INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–2–287–290
http://www.fspublishers.org

Correlation Studies among Yield and its Components in Bread Wheat under Drought Conditions

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ABSTRACT

Correlation studies were undertaken for ten yield related traits in two bread wheat crosses derived from crossing Kohistan-97 (high yielding) with Inqlab-91 (medium yielding) and Chakwal-86 (low yielding) under drought conditions. In general genetic correlation coefficients were greater than the corresponding phenotypic correlations. Grain yield per plant showed a positive and significant correlation with flag leaf area, tillers per plant, spike length, grains per spike, grain weight per spike and 1000-grain weight in both the crosses. The interrelationship between these traits showed that they are under the control of certain common genes, which can be exploited as selection criteria in breeding programs. The positive selections for one trait would also improve the other correlated traits. The interrelationship among these traits studied revealed that grain yield could be efficiently increased by obtaining maximum expression of tillers per plant, spike length, grains per spike and 1000-grain weight under drought conditions. The varieties Kohistan-97 and Inqlab-91 may be used in breeding programs to tailor for drought resistance in wheat.

Key Words: Wheat; Drought resistance; Correlation; Genes

INTRODUCTION

Information on association of yield and yield contributing traits could be useful in selection of drought tolerant/resistant genotypes. Further correlation studies among yield contributing traits may help in indirect selection of yield components. Correlation is a pragmatic approach to develop selection criteria for accumulating optimum combination of yield contributing traits in a simple genotype. Phenotypic and genetic correlations have been conducted in wheat. Sukhorukov (1989) reported reduction in grains per ear, 100-grain weight revealed low yield in wheat under drought conditions. Selection was recommended for increased spikelets per ear as it was correlated with gains per ear under drought conditions. Similarly, Atale and Zope (1991) reported that optimum selection criteria under drought condition in wheat were ears per plant, days to flowering, grain weight per ear, 1000-grain weight and grain yield. However, Tiwari and Rawat (1993) reported that grain yield per plant in wheat was significantly and positively correlated with plant height, ear length, tillers per plant, spikelets per spike, biological yield and ears per plant. Sharma *et al.* (1995) found positive correlations between grain yield and plant height, grains per spike and harvest index, whereas Budak and Yildirim (1995, 1999) noted positive correlation of grain yield with harvest index and biomass. Similarly, Singh *et al.* (1995) reviewed that grain yield was positively correlated with grains per spike, total dry matter and harvest index, while negatively correlated with days to heading and maturity. They also reported positive correlation of spike length and grain yield, 100-grain weight and grain yield, total dry matter and harvest index, while negative correlation of harvest index with flag leaf area and grains per spike.

Deswal *et al.* (1996) reported in wheat that grain yield per spike showed a direct association with total biomass, grains per spike and 100-grain weight. Vaishnavi and Bural (1996) and Singh *et al.* (2002) reported that in general genotypic correlation coefficients were higher than the corresponding phenotypic values. Singh *et al.* (2002) also reported that grain yield exhibited positive correlation with grains per spike, spike length and 1000-grain weight, while grain weight per spike was positively correlated with 1000-grain weight and harvest index. The major yield contributing characters were grains per spike, spike length and 1000-grain weight. However, Rana and Sharma (1997) reported in wheat that grain yield showed positive correlation with biological yield, grains per spike, tillers per unit area and harvest index. Biological yield also showed positive correlation with grain yield, tillers per plant, 1000-grain weight and flag leaf area, while negative association with days to heading and harvest index. Ismail *et al.* (1999) and Attarbashi *et al.* (2002) reported that grain yield was associated with increase in biological yield, harvest index, grain number and grains per spike. Subhani and Chowdhry (2000) found a direct relationship of grain yield with flag leaf area, plant height, spike length, grains per spike, 1000-grain weight, biomass per plant and harvest index, while days to heading showed negative correlation with grain yield. The objective of the current study was to find the correlations among the yield and its components in order to tab and finalize the suitable criteria for yield improvement

under drought stress.

