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Evaluation of Spring Wheat (*Triticum aestivum* L.) For Drought Field Conditions: A Morpho-physiological Study

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Abstract
Twenty wheat (*Triticum aestivum* L.) genotypes were compared for different morpho-physiological traits under drough stress to know the type and extent of their contribution to yield. There was significant variation found among whe genotypes for indicated traits. Wheat genotypes 8252, Rohtas 90, 8274 and 8244 were found high yielding under droug field conditions. However it concluded these can be selected to grow under drought stress conditions or may be useful f further cross breeding programme. Inter-relationships and path coefficient analysis revealed that stomatal frequency a osmotic pressure along with their indirect causal effects may be useful selection criteria for increasing grain yield of whe because of their direct positive effects on grain yield in wheat under drought field conditions.

Introduction
Wheat (*Triticum aestivum* L.) is one of the major cereal in the arid regions of the temperate zone and is widely grown in the area subjected to drought stress. Water stress can limit plant growth and productivity, either because of unexpected dry periods or normally low rainfall. Since all plant processes take place in aqueous medium, reduced water uptake has deleterious effects on most of the physiological processes like stomata closure, change in the protein and carbohydrate metabolism reduction, photosynthetic rate, nutrient uptake, translocation of ion and metabolites, and overall reduction in crop growth rate (Metha and Sarkar, 1991; Sharma and Bhalla, 1991). Cellular growth appears to be the most sensitive response to water stress. Decreasing the external water potential, results in a perceptible decrease in cellular growth and thus root and shoot growth (Sakurai and Kuraishi, 1988). Clearly, because growth is especially sensitive to water stress, yields can be noticeably decreased with even moderate drought. Therefore it is necessary to study the correlated response of those plant traits which are responsible for high grain yield in wheat under drought conditions. Hardwick and Andrews (1980) expressed apprehensions about total reliance on yield components analysis.

Apparently, therefore, there is a need to evolve genotypes that have efficient plant mechanisms so that they can either escape or better tolerate the conditions of drought defined as prolonged periods of dry weather. However, it is imperative to study the genetic make-up of characters, which are responsible for drought tolerance in crop plants. In the present studies efforts have been made to observe the possible contribution of various plant traits and also the type and extent of their contribution to the grain yield.

Materials and Methods
The experiment consisted of three wheat varieties and seventeen strains, viz., LU26S, Rothas 90, Inqalab 91, 8244, 8247, 8249, 8250, 8251, 8252, 8255, 825 8265, 8269, 8271, 8271-2, 8272, 8274,8277, 828 8290 respectively. The experiment was conducted research area of Department of Plant Breeding a Genetics, University of Agriculture, Faisalabad. The see of the twenty wheat genotypes were grown in the fi during the crop season 1994-95 following triplicat randomized complete block design under drought conditio (Zero irrigation). Twenty seeds per genotype were grow The distance between plant-to-plant and row-to-row w 15 cm and 22.5 cm respectively.

Ten garded plants per genotype were randomly selecte record the data. Flag leaf area (cm^2) of mother shoot selected plants in each replication was measured w electric leaf area meter. The stomatal frequency (μ) cou per unit area were made on the upper surface of the under high power (40 ×) microscopic field. The stom length and breadth (μ) were examined from the upper strips under high power (100 ×) object of microsc Upper epidermal cell length and breadth were measure micron (μ) from the peels taken from the upper leaf sur of third nodal leaf. Peels were taken and immerse Cornoy's solution during morning hours when the le fully turgid. Osmotic pressure was measured from th sap in milli-osmole per kg using automatic m osmometer. For leaf venation (μ), samples were exa under low power (10 ×) of microscope for countin number of parallel veins of selected plants leaf. Grain per plant (g) was also determined from randomly sel plants. The data were analyzed by using the m delineated by Steel and Torrie (1980) to assess signi differences among the means of wheat genotypes. test was applied to asses the significant differences a genotypes. Correlation coefficients were calc according to Kwon and Torrie (1964). Path coef analyses were determined by using the methods of D and Lu (1959).

Results and Discussion

There were highly significant differences found among wheat genotypes for all parameters (Table 1). Ali (1994) and Adnan (1995) also reported a significant genetic variability among wheat genotypes at seedling stage under drought condition. No single genotype showed highest values for all studied traits. Although, wheat genotype 8252 had greater flag leaf area and higher grain yield as compared to other genotypes. Wheat genotype Rohtas had greater stomata size and higher osmotic potential than other wheat genotypes, but it occupied second position in case of grain yield.

