INTER-RELATIONSHIP OF DROUGHT RELATED MORPHO-PHYSIO TRAITS IN WHEAT GENOTYPES

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ABSTRACT: Adequate soil moisture is indispensible for better crop harvests whereas lack of ample soil humidity at critical development stages of crop commonly grown in rainfed areas, limits crop productivity. This may be compromised by genetically improved drought tolerance coupled with yield increase. The present study investigated the inter-relationship of morpho-physio traits among 30 wheat genotypes through correlation analysis. Wheat genotypes were sown during *Rabi* season 2012-13 following RCBD, both under rain shelter and field conditions. Results revealed highly significant ($p< 0.01$) differences among genotypes. A significant positive correlation (0.97) was recorded between days to heading and maturity days as well as between number of fertile tillers/plant and total grain yield/plant (0.38) under normal field conditions. Under rain-shelter conditions the relative water content (0.48) and chlorophyll contents (0.34) showed a significant ($p< 0.05$) and positive correlation with grain yield/plant and number of grains per spike. Hence, it was suggested that traits including number of heading days, number of maturity days, number of fertile tillers per plant, grain yield/plant, relative water content, chlorophyll contents and total number of grains per spike may be used in selection strategy to develop drought tolerant wheat genotypes.

Keywords: Wheat, Drought, Morpho-Physio Traits and Correlation.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is important and major cereal crop of Pakistan grown under irrigated and rainfed conditions (Nasim *et al.,* 2017). The water scarcity causes serious damage to wheat yield in rainfed areas during drought spells that are frequent in such areas. There is a dire need to reduce the effect of water scarcity (drought) on crop production through identification and development of genotypes that are drought tolerant.

Soil moisture stress results mainly due to occasional rains and non accessibility of irrigation amenities in rainfed areas. This is the main reason of lesser yields of wheat crop when compared to yields of irrigated areas (Tokatlidis, 2014).

Punjab is the main wheat producing region of Pakistan, where 26 % of the total cultivatable land area is dependent on rainfed agriculture that contributes its share of about 10 % towards total wheat produced in Pakistan. About 25.7 million tons of wheat production during 2016-17 (Anonymous, 2017) was recorded. In most of the rainfed areas in the country, wheat crop is grown on preserved soil moisture received during *monsoon* rain spells. Very scanty rainfall occurs during the growth period of crop, whereas during the final growth stages rains are highly erratic with uneven distribution. Such pattern results in terminal drought stress thus adversely affects the final crop yield (Xu *et al.,* 2014).

Genetic improvement for drought tolerance coupled with increase in productivity per unit land is need of the hour. This task may be accomplished by selection for yield parameters grown under normal field growth and rain-shelter conditions. But selection for any one parameter perhaps may reduce a chance for a triumphant assortment of some other valuable parameters, due to a belligerent association towards the similar resource of nutrients. This implies that useful information concerning correlation of various yield parameters could be of a great significance to plant breeders and scientists because it helps to discover parameters to which selection should be aimed at, in order to boost the total yield of grain under soil moisture deficit conditions (Ahmad *et. al.,* 2010).

Moisture stress or lack of adequate water for irrigation affects the crop physiology. To mitigate the effect of drought the plant response by stomata closure and reduction of water content thus leading to turgor loss, ultimately the plant dies, due to disturbance in metabolism (Nowsherwan *et al.,* 2017).

It is imperative to categorize wheat genotypes those can endure water deficit circumstance more proficiently in order to increase the wheat yield. Earlier researchers carried out the correlation analysis studies to probe the effects of different morphological and

physiological traits on grain yield under moisture stress condition (Ahmad *et al.*, 2013b).

However, such relationships need to be ascertained in newly developed wheat genotypes. This study investigated the inter-relationship through correlation analysis of various morphological and physiological parameters among different wheat genotypes for devising a suitable selection strategy.

MATERIALS AND METHODS

The study was conducted in the research field area of Pir Mehr Ali Shah Arid Agriculture University Rawalpindi (Latitude: 33.626057, Longitude: 73.071442 and elevation: 508 m). The experiment material comprised of 30 different wheat genotypes maintained in the department (Table-4). The germplasm material was used to study the inter-relationship of various morpho-physio drought related parameters under normal field conditions as well as in rain shelter. The research experiment was carried out in the *Rabi* season 2012-13 under field and rain shelter conditions following a layout design of randomized complete block with three replications. Uniform cultural practices were followed to eliminate biasness. The rainfall data during growth period of the experiment is given in Figure 2. Under rain-shelter, the crop was deprived of any moisture through rainfall. The crop was only given water twice during growth season. Data were recorded for various morphological traits *viz*. number of heading and maturity days, days to grain filling, no. of fertile tillers/plant, one thousand grains weight, total no. of grains/spike, total grain yield/plant; and physiological traits *viz.*, relative water contents (RWC), canopy temperature depression (CTD), chlorophyll contents (CC), cell membrane stability (CMS) and osmotic adjustment (OA) following the research methodology of Bogale *et al.,* (2011) and Lopes *et al.,* (2012). The data were analysed statistically through Analysis of variance to ascertain genotypic differences. Correlation analysis was carried out to know inter-relationship between physio-morphic traits following Kwon and Torrie (1964). The statistical analysis was carried out by utilizing the software Statistix 8.1.

