Correlation and path coefficient analysis for important plant attributes of spring wheat under normal and drought stress conditions

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Abstract A comparative study was conducted in drought and normally irrigated conditions, in which 25 genotypes of wheat were evaluated for various morphological traits involving plant height, canopy temperature, flag leaf area, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike, 1000-grain weight and grain yield per hectare and relative water contents. A duplicated randomized complete block design was used in the experimental area of the Wheat Research Institute, AARI, Faisalabad. Path coefficient and correlation for above-mentioned traits in both environments estimated and results revealed that spike length, spike density and 1000-grain weight were the main contributor in yield in both concerned environments. Maximum yield was recorded for the genotype V-11164 in normal and V-11168 in drought conditions whereas most stable genotype was V-11168 for yield in drought conditions. In normal conditions maximum correlation was recorded for number of grains per spike followed by grain weight per spike whereas number of grains per spike was also have top most value of correlation in drought environment.

Keywords Wheat. Correlation and Path coefficient. Morphological Traits.

1. Introduction

Water deficit is one of the major abiotic stresses, which adversely affects crop growth and yield (Jaleel et al., 2009). In Pakistan wheat is grown under diverse climatic and soil conditions. About 1/3rd of the total cultivatable land falls in the rainfed regions where rainfall is rare (Alam, 2000). However, drought and salinity are far more important globally and are the most serious threats to agriculture (Altman, 1999). Water deficiency is a major harmful factor in arid and semi-arid regions worldwide that is limiting the area under cultivation and crop production. It is also common for many abiotic stresses to challenge a crop at same time. For example, the occurrence of high temperatures is common during periods of limited water availability (Sutton, 2006). Water deficit/drought affects every facet of plant growth and the yield through modifying the anatomy, morphology, physiology, biochemistry and finally, the productivity of crop (Lisar et al. 2012). Although marker-assisted selection is now widely deployed in wheat, it has not contributed significantly to cultivar improvement for adaptation to low-yielding environments and breeding has relied largely on direct phenotypic selection for improved performance in these difficult environments (Fleury and Jefferies, 2010). High-yielding cultivars having high water-use efficiency can play a major role in water deficit environments but success has been restrained due to the varying nature of drought and the complex genetic control of plant responses.

Several recent studies suggest that physiological selection traits have the potential to improve genetic yield gains in wheat (Reynolds, 2002). However the test system based on the investigation of young seedlings under osmotic stress conditions may not give exact information on the drought tolerance of the different wheat varieties. The drought tolerance of wheat is a complex process in respect of plant physiology, in order to characterize the drought tolerance several parameters have to be taken into consideration together, including the fertilization and the grain filling process (Forgóné, 2009). Therefore field experiments have their own value for evaluating different wheat cultivars against different abiotic stresses especially drought.

Wheat, member of family Poaceae is one of the most promising cereal crop in most of the countries of the world, including Pakistan. Wheat has been cultivated in Southwestern Asia, its geographic center of origin, for more than 10,000 years (Sleper and Poehlman, 2006). Being an important diet in Pakistan, Its contribution to value addition in agriculture is 12.50 % while to GDP was 2.60 percent (Anonymous, 2012). Due to its great importance, under all these circumstances it is necessary to produce wheat in the sufficient amount which can contribute to the economic development and prosperity of the country.

Grain yield is a complex quantitative traits which results from the interaction of different other traits known as yield components. Better yield components results in better yield, so selecting cultivars for yield components for their performance might be a better criteria than selecting directly for yield might be more effective and sustainable.

Correlation and path-coefficient analysis provide information regarding correlated response of plant characters and also about their final contribution to the yield attribute..

Path coefficient analysis is also an important tool for selecting cultivars in which various traits are contributing to yield attribute. Less information is available for drought created sub-optimal conditions because different genetic and physiological mechanism are operating under these circumstances. Development of drought tolerant cultivar in wheat thus require a comprehensive study of correlated response of different yield contributing traits. Present research studies on path-coefficient analysis were aimed to study the effect of yield components on yield under drought conditions.

