Asian Journal of Agricultural Sciences 4(5): 346-351, 2012
ISSN: 2041-3890

Submitted: June 28, 2012 Accepted: July 31, 2012 Published: September 25, 2012

Correlation and Path Coefficient Analysis in Wheat Genotypes under Irrigated and Non-Irrigated Conditions

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Abstract: Current research was conducted with the objectives to identify the utmost traits that may be beneficial for the higher productivity of the grains under stress environment. Research material consisted of thirteen genotypes which were obtained from different sources. Experiment was carried out in randomized complete block in a split plot design. Water regimes (irrigated and non-irrigated) were allocated to the main plots and genotypes to the subplots. Path coefficient could be used as an important tool to bring about appropriate cause and effects relationship between yield and yield components. According to obtained results the selection on the basis of number of spikes, number of spikelet's and number of grains in this material would likely to be most useful for increasing grain yield because of their direct positive contribution to grain yield under irrigated condition. However number of spikes, spikelet numbers, spike length and grains number may be used an effective selection criterion for increasing grain yield of wheat under different irrigation levels. Therefore it is concluded that these traits could be selected for the different stress environments and it would be beneficial for the yield.

Keywords: Agronomic traits, correlation coefficient, path coefficient, wheat

INTRODUCTION

Wheat (*Triticum aestivum*) is an important Rabi food crop in Pakistan. Being a staple food, wheat has occupied a lot of area in Pakistan. The need and importance of wheat is increasing day by day due to increase in human population. Abiotic stresses limit crop productivity (Boyer, 1970; Araus *et al*., 2002). Among various biotic stresses drought is undoubtedly one of the worst natural enemy of life. It can occur in any region of the world and can affect life from very basic personal inconvenience to nationwide. Drought can reduce crop yield, pasture deterioration and death of livestock. It strongly affects the production of cereals and poses a serious threat to the food security of households. World food security is dependent on continuous crop improvement; in particular, the development of crops with increased tolerance to abiotic stresses especially drought and salinity (Denby and Gehring, 2005).

Yield is a complex quantitative trait, considerably affected by environment. Therefore, selection of genotypes based on yield is not effective. Selection has to be made for the components of yield. Bhatt (1972) reported that only correlation studies not clearly reveal such sort of information and inadequate knowledge interrelationships of heritable traits may lead to negative results. On the other hand, path coefficient analysis measures the direct and indirect effect for one variable upon another and permits the separation of the correlation coefficient into components of direct and indirect effect (Dewey and Lu, 1959). Path analysis focused direct and indirect effect of component traits on yield. With these objectives, present study was carried out to detect correlation and path for increased yield in wheat under irrigated and non-irrigated conditions.

MATERIALS AND METHODS

Plant materials: The experimental material comprised of thirteen wheat genotypes included eleven advanced wheat lines, one synthetic hexaploid and their durum parent which were provided by CIMMYT, Mexico and NARC, Islamabad, Pakistan. Water stress imposed by withholding irrigation, were as follows: Control plants were watered regularly and never allowed to dry out whereas tillering stress was imposed at 38 days after sowing and continued till 47 days after sowing or completion of tillering. Stress was also imposed before anthesis began in each genotype (avoiding spikes with any sheded pollens), with subsequent irrigations at intervals of fifteen days till harvesting and was named as anthesis stress. Grain-filling stress was imposed after anthesis and continued till harvesting. Plants were watered at fifteen days intervals during this period. All the genotypes were grown in the screen house of Genetics department, University of Karachi. Data was recorded for the year 2006-2007. Experiment was repeated twice. Experiment was carried out in a randomized complete block in a split plot arrangement.

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Water regimes (irrigated and non-irrigated) were allocated to the main plots and genotypes to the subplots. The experiments were conducted using earthen/ceramics pots (40×40 cm) filled with sandy loam soil and manure.

Climatic data: Weather data were recorded regularly during growing seasons. During Nov 2006-April, 2007 mean temperature was 18.0-30.50°C with humidity 54.45% throughout the growing season. Moveable plastic sheet cover was used for protecting the plants from rain. Total rainfall recorded during the growing season was provided by Pakistan Meteorological Department, Karachi, Pakistan.