RESULTS AND DISCUSSION

Drought or insufficient moisture causes serious damage during growth season and near grain maturity in wheat. The analysis of variation results (Table 1a and Table 1b) showed highly noteworthy ($p< 0.01$) variations among genotypes for all the morphological and physiological traits studied under field and under rain-shelter conditions. This inferred that genotypes possess great variations which can be exploited for wheat improvement for better yield under drought conditions. This enables us to breed such varieties those can cop up with insufficient moisture during growth season or near grain maturity.

A perusal of Figure-1 indicated that the mean performance of genotypes under the field and rain shelter conditions varied respectively for various traits *viz.*, number of heading days (150 ±0.58 and 125 ±0.83), number of maturity days (175 ±0.49 and 160 ± 0.41) and number of grains/spike (42 ±1.26 and 36 ± 0.76). However, some of the studied traits *viz.*, grain filling period (25 ± 0.73 and 23 ± 0.74), no. of fertile tillers/plant (5 ±0.34 and 4 ±0.32), thousand seed weight (30 ±0.25 and 38 ±0.27), total grain yield/plant (6 ±0.046 and 4 ±0.028), canopy temperature depression (1 ± 0.068 and 2 ±0.066), relative water content (75 ±1.91 and 72 ±3.19) and chlorophyll content (50 ±1.37 and 46 ±1.61) showed a little variation under field and rain shelter condition. This suggests that the genotypes possessed inherent capability to cope with soil moisture stress conditions. From these findings it can be deduced that, such traits which depict least variations for their mean values under both field and rain shelter condition, may serve as selection criterion for further improvement of wheat breeding material for soil moisture stress conditions.

Field condition: Under field condition the crop was dependant only on the rainwater throughout the growth period of the crop. A perusal of table-2 revealed that, number of heading days (DH) showed positive and highly noteworthy correlation (0.97) with number of maturity days (DM). This clearly indicates that a genotype will take more time to mature if it took more days to head under rainfed conditions, similarly if any genotype took lesser days to head so it may mature early as well. Comparable results were observed by Mondal *et al.*, (2016) and Mwadzingeni *et al.,* (2016). The number of heading days showed a negative correlation (-0.44) with thousand grains weight. This suggested that an increase in DH may cause increase in DM. The TGW had significantly negative correlation (-0.49) with DM. This may conclude that prolonged maturity duration may render the grain weights to decline due to lethal drought stress in areas where the crop is solely dependent on moisture through rainfall only. No. of fertile tillers per plant had a positive and significant correlation (0.38) with total grain yield per plant. This is also comparable to the findings of Srikanth *et al.,* (2017) and Khan *et al.*, (2013). The positive correlation indicated that, genotypes having more number of fertile tillers per plant may ultimately contribute towards higher yields.

Thousand grains weight (TGW) is an important parameter that contributes towards the total grain yield of the crop. It showed a negative correlation (-0.47) with cell membrane stability (CMS), this may infer that, if any

genotype, has greater value of CMS then it may have lower TGW. This may be due to the stress tolerated by that genotype and thus compromising TGW. Similar results were also reported by Gajghate, (2013).

Rain-shelter condition: In the rain shelter structure, the wheat genotypes were under moisture deficit condition therefore could be tested for their innate ability to cope drought. Table 3 showed the correlation coefficients of various morpho-physio parameters among different wheat genotypes grown under a rain shelter structure. The parameter DH showed a highly significant and positive correlation (0.98) with DM and a significantly positive correlation (0.39) with relative water content (RWC). On contrary to this, it had a significant but a negative correlation (-0.31) with number of grain filling days. It is evident from the correlation table for coefficients of various parameters of genotypes in rain-shelter (Table 3) that, number of maturity days depicted positive and significant correlation (0.38) with relative water contents (RWC) under the rain shelter structure conditions. These findings surmise that by increasing the DM may cause the genotypes to have higher value of relative water content (RWC). Similar results were observed by Singh and his colleagues in 2017. The grain filling days had a significant but negative correlation (-0.36) with Canopy Temperature Depression (CTD). It may be deduced from these findings that a prolonged grain filling duration may cause reduction in the CTD value. Many scientists have used CTD as a selection measure to improve drought tolerance ability (Purushothaman *et al.,* 2015; Rauf *et al.,* 2016).