2. Materials and Methods

The present study was carried out in randomized complete block design with two replications for each set of experiment. Agronomic and cultural practices were normal throughout the season i.e. fertilizer application was in the ratio of 120: 90: 62, N: P: K (Kg ha-1) respectively. Data was recorded for following traits on individual plant as well as per unit basis:

Plant height (cm), Canopy temperature (ºC), Spike length (cm), Number of spikelets per spike, Flag leaf area (cm2), Relative water contents of flag leaf, Spike density, Grain weight per spike (g), 1000-grain weight (g) and Grain yield (kg ha-1). Whereas following methods were used for the estimation of Flag leaf area (cm2), Relative water contents of flag leaf and Spike density.

Flag leaf area (cm2):Length and width of flag leaf of each guarded plant was measured in centimeters and then multiplied with 0.74 to get flag leaf area according to the following formula of Muller (1991),

Flag leaf area = Flag leaf length × Flag leaf Width × 0.74)

Relative water contents of flag leaf: Dry weight was measured after oven drying the leaves samples at 72°C. RWC was calculated by using the following formula (Karrou and Maranville, 1995).

RWC %=(Fresh weight-Dry weight)/(Turgid weight-Dry weight)× 100

Spike density: Spike density was measured by dividing number of spikelets of that spike with spike length.

Spike density=(Number of Spikelets per spike)/(Spike length)

STATISTICAL ANALYSIS: Data thus recorded was subjected to analysis of variance according to the method of Steel et al. (1997). Duncan's new multiple range test was used for individual comparison of treatment mean (Waller and Duncan, 1969). The mean of each character was calculated and variance was portioned into phenotypic and genotypic components.

GCV = Genotypic coefficient of variation

PCV = Phenotypic coefficient of variation

$\bar{x}$ = Grand mean of the trait

Correlation Analysis: Genotypic correlation coefficient was worked out according to method of Kwon and Torrie (1964).

Genotypic correlation was tested for their significance against the value of S.E. The rg was considered as significant when its value exceeded double value of its S.E. Standard error was calculated using formula provided by Reeve (1955) and Robertson (1959).Phenotypic correlation was measured by the method described by Falconer and Mackay, (1996).

Statistical significance of phenotypic correlation was determined by using "t-Test" as described by Steel et al, (1997). Path coefficient analysis was done through the method described by Dewey and Lu (1959).

3. Results and Discussion

Results of analysis of variance showed significant difference among genotypes for all studied characters. Whereas genetic analysis of the traits studied i.e. plant height, canopy temperature, flag leaf area, relative water contents of flag leaf, spike length, number of spikelets per spike, number of grains per spike, spike density, grain weight per spike, 1000-grain weight and grain yield was described in this manuscript.

Environment i.e drought effected the traits inversely in significant way this statement is supported by Annicchiarico and Mariani, (1996). Mean performance under both environments and the difference among performance of ith trait described in Tables revealed their resistance to drought. Genotypes with least difference could be predicted as most stable for the given character. Association of traits with each other also get effected due to drought conditions. Some relations appeared in the study might be not of routine, this could be justified by unexpected rains at late maturity of crop. Under normally irrigated conditions, Plant height have positive association with grain yield this is also reported by Safeer-ul Hassan et al. (2004). Flag leaf area have positive phenotypic and genotypic association with grain yield, this is not in accordance with Alam et al 1993 but Jaleel et al., (2009) reported the similar results. Spike length it also have positive phenotypic but non significant while positive and significant genotypic association with spikelets per spike,

Table 1: Correlation for plant attributes in Normal (N) and Drought (D) Environment