Agronomic traits: Data were recorded for yield and yield related components at different timing of growth stages under different water stress levels. Phenotypic correlation coefficients of yield and its components and plant traits were obtained through statistical package SPSS Version 11. After computing the correlation coefficients between all characters, path coefficient analysis were performed using phenotypic correlation considering grain yield as the response variable and number of spikes, spike length, number of spikelet's per spike and number of grains as a predictor variables by the method described by Dewey and Lu (1959). Before computing the path coefficients, data were transformed to decimal logarithms in order to convert the relationships between variables from multiplicative to additive and subsequently standardize them. Residual factor was calculated as:

$$1 = P^2X_5 + P^2_{15} + P^2_{25} + P^2_{35} + P^2_{45} + 2P_{15}r_{12}P_{35} + 2P_{15}r_{13}P_{35} + 2P_{15}r_{14}P_{45} + 2P_{25}r_{23}P_{35} + 2P_{25}r_{24}P_{45} + 2P_{35}r_{34}P_{45}$$

RESULTS

Correlation coefficient: The phenotypic correlations are presented in Table 1. Results revealed that number of spikes showed positive significant correlation with spike length, grain numbers and grain yield under irrigated condition. On tillering stress, number of spikes depicted positive and highly significant relationship with grain numbers and grain yield however it had inverse correlation with spikelet numbers. In case of anthesis stress, number of spikes showed positive significant correlation with all yield components. Under grain filling stress, the situation has similar with tillering stress as spike numbers exhibited positive and significant association with grain numbers and grain yield. Spike length showed positive and highly significant correlation with all yield related characters under non-stress condition. When stress was imposed at tillering, spike length exhibited same results as control condition. The situation has slightly changed under anthesis stress as spike length showed significant positive correlation with spikelet and grain numbers. Similar results were obtained under grain filling stress as irrigated and tillering stress. Number of spikelet's had positive significant correlation with grain numbers and grain yield under irrigated condition. Similar results were found under tillering, anthesis and grain filling stress. Number of grains had strong positive relationship with grain yield under irrigated condition. Similar pattern were observed under all stresses.

Path coefficient: The correlations were analyzed further by the path coefficient technique, which involves partitioning the correlation coefficients into direct and indirect effects via alternative characters or pathways. Grain yield was performed by the complex outcome of different characters considered to be the resultant variable and numbers of spikes, spike length, spikelet and grain numbers were casual variables. The direct and indirect effects of the 4 grain yield related traits are shown in Table 2. The path coefficient analysis under irrigated condition showed that the direct effect of spike numbers on grain yield was moderate and positive (0.31). The indirect effect via number of grains had strong and positive effect on grain yield. Under tillering stress, the moderate and positive direct effect of spike numbers on grain yield with a value of 0.13. The direct effect of spike numbers was negligible (-0.008) on grain yield under anthesis stress however the lowest direct effect belonged to number of spikes (0.06) under grain filling stress. The direct effect of spike length on grain yield was positive and low (0.04) under non-stress condition. A positive and significant direct effect of spike length (0.1) was registered under tillering stress. Path coefficient analysis under anthesis stress exhibited that spike length had negative and almost negligible on grain yield (-0.01). The direct effect of spike length on grain yield was lowest and non-significant (0.12) under grain filling stress. Path coefficient analysis indicated that spikelet numbers had a positive direct effect on grain yield under irrigated, tillering and anthesis stress with values of 0.10, 0.18 and 0.32, respectively. The direct effect of spikelet numbers was positive but the lowest effect on grain yield (0.1) at grain filling stress. In non-stressed

Table 1: Phenotypic correlation coefficients of yield and yield trait components in bread wheat advanced lines under irrigated and non-irrigated conditions

Grain yield	No. of spikes	Spike length	No. of spikelet's	No. of grains
C	0.82**	0.31**	0.33**	0.94**
T	0.41**	0.54**	0.48**	0.91**
A	0.75**	0.13	0.34**	0.92**
G	0.52**	0.44**	0.38**	0.86**

C: Control; T: Tillering; A: Anthesis; G: Grain filling

Table 2: Direct and indirect effects of factors influencing grain yield in bread wheat advanced lines under irrigated and non-irrigated conditions