The 8274 wheat genotype was found at the third position in case of grain yield, but had greater stomatal frequency and epidermal cell size than other wheat genotypes. The genotype 8244 had higher leaf venation, but in case of grain yield occupied the fourth position. The results of this study suggested that wheat genotypes 8252, Rohtas 90, 8274 and 8244 can be selected to grow under drought stress conditions or may be useful for further cross breeding programme. Sinha *et al.* (1986) reported that *Triticum aestivum* genotypes were more drought resistant than triticale's and *Triticum durum* cultivars.

Most of the phenotypic correlation coefficients (Table 2) were found to be non significant among studied traits, although grain yield had highly significant and positive phenotypic correlation with flag leaf area, stomatal frequency and leaf venation. Ali (1994) reported significant and positive relationship between flag leaf area and grain yield, leaf venation and grain yield in wheat under drought conditions. Adnan (1995) found significant inter-relationship among most of morpho-physiological traits in wheat at seedling stage under drought conditions. Epidermal cell size had highly significant positive phenotypic correlation with flag leaf area but negative with stomatal frequency. In case of genotypic correlation coefficients the r_G magnitude (Table 2) found to higher between grain yield and flag leaf area, between stomatal frequency and grain yield and between grain yield and leaf venation.

In path-coefficient analysis (Table 3), direct effect of flag leaf area, stomata size and epidermal cell size on grain yield was negative. Although, direct effect of stomatal frequency, osmotic pressure and leaf venation was found to be positive on grain yield. Indirect effects via stomatal frequency, stomata size, epidermal cell size, osmotic pressure were negative, but indirect effect via leaf venation was positive on grain yield. The indirect effects of stomatal frequency via flag leaf area, stomata size and epidermal cell size were positive. But it had negative indirect effects via osmotic pressure and leaf venation. In case of stomata size, the indirect effects via stomatal frequency, flag leaf area and osmotic were negative, but positive via epidermal cell size and leaf venation. The epidermal cell size had negative indirect effects via stomatal frequency, flag leaf

Table 1: Means for grain yield and some morpho-physiological traits of twenty wheat genotypes under drought stress conditions.

Genotypes	Flag leaf area	Stomatal frequency	Stomata size	Epidermal cell size	Osmotic pressure	Leaf venation	Grain yield
U26S	16.3^{b}	5.03^{abc}	955^{f}	1781^{fgh}	645^{cde}	4.73^{abcde}	17.9^{a}
Rohtas 90	18.1^{ab}	5.29^{ab}	1253^{a}	2833^{ab}	815^{a}	5.10^{a}	18.1^{a}
nqalab 91	17.8^{ab}	4.20^{e}	1074^{bcdef}	1878^{efgh}	535^{fgh}	4.63^{abcdef}	16.5^{abcd}
244	19.7^{ab}	5.17^{ab}	1199^{ab}	2566^{bc}	691^{bc}	5.12^{a}	17.9^{a}
247	18.9^{ab}	4.30^{de}	1137^{abcd}	1604^{gh}	211^{k}	4.50^{bcdef}	16.7^{abc}
249	18.1^{ab}	4.80^{abcde}	1161^{abc}	1518^{h}	234^{k}	4.20^{efg}	16.0^{abcd}
250	18.4^{ab}	4.97^{abc}	1149^{abcd}	1770^{fgh}	436^{hij}	4.67^{abcdef}	14.9^{abcd}
51	18.4^{ab}	4.90^{abcd}	1027^{cdef}	1853^{efgh}	362^{i}	4.70^{abcdef}	17.3^{ab}
52	20.9^{a}	5.27^{ab}	1206^{ab}	3137^{a}	771^{ab}	5.03^{ab}	18.7^{a}
255	18.7^{ab}	4.70^{bcde}	1065^{bcdef}	2279^{cde}	502^{fgh}	4.83^{abcd}	12.7^{cd}
56	19.0^{ab}	5.13^{ab}	987^{ef}	1940^{efgh}	485^{fgh}	4.90^{abc}	17.3^{ab}
65	17.2^{ab}	4.40^{cde}	1203^{ab}	2150^{cdef}	432^{hij}	4.57^{abcdef}	17.2^{abc}
69	17.4^{ab}	5.01^{abc}	1117^{abcde}	1875^{efgh}	379^{ij}	4.30^{defg}	14.3^{abcd}
71	18.5^{ab}	4.97^{abc}	937^{f}	1779^{fgh}	480^{ghi}	4.00^{g}	17.2^{abc}
71-2	16.3^{b}	4.97^{abc}	1123^{abcde}	2015d^{efg}	501^{fgh}	4.10^{fg}	17.9^{a}
72	16.2^{b}	4.80^{abcde}	1022^{cdef}	1888^{efgh}	583^{defg}	4.37^{cdef}	17.1^{abc}
74	19.5^{ab}	5.47^{a}	1246^{a}	3144^{a}	670^{bcd}	4.72^{abcdef}	18.0^{a}
77	19.2^{ab}	4.40^{cde}	953^{f}	1772^{fgh}	594^{cdef}	4.83^{abcd}	13.3^{bcd}
34	17.3^{ab}	5.27^{ab}	1006^{def}	2307^{cde}	507^{fgh}	4.91^{abc}	13.2^{bcd}
90	19.3^{ab}	5.27^{ab}	1141^{abcd}	2410^{bcd}	549^{efg}	4.94^{abc}	12.3^{d}

