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Study of Morphological Traits Affecting Grain Yield in Wheat (*Triticum aestivum* L.) Under Field Stress Condition

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Abstract: Inter-relationship among yield and different yield related traits were investigated by correlation and path coefficient analysis through sowing wheat varieties/lines under moisture stress conditions using randomized complete block design with three replications. The obtained results indicated that grain yield had positive correlation with peduncle length, spike length, grains per spike and 1000-grain weight, whereas, negative correlation with days to heading, plant height and tillers per plant. Furthermore, path analysis indicated that 1000-grain weight had the highest positive direct effect on yield followed by spike length and days to heading while, tillers per plant, plant height, grains per spike and peduncle length had negative direct effect on yield. So, these results suggested that traits such as spike length and 1000-grain weight having positive correlation and direct effect on grain yield can be used as suitable selection criteria to develop high yielding genotypes.

Key words: Genotypes · Correlation · Path analysis · Selection · Yield

INTRODUCTION

Wheat is the world's most important cultivated crop, being the foremost food staple of mankind contributing more calories and more protein to world's diet than any other food crop. The evolution of short stature and fertilizer responsive wheat varieties has been a landmark in the annals of genetic improvement of wheat that resulted in a remarkable increase in its potential for grain yield. However, by and large a vast array of varieties have been developed to adapt to rather quite uniform environmental conditions, where temperatures are moderate and rainfall is either adequate or can be supplemented or substituted by irrigation [1].

Drought is the most serious constraint in way of successful wheat crop production. The problem of drought is acute in developing countries of the world where about 37% of wheat growing areas are semi-arid in which available limited soil moisture constitutes a primary hurdle in way of wheat production [2]. According to Kramer [3], the world wide losses in yield caused by water shortage and salinity are greater than those caused by all other factors together. Areas where wheat is grown under supplemental irrigation are also hit by drought during the late stages of plant growth causing considerable reduction in yield, sometimes in severe cases, reaching up to 81% [4]. On the other hand, world demand for grain in year 2020 is expected to be 40 percent higher than that of its level in the later half of the 1990s [5]. So, it is a dire need of time to evolve new genotypes with traits that could not only tolerate serious soil and atmosphere moisture stress at various stages of growth but can also produce higher economical grain yield under drought stress conditions.

Genetic improvement in drought tolerance along with increase in production may be accomplished by selection for grain yield traits under water stress field condition in the breeding program [2, 6]. But**,** selection for one trait can reduce a chance for a successful selection for some other trait, due to a competitive relationship towards the same source of nutrients. However, the combination of traits that in various ways contribute to the improvement of yield can result in a maximum gain of each trait individually [7]. So, information of correlations among traits can be of a great use to breeders, as it points out to the traits to which selection should be directed in order to increase the yield under certain environmental conditions. Genetic correlations point out the cohesion of traits after

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variations due to environmental effects that are eliminated providing basis for indirect selection [8]. But simple correlation can not provide the reasons of association among traits. For that, path coefficient analysis may be used that measures the influence of one variable upon another and determines which yield component is influencing the yield substantially [9]. Through this information, selection can be practiced on that criterion, making possible great progress through selection within short period of time. Many researchers carried out correlation and path analysis studies to investigate the effects of different morph-physiological traits on grain yield under moisture stress condition [1, 2, 4, 8, 10-13]. The association of grain yield in spring wheat with other agronomic traits is quite complicated and not clearly understood due to quantitative inheritance pattern. Keeping this in view, the present investigation was undertaken with objective to identify and evaluate agronomic traits associated to grain yield under drought stress condition and also to characterize traits that have highest direct and indirect effects on yield in this condition.

MATERIALS AND METHODS

This study was carried out at University of Agriculture, Faisalabad, Pakistan using twelve wheat varieties/inbred lines (AVP-4008, DN-52, NR-356, ESW-9525, V-07194, V-5066, ZAS-70, QS-111, CT-4192, Inqilab-92, Chakwal-86, Fareed-2006).These genotypes were sown in the field under moisture stress condition (zero tillage) through dibbler in triplicate randomized block design. Each plot consisted of 3 rows of 5m length keeping rows 30 cm and plants 15 cm apart. Recommended doses of fertilizers were applied at the time of sowing. No irrigation was applied during the growing season. Data were recorded on days to heading, plant height, peduncle length, number of tillers per plant, spike length, number of grains per spike, 1000-grain weight and grain yield.