		Plant height	Canopy Temp.	Flag leaf area	Relative water contents	Spike length	Spike density	Grain weight per spike	1000-grain weight	Yield
N	**Plant height**		0.011	0.109	0.452*	0.296	-0.078	**0.644****	0.173	0.502*
D			-0.365*	0.371*	-0.607**	0.322	-0.345*	0.062	-0.438**	0.452**
N	**CT**	0.152		-0.003	-0.125	0.074	0.056	0.365*	-0.034	0.004
D		-0.396*		-0.418**	0.33	-0.613**	0.045	-0.115	0.07	-0.221
N	**Flag leaf area**	-0.053	-0.116		0.421*	-0.336	0.209	0.284	-0.068	0.307
D		0.248	-0.338*		0.009	0.224	-0.039	0.123	-0.046	0.243
N	**RWC**	0.286*	-0.12	0.379*		-0.393	0.462*	0.25	-0.195	0.374*
D		-0.406*	0.333	0.032		-0.264	0.23	0.028	0.485**	0.043
N	**Spike length**	0.104	0.012	-0.241	-0.254		-0.943**	0.098	-0.241	0.067
D		0.106	-0.299	0.158	-0.203		-0.698**	0.363	-0.247	-0.265
N	**Spike density**	-0.003	0.03	0.158	0.287*	-0.933**		0.039	0.219	0.158
D		-0.18	0.058	-0.03	0.218	-0.630**		0.076	0.201	0.144
N	**Gr W/ spike**	0.371*	0.19	0.096	0.204	0.129	-0.005		0.303	**0.516****
D		0.172	-0.127	0.092	0.099	0.184	-0.105		0.366*	0.218
N	**1000-grain W.**	0.121	0.035	-0.105	-0.2	-0.218	0.19	0.288*		0.158
D		-0.203	0.106	-0.051	0.282	0.137	-0.121	0.271		0.069
N	Yield	0.136	-0.116	0.239	0.233	0.014	0.069	0.337*	0.18	
D		0.263	-0.179	0.226	0.029	-0.093	0.125	0.176	0.114	

Table 2: Path-analysis for plant attributes in Normal (N) and Drought (D) Environment.

		Plant height	**Canopy Temp.**	**Flag leaf area**	**Relative water**	**Spike length**	**Spike density**	**Grain weight per spike**	**1000-grain weight**	**r_g**
I	**Plant height**	**-21.343**	-0.078	1.036	4.04	11.147	-2.04	0.574	1.87	0.502
I		**-0.173**	6.988	-0.433	-1.629	16.346	-33.998	0.752	0.938	0.452
I	**Canopy Temp.**	-0.242	**-6.862**	-0.032	-1.118	2.783	1.458	0.325	-0.367	0.004
I		0.063	**-19.151**	0.489	0.885	-31.142	4.405	-1.391	-0.149	-0.221
I	**Flag leaf area**	-2.324	0.023	**9.513**	3.764	-12.675	5.483	0.253	-0.733	0.307
I		-0.064	8.005	**-1.169**	0.025	11.381	-3.802	1.49	0.099	0.243
I	**Relative water contents**	-9.639	0.858	4.003	**8.945**	-14.809	12.097	0.223	-2.11	0.374
I		0.105	-6.312	-0.011	**2.684**	-13.397	22.662	0.339	-1.038	0.043
I	**Spike length**	-6.309	-0.507	-3.198	-3.513	**37.707**	-24.736	0.088	-2.603	0.067
I		-0.056	11.731	-0.262	-0.707	**50.838**	-68.522	4.387	0.528	-0.265
I	**Spike density**	1.66	-0.382	1.989	4.127	-35.571	**26.222**	0.035	2.366	0.158
I		0.06	-0.857	0.045	0.618	-35.37	**98.487**	0.917	-0.431	0.144
I	**Grain weight per spike**	-13.748	-2.502	2.703	2.238	3.702	1.025	**0.891**	3.279	0.515
I		-0.011	2.204	-0.144	0.075	18.451	7.472	**12.087**	-0.784	0.218
I	**1000-grain weight**	-3.692	0.233	-0.645	-1.746	-9.078	5.738	0.27	**10.813**	0.158
I		0.076	-1.333	0.054	1.301	-12.532	19.832	4.426	**-2.141**	0.069