The number of tillers per plant had a positive and highly noteworthy correlation (0.51) with total grain yield. Whereas, a highly significant but negative correlation (-0.41) was observed with CTD in the rain shelter structure. Thus by assortment of such wheat genotypes which have more number of tillers per plant may increase the total grain yield. Karimizadeh *et al.* (2011) reported that CTD is correlated to yield under hot, dry and irrigated conditions in Mexico.

The Pearson's correlation investigation showed that total no. of grains per spike had a positive and significant correlation (0.34) with chlorophyll contents under rain shelter structure. This may infer that, a wheat genotype with high chlorophyll contents will have higher photosynthetic rate and thus that genotype may have greater number of total grains per spike. These findings are in accordance to those of Kiliç and Yağbasanlar, (2010).

Under rain shelter conditions a highly significant and positive correlation (0.48) was observed between total grain yield per plant and relative water contents. This may infer that, by increasing the relative water contents through process of selection can cause the total grain yield per plant to increase. These findings are in accordance with the results obtained by Lopes and Reynolds, (2010).

Table-1A: Analysis of variance for various morphological and physiological traits under field condition.

SOV	DF	DH	DM	GFP	TPP	GPS	TGW
Gen.	29	180.69**	104.6**	44.6**	3.87**	499.4**	182.68**
Rep.	2	0.23	9.7	9.07	1.01	1.91	0.155
Error	58	1.02	0.72	1.64	0.35	4.77	0.197
SOV	**DF**	**YPP**	**CTD**	**RWC**	**CC**	**CMS**	**OA**
Gen.	29	1.28**	1.69**	58.08**	22.04**	319.7**	0.0016**
Rep.	2	0.75	0.012	12.15	1.20	13.00	1.44E^{-7}
Error	58	0.006	0.014	11.03	5.67	14.07	6.39E^{-8}

** = Highly Significant, SOV= Source of variation, Gen. =Genotypes, Rep. =Replication, DF=Degree of freedom, DH= No. of days to heading, DM= No. of days to maturity, GFP= Grain filling period, TPP= No. of fertile tillers/plant, GPS= No. of grains/spike, TGW= 1000-grain weight, YPP= Grain yield/plant, CTD= Canopy Temperature Depression, RWC= Relative Water Content, CC= Chlorophyll Content, CMS= Cell Membrane Stability, OA= Osmotic Adjustment.

Table-1B: Analysis of variance for various morphological and physiological traits under rain shelter condition.

SOV	DF	DH	DM	GFP	TPP	GPS
Gen.	29	217.3**	127.03**	78.28**	1.25**	236.56**
Rep.	2	1.078	8.23	6.93	4.23	8.63
Error	58	2.07	0.509	1.64	0.32	1.73
SOV	**DF**	**TGW**	**YPP**	**CTD**	**RWC**	**CC**
Gen.	29	105.73**	1.51**	0.832**	248.17**	44.36**
Rep.	2	17.58	0.71	0.017	0.42	0.57
Error	58	0.23	0.002	0.013	30.60	7.85

** = Highly Significant, SOV= Source of variation, Gen. =Genotypes, Rep. =Replication, DF=Degree of freedom, DH= No. of days to heading, DM= No. of days to maturity, GFP= Grain filling period, TPP= No. of fertile tillers/plant, GPS= No. of grains/spike, TGW= 1000-grain weight, YPP= Grain yield/plant, CTD= Canopy Temperature Depression, RWC= Relative Water Content, CC= Chlorophyll Content, CMS= Cell Membrane Stability, OA= Osmotic Adjustment.

Table-2: Correlation coefficient among various traits of wheat genotypes under field condition.