The data recorded on these eight characters were subjected to variance and covariance [14], genotypic and phenotypic correlation coefficients according to Know and Torrie [15] and path coefficient analysis according the procedure as given by Dewey and Lu [9].

The average temperature (°C) and average rainfall (mm) recorded during the experiment period had been shown in Fig. 1.

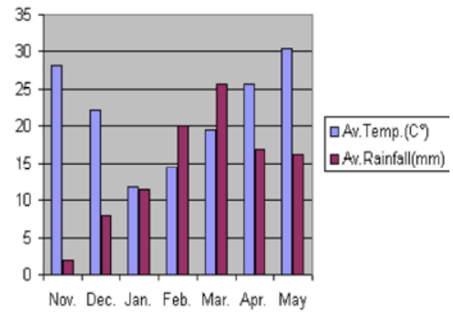

Fig. 1:

RESULTS AND DISCUSSION

Correlation: Genotypic and phenotypic correlation coefficients for all possible combinations of traits under study has been presented in Table 1. In most all the cases, genotypic correlations were higher as compared to phenotypic ones. It might be due to depressing effect of environment on character association [16, 17]. The explanation of observations regarding the association of various traits with yield was as below. Days to heading showed positive and significant correlation with plant height and tillers per plant at both genotypic and phenotypic levels whereas, negative but non-significant correlation with peduncle lengthy and spike length. A positive weak association of days to heading with grain per spike and 1000-grain weight was found. There was found negatively significant correlation between days to heading and grain yield per plant [11, 18] indicating clearly the effectiveness of early maturing genotypes to obtain higher grain yield in rainfed areas.

Plant height showed positive significant correlation with peduncle length and non-significant with tillers per plant and spike length at both levels [19]. Whereas, negative and significant correlation of plant height with grains per spike and 1000-grain weight was observed at both levels indicating longer the genotypes, lesser would be both grains per spike and 1000-grain weight that may be due to production of small shriveled type grains by longer genotypes due to moisture stress. Similarly, association of plant height with grain yield was observed highly significant negative at both genotypic and phenotypic levels [20, 21]. One possible reason may be that longer genotypes are more susceptible to lodging than shorter ones leading to cause reduction in grain yield ultimately. So, it seems logical to go with selection for short stature genotypes for lodging resistance coupled with high yield under drought stress conditions.

Table 1: Genotypic and phenotypic correlation coefficients matrix under field stress condition.

Characters		Plant height	Peduncle length	Tillers/ plant	Spike length	Grains/ spike	1000-grain wt.	Grain yield
Days to	r_g	0.317*	-0.167	0.301*	-0.089	0.134	0.204	-0.297*
heading	r_p	0.289*	-0.14	0.288*	-0.062	0.109	0.181	-0.280*
Plant	r_g		0.284*	0.149	0.211	-0.295*	-0.329*	-0.579**
height	r_p		0.259*	0.13	0.182	-0.271*	-0.307*	-0.552**
Peduncle	r_g			-0.083	0.129	0.308*	0.166	0.335*
length	r_p			-0.069	0.109	0.267*	0.145	0.309*
Tillers/	r_g				0.286*	0.142	-0.089	-0.379*
plant	r_p				0.237	0.116	-0.061	- 0.287*
Spike	r_g					0.169*	-0.223	0.299*
length	r_p					0.154*	-0.206	0.264*
Grains/	r_g						0.2-17	0.326*
spike	r_p						0.198	0.209
1000-	r_g							0.490**
grain wt.	r_p							0.464**

* = Significant at 5% level

** = Highly Significant at 1% level

Table 2: Direct (in parenthesis) and indirect effect of different traits on grain yield