these results are in accordance with Waqar-ul Haq et al. (2010). A positive and significant association was reported between spike density and relative water contents. Grain weight per spike had maximum as well as highly significant, genotypic correlation with plant height followed by number of spikelets per spike. It also had positive association with spike density. Whereas in drought stress association of traits significantly deviated from normal environment. there is a maximum positive genotypic correlation between grain yield and plant height, A positive association was also reported with number of grains per spike followed by flag leaf area, grain weight per spike and spike density. These results are in accordance with Sultana et al. (2002) and Saleh (2011). Phenotypic correlation portion of Table 4.14 represented positive correlation between grain yield and number of grains per spike and number of spikelets per spike. Similar results were reported by Kilic and YaÄŸbasanlar, (2010). Plant height have positive association with grain yield this is also reported by Safeer-ul-Hassan et al. (2004). Maximum negative but significant phenotypic correlation had observed between plant height and relative water contents followed by canopy temperature. These findings are not inconsistence with Kilic and

YaÄŸbasanlar (2010) while Afshan and Naqvi (2011) reported similar findings. Canopy temperature had positive genotypic association with spike density while had maximum significant negative genotypic association with number of grains per spike, number of spikelets per spike and plant height. Significant negative phenotypic association was observed between canopy temperature and number of grains per spike and number of spikelets per spike Positive and significant correlation was observed for flag leaf area with plant height results are supported by Kashif and Khaliq, (2004). Positive but non-significant phenotypic correlation with flag leaf area and plant height. Spike length have negative correlation with grain yield, this finding is in consistence with Laghari et al. (2010). Genotypically, negative association was reported with canopy temperature which is also significant, however negative association was also reported with plant height and spike length. Whereas positive correlation was reported with flag leaf area and relative water contents. Results are supported by Afshan and Naqvi (2011). Spike density have maximum positive genotypic correlation with umber of spikelets per spike followed by number of grains per spike. However it also had positive association with relative water contents and canopy temperature. These results are not in accordance with Farooq et al., (2011). Maximum negative genotypic correlation was observed with spike length, followed by plant height. However it also have negative genotypic association with flag leaf area. Grain weight per spike had maximum, significant, genotypic correlation with number of grains per spike followed by number of spikelets per spike. Significant and positive genotypic correlation it had with relative water contents, followed by grain weight per spike. This is not in accordance with Sultana et al. (2002) where they reported negative association between grain weight per spike and 1000-grain weight.

Path analysis revealed in both environments that number of grains per spike and pike length could be used for direct selection for the yield. Plant height, 1000-grian weight and relative water contents also contributed for the grain yield in positive way. Canopy temperature could also be used as differentiating trait for the selection of best surviving genotype under drought conditions.

Path analysis under normal condition exhibited that Plant height have negative direct effect on yield, but this negativity was countered by its positive indirect through spike length, relative water contents and lea area respectively these results are in accordance with Kashif and Khaliq, (2004)

Relative water content have positive direct effect on yield. Similar statement was given by Saleh (2011). However it have negative indirect effect through plant height, (-9.64) spike length (-14.81) and 1000-grain weight (-2.11).

Spike length have positive direct effect on yield, Jaleel et al. (2009) also reported the same finding.

Spike density had positive direct effect on yield. Khaliq et al. (2004) also reported similar statement. It had positive indirect effect through number of grains per spike, plant height, grain weight per spike, 1000-grain weight, relative water contents and flag leaf area.

Grain weight per spike have maximum negative indirect effect on yield through plant height followed canopy temperature and number of grains per spike. Whereas it had positive direct effect, also reported by Aycicek and Yildirim (2006b).