Pathway of association	C	T	A	G
Grain yield vs. number of spikes				
Direct effect, P_{15}	0.310**	0. 130**	-0.008	0.060
Indirect effect via spike length, $r_{12}P_{25}$	0.006	-0.001	-0.002	0.008
Via number of spikelet spike^{-1}, $r_{13}P_{35}$	-0.009	-0.040	0.050	-0.010
Via number of grains spike^{-1}, $r_{14}P_{45}$	0.450	0.270	0.540	0.310
Total correlation	0.760	0.350	0.590	0.370
Grain yield vs. spike length				
Direct effect, P_{25}	0.040	0.100*	-0.010	0.120
Indirect effect via number of spikes, $r_{12}P_{15}$	0.040	-0.001	-0.001	0.004
Via number of spikelet spike^{-1}, $r_{23}P_{35}$	0.050	0.120	0. 130	0.080
Via number of grains spike^{-1}, $r_{24}P_{45}$	0.190	0.310	0. 130	0.310
Total correlation	0.330	0.530	0.240	0.530
Grain yield vs. number of spikelet's spike^{-1}				
Direct effect, P_{35}	0.100*	0.180**	0.320***	0.100
Indirect effect via number of spikes, $r_{13}P_{15}$	-0.020	-0.030	-0.001	-0.005
Via spike length, $r_{23}P_{25}$	0.020	0.060	-0.007	0.100
Via number of grains spike^{-1}, $r_{34}P_{45}$	0.210	0.300	0.300	0.280
Total correlation	0.310	0.520	0.610	0.490
Grain yield vs. number of grains spike^{-1}				
Direct effect, P_{45}	0.570***	0.630***	0.650***	0.550***
Indirect effect via number of spikes, $r_{14}P_{15}$	0.240	0.050	-0.006	0.030
Via spike length, $r_{24}P_{25}$	0.010	0.050	-0.003	0.060
Via number of spikelet's spike^{-1}, $r_{34}P_{45}$	0.030	0.080	0.140	0.050
Total correlation	0.870	0.820	0.790	0.710
Residual, Px_5	0.470	0.530	0.540	0.680

C: Control; T: Tillering; A: Anthesis; G: Grain filling

condition, direct effect of grain numbers on grain yield was high and significant (0.57). Path coefficient analysis was conducted under tillering stress to describe the effect of number of grains with grain yield. Grain numbers had high and positive direct effect on grain yield (0.63). The highest direct effect of grain numbers on grain yield 0.65 followed by 0.55 under anthesis and grain filling stress.

DISCUSSION

The correlation coefficients is the measure of degree of symmetrical association between 2 variables or characters and help us in understanding the nature and magnitude of association among yield and yield components. Results indicate that number of spikes depicted positive significant correlation with spike length, grain numbers and grain yield under irrigated condition. Mohsin *et al*. (2009) reported that spike numbers is highly positive and significantly correlated with grain yield in synthetic elites of wheat under normal condition. Tamman *et al*. (2000) also observed that grain yield per plant had positive correlation with number of spikes. The similar pattern was observed under anthesis stress. On tillering stress, number of spikes exhibited positive and highly significant relationship with grain numbers and grain yield however it had inverse correlation with spikelet numbers. Under grain filling stress, the situation has similar with tillering stress as spike numbers exhibited positive and significant association with grain numbers and grain yield. Spike length showed positive and significant correlation with number of spikelet's (Safeer-ul-Hassan *et al*., 2004), grain numbers (El-Shazly, 2000) and grain yield (Kashif and Khaliq, 2004; Singh *et al*., 2010) under non-stress condition. The increase in spike length is directly associated with increase in number of spikelet's, grain numbers and ultimately the grain yield (Akram *et al*., 2008). When stress was imposed at tillering, spike length had positive and significant relationship with number of spikelet's, grain numbers and grain yield. These results suggested that longer the spike length the higher was the number of spikelet's, grain numbers and grain yield (Sultana *et al*., 2002). Under anthesis stress, spike length showed significant positive correlation with spikelet and grain numbers (Bessonova, 1988). At grain filling stress, spike length exhibited positive relationship with all yield contributing traits. Association studies between spike length, spikelet numbers and grain yield indicated a tendency of spike length to increase with increase of spikelet numbers and grain yield. Similar results were also reported by Khaliq *et al*. (2004) and Khan *et al*. (2005). Number of spikelet's showed positive and significant correlation with grain numbers (Kashif and Khaliq, 2004; Subhani and Chowdhry, 2000) under irrigated condition. At tillering stress, spikelet numbers showed positive correlation with grain numbers (Wang *et al*., 1991) and grain yield (Jaimini *et al*., 1974). Similar results were found under anthesis and grain filling stress. It indicated that increase in number of spikelets will also increase grain yield. Number of grains had strong positive relationship with grain yield (Ashfaq *et al*., 2003; Burio *et al*., 2004) under irrigated condition. A positive and highly significant correlation was observed between grain numbers and spikelet numbers in current work which indicated that with an increase in spikelet numbers there would be an increase in number of grains. The correlation coefficient between grain numbers and grain yield was found to be positive and highly significant indicating that increase in grains per spike will also have a better influence on grain yield (Nabi *et al*., 1998; Aycicek and Yildirim, 2006). Grain numbers exhibited strong positive correlation with grain yield; it means that an increase in number of grains would also ultimately increase the grain yield under different stresses.