	DH	DM	GFP	TPP	GPS	TGW	GYP	CTD	RWC	CMS	OA
DM	0.97 **										
GFP	0.05 NS	0.26 NS									
TPP	-0.03 NS	-0.01 NS	0.08 NS								
GPS	-0.02 NS	0.007 NS	0.13 NS	-0.0 NS							
TGW	-0.44 *	-0.49 **	-0.33 NS	0.05 NS	-0.10 NS						
GYP	0.24 NS	0.22 NS	-0.09 NS	0.38 *	-0.10 NS	-0.04 NS					
CTD	-0.10 NS	-0.06 NS	0.15 NS	0.28 NS	-0.10 NS	0.04 NS	0.12 NS				
RWC	-0.22 NS	-0.17 NS	0.23 NS	0.25 NS	-0.05 NS	0.22 NS	0.16 NS	0.26 NS			
CMS	0.06 NS	0.12 NS	0.23 NS	0.18 NS	0.02 NS	-0.47 **	0.24 NS	0.07 NS	-0.16 NS		
OA	-0.26 NS	-0.29 NS	-0.19 NS	0.05 NS	0.29 NS	0.007 NS	0.17 NS	0.32 NS	0.03 NS	0.09 NS	
CC	-0.12 NS	-0.10 NS	0.09 NS	-0.006 NS	-0.10 NS	-0.35 *	-0.26 NS	-0.04 NS	-0.03 NS	0.25 NS	0.19 NS

**= Highly significant, *= Significant, NS= Non significant, DM= No. of days to maturity, DH= No. of days to heading, GFP= Grain filling period, TPP= No. of fertile tillers/plant, GPS= No. of grains/spike, TGW= 1000-grain weight, GYP=Grain yield/plant, CTD= Canopy temperature depression, RWC= Relative water content, CMS= Cell membrane stability, OA= Osmotic adjustment, CC= Chlorophyll content.

Table-3: Correlation coefficients of various traits of wheat genotypes under rain-shelter condition.

	DH	DM	GFP	TPP	GPS	TGW	GYP	CTD	RWC	CMS	OA
DM	0.98 **										
GFP	-0.31 *	-0.14 NS									
TPP	-0.01 NS	0.05 NS	0.33 NS								
GPS	0.19 NS	0.14 NS	-0.31 NS	-0.34 NS							
TGW	0.03 NS	0.02 NS	-0.05 NS	0.04 NS	0.02 NS						
GYP	0.13 NS	0.15 NS	0.04 NS	0.51 **	0.06 NS	0.28 NS					
CTD	-0.06 NS	-0.13 NS	-0.36 *	-0.41 **	0.05 NS	0.18 NS	-0.33 NS				
RWC	0.39 *	0.38 *	-0.14 NS	0.21 NS	-0.10 NS	0.17 NS	0.48 **	-0.19 NS			
CMS	0.02 NS	0.02 NS	-0.009 NS	-0.17 NS	0.08 NS	0.09 NS	-0.08 NS	0.19 NS	0.11 NS		
OA	-0.27 NS	-0.27 NS	0.08 NS	0.11 NS	-0.05 NS	-0.04 NS	-0.27 NS	0.16 NS	-0.34 NS	0.09 NS	
CC	-0.15 NS	-0.14 NS	0.12 NS	0.07 NS	0.34 *	-0.13 NS	-0.04 NS	-0.09 NS	-0.02 NS	0.28 NS	0.16 NS

**= Highly significant, *= Significant, NS= Non significant, DM= No. of days to maturity, DH= No. of days to heading, GFP= Grain filling period, TPP= No. of fertile tillers/plant, GPS= No. of grains/spike, TGW= 1000-grain weight, GYP=Grain yield/plant, CTD= Canopy temperature depression, RWC= Relative water contents, CMS= Cell membrane stability, OA= Osmotic adjustment, CC= Chlorophyll content.

Table-4: List of wheat genotypes used in the study.

Sr.No.	Genotype	Sr.No.	Genotype	Sr.No.	Genotype
1	DR77MP3	**11**	DR91MP3	**21**	DR103MP3
2	DR78MP3	**12**	DR92MP3	**22**	DR104MP3
3	DR79MP3	**13**	DR93MP3	**23**	DR105MP3
4	DR80MP3	**14**	DR94MP3	**24**	DR106MP3
5	DR85MP3	**15**	DR95MP3	**25**	DR107MP3
6	DR86MP3	**16**	DR97MP3	**26**	DR109MP3
7	DR87MP3	**17**	DR99MP3	**27**	DR110MP3
8	DR88MP3	**18**	DR100MP3	**28**	DR112MP3
9	DR89MP3	**19**	DR101MP3	**29**	DR113MP3
10	DR90MP3	**20**	DR102MP3	**30**	DR114MP3