MATERIALS AND METHODS

The experimental material comprised of three wheat varieties Kohistan-97 (high yielding), Inqlab-91 (Medium yielding) and Chakwal-86 (low yielding). High yielding wheat variety Kohistan-97 was crossed with medium yielding (Inqlab-91) and low yielding (Chakwal-86) varieties to produce F_1s during 1997 - 98. Seed of the parents and F_1s were sown during 1998 - 99 to develop their back crosses (BC_1 & BC_2). All precautionary measures were ensured during the crossing operations to keep the avoid crossing materials free of contamination. The female parents were hand emasculated to produce enough seed and pollinated for all the crosses. Seed of the parents, F_1, F_2 and BC_1, BC_2 were space planted in the field under drought conditions during the wheat crop season (1999 - 2000). A triplicate randomized complete block design was used. A single 5 m length for each parent and F_1 generation, two rows for each back cross and three rows for each F_2 generation were planted. The distance between plant to plant and row to row was 15 and 30 cm, respectively. Non-experimental lines were also planted at the start and end of each replication to eliminate edge effects. The field was irrigated for seed bed preparation. After planting the populations, the experiment entirely depended upon natural precipitation and no surface irrigation was applied. All other operations were performed according to the standard practices. During 1999 - 2000 (July to June) 80.1 mm rainfall was received and out of which 22.6 mm was during the experiment i.e., November to April.

The data were recorded on the competitive plants for each character at maturity except days to heading, fourth and flag leaf area and stomatal frequency for which observations were made when the plants were green and leaves were fully expanded. Five plants were selected randomly for data recording from each row for each parent, F_1 back cross and ten plants for F_2 generations in each replication. Data on per plant basis for days to heading, flag leaf area, tillers per plant, spike length, grains per spike, grain weight per spike, 1000-grain weight, grain yield per plant, biomass per plant and harvest index were recorded. Phenotypic correlations (rp) between two traits x and y were calculated by using method of Kwon and Torrie (1964). The correlation between yield and its components were calculated from the F_2 population as:

$$rp = Covp\ (x, y) \sqrt{Vp\ (x), Vp\ (y)}$$

Where

Covp (x, y) = Mean product of xyth traits in F_2 generation.

VP (x) and VP (y) = Mean squares for xth and yth traits, respectively in F_2 generation.

The genetic correlations (rG) between two characters, x and y, were calculated by the formula of Falconer (1981).

$$rG = Covg\ (x,y) \sqrt{Vg\ (x), Vg\ (y)}$$

RESULTS AND DISCUSSION

Phenotypic correlations. Genotypic correlation coefficients, in general had higher magnitudes than the phenotypic ones, which was in line with the findings of Vaishnavi and Bural (1996) and Singh *et al.* (2002) that in general genotypic correlation coefficients were higher than the corresponding phenotypic values. Days to heading showed the negative association among most of the traits except tillers per plant and plant height in both the crosses (Table I & II). Singh *et al.* (1995), Rana and Sharma (1997) and Subhani and Chowdhry (2000) also reported similar findings in wheat. Flag leaf area was positively and significantly correlated with most of the studied traits but negatively with days to heading, grains per spike and harvest index (Singh *et al.*, 1995). Tillers per plant were positively correlated with almost all the traits in both the crosses (Table I & II) but negatively associated with days to heading Rana and Sharma (1997) also reported similar finds. Spike length showed positive association with all the traits, while negative with harvest index, 1000-grain weight and days to heading (Table I & II). Tiwari and Rawat (1993) and Sharma *et al.* (1995) also reported similar results. Positive and significant association of grains per spike was observed in all the studied traits except days to heading and flag leaf area (Table I & II). Attarbashi *et al.* (2002), Subhani and Chowdhry (2000), Singh *et al.* (1995) and Sharma *et al.* (1995) also reported the similar results. Grain weight per spike and 1000-grain weight were positively associated with all the traits, while negatively with days to heading in both the crosses (Table I & II). Singh *et al.* (1995) also reported that 100-grain weight showed positive correlation with other traits, while Singh *et al.* (2002) reported positive correlation of grain weight per spike and 1000-grain weight with grains per spike, spike length and harvest index (Table I & II). Grain yield per plant showed positive relationship with flag leaf area, tillers per plant, spike length, grains per spike and 1000-grain weight, while it showed no relationship with days to heading, biomass per plant and harvest index (Table I & II). These results confirm the findings of Singh *et al.* (2002), Subhani and Chowdhry (2000), Vaishnave and Bural (1996), Sharma *et al.* (1995), Singh *et al.* (1995) and Tiwari and Rawat (1993) and contrast with the findings of Attarbashi *et al.* (2002) Budak and Yildirim (1995, 99) and Ismail *et al.* (1999). Biomass per plant exhibited positive and significant phenotypic correlation with all the studied traits, while it showed negative association with days to heading, grain yield and harvest index Budak and Yildirim (1995, 99) and Rana and Sharma (1997) reported similar findings. Positive phenotypic correlation coefficients of harvest index with grains per spike, grain weight per spike and 1000-grain

