20: 416–21

Walton, P.D., 1972. Factor analysis of yield in spring wheat (*Triticum aestivum* L.). *Crop Sci*., 12: 731–3

Worland, A.J., V. Korzun, M.S. Roder, M.W. Ganal and C.N. Law, 1998. Genetic analysis of the dwarfing gene Rht in wheat. Part II. The distribution and adaptive significance of allelic variants at the *Rht* locus of wheat as revealed by microsatellite screening. *Theor. Appl. Genet*., 96: 1110–20

(Received 01 August 2006; Accepted 20 December 2006)