1000-grain weight had positive indirect effect through spike density (5.7), canopy temperature (0.23) grain weight per spike (0.27), and number of grains per spike (0.09).

While under drought stress Plant height have negative direct effect on yield, but this negativity was countered by its positive indirect through spike length, relative water contents and lea area respectively these results are in accordance with Kashif and Khaliq, (2004)

Relative water content have positive direct effect on yield. Similar statement was given by Saleh (2011). However it have negative indirect effect through plant height, (-9.64) spike length (-14.81) and 1000-grain weight (-2.11).

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Spike density had positive direct effect on yield. Khaliq et al. (2004) also reported similar statement. It had positive indirect effect through number of grains per spike, plant height, grain weight per spike, 1000-grain weight, relative water contents and flag leaf area.

Grain weight per spike have maximum negative indirect effect on yield through plant height followed canopy temperature and number of grains per spike. Whereas it had positive direct effect, also reported by Aycicek and Yildirim (2006b).

1000-grain weight had positive indirect effect through spike density (5.7), canopy temperature (0.23) grain weight per spike (0.27), and number of grains per spike (0.09).

Table 3: Significance of ANOVA for yield contributing plant attributes

		Genotypic SS	Genotypic MS	F (cal)
Plant height	N	1045.9	43.579	2.267*
	D	503.5	20.98	2.764**
Canopy temperature	N	111.7	4.654	4.594**
	D	85.49	3.562	5.142**
Flag leaf area	N	415	17.3	7.403**
	D	307.61	12.817	58.64**
RWC^ of flag leaf	N	4737.5	197.4	17.62**
	D	2177.672	90.736	10.74**
Spike length	N	80.653	3.361	4.245**
	D	13.857	0.577	2.888**
Number of spikelets spike^{-1}	N	26.827	1.118	3.987**
	D	53.87	2.245	3.759**
Number of grains per spike	N	1053.2	43.882	2.202**
	D	1294	53.93	4.839**
Spike density	N	1.664	0.069	3.048**
	D	1.271	0.053	5.357**
Grain weight per spike (g)	N	5.65	0.24	4.811**
	D	2.187	0.091	3.615**
1000-grain weight (g)	N	639.5	20.528	5.843**
	D	325.041	13.543	2.240*
Grain yield (kg ha^{-1})	N	11044360	460181.7	4.621**
	D	6730518	280438.3	5.312**

^RWC=Relative water contents

plant height had negative direct effect on yield but it had effected yield indirectly through number of spikelets per spike (12.10), spike length (16.34), canopy temperature and grain weight per spike in positive way. Whereas it had negative indirect effect on yield through spike density (33.99), relative water contents, leaf area and number of grains per spike. Similar findings were reported by Doğan, (2009).

Canopy temperature had maximum positive indirect effect on yield spike length (31.14).

Flag leaf area had effected yield indirectly through spike length (11.38), followed by canopy temperature (8.01) in positive way

Similar finding for flag leaf area was reported by Vesna et al. (2009).

Relative water contents had maximum indirect effect through spike density (22.66) and had negative indirect effect through spike length (-13.39).

Spike length having significantly higher effect on yield also effected yield positively through canopy temperature (11.73), followed by grain weight per spike (4.38).

Spike density have maximum direct effect on yield in drought condition with the value of 98.487

Grain weight per spike have positive direct effect on yield, this statement is also supported by Kilic and YaÄŸbasanlar (2010).

Although 1000-grain weight had negative direct effect on yield, but it had significant positive indirect through spike density (19.83).

3. Conclusion

In normal conditions maximum correlation was recorded for number of grains per spike followed by grain weight per spike whereas number of grains per spike was also have top most value of correlation in drought environment.

Path analysis revealed in both environments that number of grains per spike and pike length could be used for direct selection for the yield. Plant height, 1000-grian weight and relative water contents also contributed for the grain yield in positive way. Canopy temperature could also be used as differentiating trait for the selection of best surviving genotype under drought conditions.

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