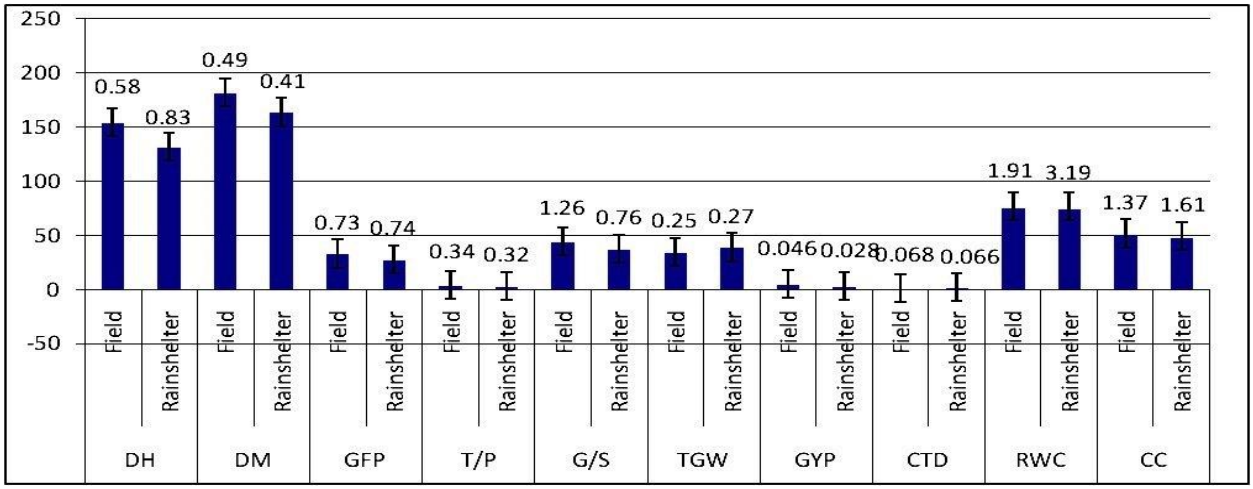

Figure-1: **Mean performance of wheat genotypes indicating error mean bars under field and rain shelter conditions for various Morpho- physio traits where; DH= No. of days to heading, DM= No. of days to maturity, GFP= Grain filling period, T/P= No. of tillers/plant, G/S= No. of grains per spike, TGW= 1000-grain weight, GYP=Grain yield per plant, CTD= Canopy temperature depression, RWC= Relative water contents and CC= Chlorophyll content.**

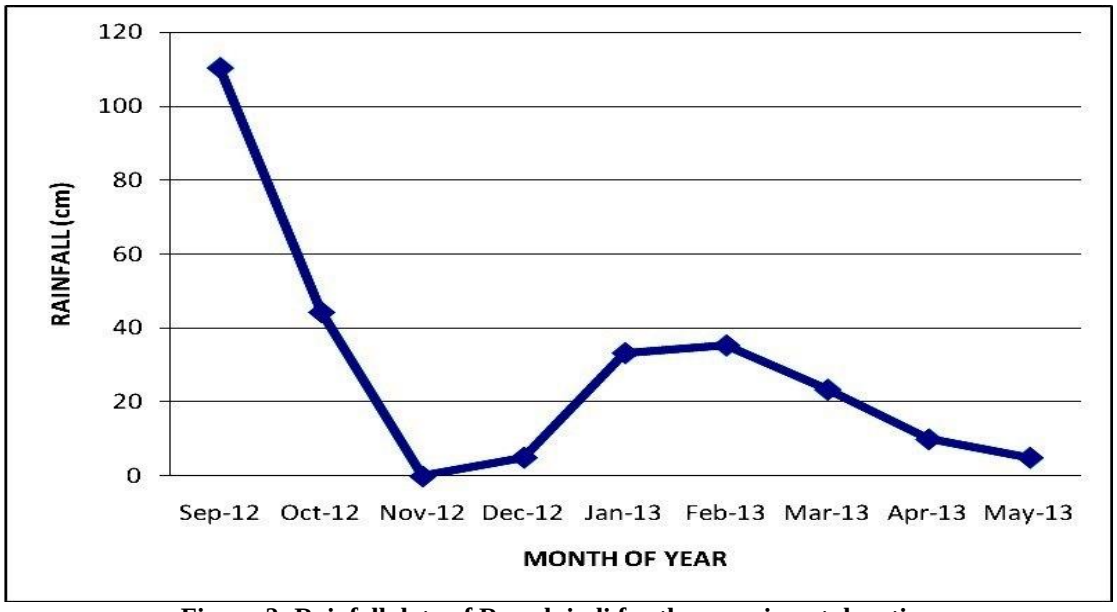

Figure-2: Rainfall data of Rawalpindi for the experiment duration

Conclusion: It was concluded that traits including number of heading days, number of maturity days, number of fertile tillers per plant, grain yield/plant, relative water content, chlorophyll contents and total number of grains per spike may be used in selection strategy to develop drought tolerant wheat genotypes.

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