Table I. Phenotypic correlation coefficients (rp) for yield and various quantitative traits of the cross Kohistan-97 x Chakwal-86

Trait	Days to heading	Flag leaf area	Tillers per plant	Spike length	Grains per spike	Grain weight per spike	1000-grain weight	Grain yield per plant	Biomass per plant
Flag leaf area	-0.054^{NS}								
Tillers per plant	0.094^{NS}	0.213**							
Spike length	-0.185**	0.130^{NS}	0.004^{NS}						
Grains per spike	-0.128^{NS}	0.166**	0.084^{NS}	0.199**					
Grain weight per spike	-0.287**	0.243*	0.080^{NS}	0.289**	0.803**				
1000-grain weight	-0.306**	0.146*	0.047^{NS}	-0.018^{NS}	0.185**	0.388**			
Grain yield per plant	-0.259**	0.278**	0.688**	0.129^{NS}	0.435**	0.563**	0.417*		
Biomass per plant	-0.197**	0.332*	0.776**	0.147*	0.354**	0.448**	0.318*	-0.071^{NS}	
Harvest index	-0.207*	-0.163*	-0.178^{NS}	-0.020^{NS}	0.339**	0.440**	0.336*	-0.073^{NS}	-0.030^{NS}

Table II. Phenotypic correlation coefficients (rp) for yield and various quantitative traits of the cross Kohistan-97 x Inqlab-91

Trait	Days to heading	Flag leaf area	Tillers per plant	Spike length	Grains per spike	Grain weight per spike	1000-grain weight	Grain yield per plant	Biomass per plant
Flag leaf area	-0.162*								
Tillers per plant	-0.115^{NS}	0.064^{NS}							
pike length	0.124^{NS}	0.003^{NS}	0.102^{NS}						
Grains per spike	-0.064^{NS}	-0.002^{NS}	0.083^{NS}	0.015^{NS}					
Grain weight per spike	-0.287**	0.173*	0.143*	0.139*	0.785**				
1000-grain weight	-0.428**	0.075^{NS}	0.197**	0.078^{NS}	0.035^{NS}	0.375**			
Grain yield per plant	-0.321^{NS}	0.261**	0.762**	0.147**	0.270**	0.455**	0.423**		
Biomass per plant	-0.256**	0.231**	0.800**	0.190**	0.234**	0.352**	0.304**	-0.122^{NS}	
Harvest index	-0.165*	0.047^{NS}	-0.098^{NS}	-0.101^{NS}	0.139*	0.321**	0.342**	-0.079^{NS}	-0.032^{NS}

* $P \leq 0.05$, ** $P \leq 0.01$, NS = Non-significant

Table III. Genetic correlation (r_G) for yield and various quantitative traits of the cross Kohistan-97 x Chakwal-86

Trait	Days to heading	Flag leaf area	Tillers per plant	Spike length	Grains per spike	Grain weight per spike	1000-grain weight	Grain yield per plant	Biomass per plant
Flag leaf area	-0.040								
Tillers per plant	-0.136	0.231							
Spike length	-0.186	0.143	0.005						
Grains per spike	-0.122	0.191	0.127	0.267					
Grain weight per spike	-0.247	0.301	0.137	0.423	0.849				
1000-grain weight	-0.366	0.207	0.080	-0.027	0.209	0.488			
Grain yield per plant	-0.273	0.296	0.712	0.147	0.481	0.664	0.473		
Biomass per plant	-0.223	0.362	0.809	0.175	0.388	0.527	0.351	-0.073	
Harvest index	-0.190	-0.239	-0.247	-0.055	0.430	0.642	0.465	-0.062	-0.025