Yield components and plant traits contribution on grain yield may be important for breeding strategies. Simple correlation analysis that relates grain yield to a single variable may not provide a complete understanding of the importance of each component in determining grain yield. Path coefficient analysis allows an effective means of partitioning correlation coefficients into unidirectional pathway and alternate pathway. This analysis permits a critical examination of specific factors that produce a given correlation and could be successfully employed in formulating an effective selection strategy (Okuyama *et al*., 2004).

Path coefficient analysis for yield components under irrigated condition revealed that spike numbers had direct effect on grain yield. The current results are in agreement with the findings of Dofing and Knight (1992), Shah *et al*., (1994) and Mohsin *et al*., (2009). It may be suggested that more spike numbers produce large number of grains and ultimately an increase in grain yield under non-stress condition. Similar kind of results was obtained under tillering stress. Positive direct effect of the number of spikes on grain yield has been reported under irrigated (Li *et al*., 2006) and non-irrigated water regimes (Okuyama *et al*., 2004). Therefore it is suggested that case direct selection for higher spike numbers would be beneficial to increase grain yield. These results are similar to those obtained by Simane *et al.* (1998) and Del Blanco *et al.* (2001). However at anthesis and grain filling stress no direct effect of the spike numbers on grain yield had been noticed. So this trait may not be effective under severe stress. Current study exhibited that spike length had positive direct effect on grain yield under tillering stress only whereas in irrigated condition, anthesis and grain filling stress had no effect on grain yield. Under non-irrigated condition grain yield reported to have positive direct effect on spike length (Okuyama *et al*., 2004 and 2005; Naserian *et al*., 2007). Current work revealed that spikelet numbers had positive direct effect on grain yield under irrigated, tillering and anthesis stress. Spikelets number contribute largely to grain yield (Alam *et al*., 1992) and had direct positive effect under irrigated (Anwar *et al*., 2009; Khan and Dar, 2010) as well as drought condition (Khan *et al*., 2005). Lad *et al.* (2003) also observed that grain yield exhibited highly significant and positive correlation with productive spikelet's per spike under non-stress environment. It is suggested that selection for high yield might be effective by simultaneous improvement of yield determinants like tiller numbers and grain numbers and yield could be increased through the selection of plants with more spikelet's (Zaheer, 1991). Hence, spikelet's can be regarded as a reliable source of getting high yield in wheat under irrigated condition as well as tillering and an thesis water stress.

Path coefficient analysis revealed that grain numbers had high positive effect on grain yield under irrigated and non-irrigated conditions. Earlier Larik (1979) reported that grain numbers had highest direct effect on grain yield. It is clearly understood from the current study that the character which influence most on grain yield was grain numbers which is supported by Smocek (1977), Ehdaie and Waines (1989), Naserian *et al*. (2007) and Kotal *et al*. (2010). These findings led to conclude grains per spike as a reliable criterion for getting high yield in wheat plants. Under drought stress conditions, number of kernels per spike had a significant positive direct effect on grain yield (Wang *et al*., 1991; Dornescu, 1986; Dencic *et al*., 2000). Grain numbers seems to be the most important factor in determining grain yield both irrigated and non-irrigated conditions (Singh *et al*., 2010; Dencic *et al*., 2000; Slafer and Andrade, 1991; Sen and Toms, 2007). Therefore selection for this trait may contribute to important increases in grain yield, particularly in drought prone-environments.

CONCLUSION

The results of the current study showed that more spikes, greater spikelet numbers with maximum grain numbers should be considered as selection criteria for wheat yield improvement under irrigated condition and water stress at tillering. Under anthesis stress, more spikelet's with large number of grains mainly contributed to grain yield. Whereas only grain numbers are mainly contributed to grain yield under grain filling stress. The current study confer that these characters showed positive and significant association with yield and those exerting maximum direct positive effect should be considered suitable for further future wheat breeding programme.

ACKNOWLEDGMENT

The authors wish to acknowledge CIMMYT, Mexico and NARC, Islamabad for providing germplasm and also thanks to Deans Science that provided research funds to the authors for conducted research in the department.

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