ns sharing same letters are not significantly different.

Table 2: Genotypic (r_G) and phenotypic (r_P) in parentheses correlation among indicated traits in twenty wheat genotypes under drought stress conditions.

Trait	Stomatal frequency	Stomata size	Epidermal cell size	Osmotic pressure	Leaf venation	Grain yield
Flag leaf area	-0.007 (-0.006^{NS})	0.240 (0.199^{NS})	0.307 (0.245*)	-0.210 (-0.205^{NS})	0.020 (-0.086^{NS})	0.287 (0.275*)
Stomatal frequency		-0.236 (-0.224^{NS})	-0.542 (-0.472*)	-0.266 (-0.212^{NS})	-0.047 (-0.036)	0.359 (0.301*)
Stomata size			-0.162 (-0.143^{NS})	-0.118 (-0.078^{NS})	0.095 (0.082^{NS})	-0.244 (-0.234^{NS})
Epidermal cell size				-0.008 (-0.007^{NS})	0.225 (0.214^{NS})	-0.219 (-0.154^{NS})
Osmotic pressure					-0.191 (-0.187^{NS})	0.242 (0.234)
Leaf venation						0.396 (0.279*)

NS = P < 0.05, * = P 0.05

Table 3: Direct and indirect effects of some morpho-physiological traits on grain yield under drought stress conditions.

Path association	Direct path coefficient (P)	Indirect path coefficient (P x r)
Direct effect of flag leaf area	-0.091	
Indirect effect via stomatal frequency		-0.001
Indirect effect via stomata size		-0.199
Indirect effect via epidermal cell size		-0.162
Indirect effect via osmotic pressure		-0.025
Indirect effect via leaf venation		0.030
Direct effect of stomatal frequency	0.171	
Indirect effect via flag leaf area		0.001
Indirect effect via stomata size		0.196
Indirect effect via epidermal cell size		0.287
Indirect effect via osmotic pressure		-0.322
Indirect effect via leaf venation		-0.070
Direct effect of stomata size	-0.831	
Indirect effect via stomatal frequency		-0.040
Indirect effect via flag leaf area		-0.021
Indirect effect via epidermal cell size		0.086
Indirect effect via osmotic pressure		-0.144
Indirect effect via leaf venation		0.143
Direct effect of epidermal cell size	-0.529	
Indirect effect via stomata size		0.135
Indirect effect via stomatal frequency		-0.092
Indirect effect via flag leaf area		-0.027
Indirect effect via osmotic pressure		-0.010
Indirect effect via leaf venation		0.336
Direct effect of osmotic pressure	1.211	
Indirect effect via epidermal cell size		0.004
Indirect effect via stomata size		0.099
Indirect effect via stomatal frequency		-0.045
Indirect effect via flag leaf area		0.002
Indirect effect via leaf venation		-0.286
Direct effect of leaf venation	1.495	
Indirect effect via osmotic pressure		-0.231
Indirect effect via epidermal cell size		-0.118
Indirect effect via stomata size		-0.079
Indirect effect via stomatal frequency		-0.008
Indirect effect via flag leaf area		-0.001

area and osmotic pressure and positive via stomata size and leaf venation. The osmotic pressure had negative indirect effects via stomatal frequency and leaf venation, but positive via epidermal cell size, stomata size and flag leaf area. The leaf venation had negative indirect effects via all studied parameters on yield. However, it is concluded from the results that stomatal frequency and osmotic pressure along with their indirect causal effects may be used as an effective selection criteria for increasing grain yield of wheat because of their direct positive effects on grain yield. Keim and Kronstak (1981) reported in path coefficient analysis that osmotic pressure affected yield by change in grain weight at least stressed site.

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