Table IV. Genetic correlation (r_G) for yield and various quantitative traits of the cross Kohistan-97 x Inqlab-91

Trait	Days to heading	Flag leaf area	Tillers per plant	Spike length	Grains per spike	Grain weight per spike	1000-grain weight	Grain yield per plant	Biomass per plant
Flag leaf area	-0.160								
Tillers per plant	-0.112	0.080							
Spike length	0.194	0.043	0.160						
Grains per spike	-0.061	-0.003	0.079	0.172					
Grain weight per spike	-0.297	0.173	0.162	0.191	0.837				
1000-grain weight	-0.458	0.087	0.198	0.077	0.140	0.430			
Grain yield per plant	-0.347	0.272	0.852	0.151	0.271	0.493	0.462		
Biomass per plant	-0.284	0.245	0.897	0.229	0.240	0.378	0.328	-0.130	
Harvest index	-0.203	0.045	-0.173	-0.264	0.161	0.456	0.499	-0.093	-0.038

weight were observed, while it showed negative correlation with days to heading, spike length, tillers per plant, grain yield and biomass per plant in both the crosses (Table I & II). These findings conform to those of Rana and Sharma (1997).

Genetic correlations. Days to heading showed negative correlations with all the studied traits in both the crosses except spike length for Kohistan-97 x Inqlab-91 (Table III & IV), which conforms to the earlier findings of Singh *et al.* (2002), Subhani and Chowdhry (2000), Vaishnavi and Bural (1996) and Singh *et al.* (1995). Flag leaf area showed positive genetic correlation with all the traits except days to

heading, which showed negative correlation with flag leaf area in both the crosses (Table III & IV). Harvest index in Kohistan-97 x Chakwal-86, while grains per spike in Kohistan-97 x Inqlab-91 revealed negative genetic correlation. Similar results have also reported by Subhani and Chowdhry (2000) and Vaishnavi and Bural (1996). Positive genetic effects were observed for tillers per plant and spike length with all the traits except days to heading and harvest index, where these traits showed negative correlation in both the crosses (Table III & IV). The results also confirmed that grain per spike exhibited positive genetic association with all the studied traits, while negative correlation was found with days to heading in both the crosses (Table III & IV), which is in agreement of previous reports Attarbashi *et al*. (2002), Singh *et al.* (2002), Subhani and Chowdhry (2000), Deswal *et al.* (1996) and Singh *et al.* (1995). Biomass per plant showed positive genetic correlation with studied traits except days to heading, grain yield and harvest index, where as it showed negative correlation in both the crosses (Table III & IV). Attarbashi *et al.* (2002), Subhani and Chowdhry (2000) and Deswal *et al.* (1996) also sported these findings in wheat. Harvest index revealed positive genetic correlation with grains per spike, grain weight per spike and 1000-grain weight, while it manifested negative association with days to heading, tillers per plant, spike length, grain yield and biomass per plant in both the crosses (Table III & IV). Subhani and Chowdhry (2000) supported that harvest index had negative correlation with days to heading and tillers per plant, while Singh *et al.* (1995), Subhani and Chowdhry (2002) and Attarbashi *et al*. (2002) reported contrasting data on these lines.

The study of the correlation is of interest in connection with the genetic causes of correlation through pleitrophy, where a gene affects two or more traits via linkage. In both cases segregation of gene causes simultaneous variation in character it affects or is liked with genes of other traits. However, incomplete linkage is a cause of transient correlation, particularly populations derived from crosses between divergent strains. The present study suggested that drought tolerance showed genotypic correlations, which could lead to predictable correlated responses that can be usefully exploited for selection of drought tolerant wheat from these crosses.

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(Received 05 July 2006; Accepted 28 November 2006)