Characters	Days to Heading	Plant height	Peduncle length	Tiller/ plant	Spike length	Grains/ spike	1000-grain wt.
Days to heading	-0.328	-0.045	0.024	0.17	0.013	-0.217	-0.248
Plant height	-0.394	(-0.228)	0.034	-0.044	0.148	0.157	-0.488
Peduncle length	0.128	-0.112	(-0.059)	0.019	0.163	-0.029	-0.225
Tillers/ plant	0.244	-0.011	0.161	(-0.739)	0.062	-0.013	0.265
Spike length	0.186	0.029	-0.068	0.048	-0.751	0.096	0.065
Grains per spike	-0.218	0.113	0.038	-0.259	0.349	(-0.318)	-0.314
1000-grain weight	-0.212	0.153	0.066	-0.135	0.104	0.137	-0.97

The correlation of peduncle length with tillers per plant was recorded negatively non-significant whereas, positively non-significant association of peduncle length with spike length and 1000-grain weight was observed at both genotypic and phenotypic levels. A significant and positive correlation of peduncle length with grains per spike and grain yield was recorded at both levels indicating longer the peduncle length, more may be grains per spike and hence, more would be grain yield [22].

A positive and significant correlation between tillers per plant and spike length was observed at genotypic level suggesting breeding for increase in tillers per plant may lead to cause longer spike length. There was found positive weak association of tillers per plant with grains per spike and negative weak association with 1000-grain weight. While, correlation between tillers per plant and grain yield was observed significantly negative at both levels, that may be due to increase in competition among plants for limited soil moisture available for growth under drought environment.

There was observed positive significant correlation of spike length with grains per spike and grain yield at both genotypic and phenotypic levels indicating its utility as direct selection criteria to improve yield [23, 24]. The correlation between spike length and 1000-grain weight was recorded non-significantly negative at both levels. There was observed positive non-significant correlation between grains per spike and 1000-grain weight at both levels**.** Similar but significant positive correlation was observed between grains per spike and yield at genotypic level, indicating its importance in breading program designed to develop higher yielding genotypes for a target environment. These results were in contradiction with the finding of Khan *et al*. [13] who reported strong negative association of grains per spike with yield.

The correlation between 1000-grain weight and grain yield was found highly significant positive at both genotypic and phenotypic levels suggesting the effectiveness of this trait to select and identify desirable wheat lines for drought environment. Similar results had been reported by Mondal *et al*. [25].

Path Coefficient Analysis: Results pertaining to the path analysis are presented in Table 2. The direct effect of days to heading on grain yield was recorded positive with path coefficient value of 0.328 also earlier reported by Josm [26]. The indirect effects through peduncle length, tillers per plant and spike length were found positive with path coefficient values of 0.024, 0.170 and 0.013, respectively whereas, negative indirect effects through plant height (0-.045), grains per spike (-0.217) and 1000-grain weight (-0.248) were observed. So, positive direct effect of days to heading was nullified by the negative indirect effects of plant height, grains per spike and 1000-grain weight resulting in significant negative correlation with yield.

Plant height showed negative direct effect on grain yield with value of -0.228 that may be due to high percentage of dry matter accumulation in vegetative parts of taller plant thereby reducing grain yield. It had positive indirect effects through peduncle length (0.034), spike length (0.148) and grain per spike (0.157) while, negative indirect effects *via* days to heading (-0.394), tiller per plant (-0.044) and 1000-grian weight (-0.488). These results contradicted the findings of Khan *et al.* [13] and Akhtar *et al*. [27] who reported positive direct effect of plant height on yield.

The path analysis indicated that peduncle length had negative direct effect (-0.059) on grain yield [13]**.** While, positive values were obtained from indirect effects through days to heading (0.128), tillers per plant (0.019) and spike length (0.163) whereas, negative indirect effects *via* plant height (-0.112), grain per spike (-0.029) and 1000 grain weight (-0.225) were observed. So, it is advisable to avoid direct selection based on peduncle length in breeding program designed to improve grain yield due to its direct and indirect deleterious effects on yield.

The direct effect of tillers per plant on grain yield was found negative (-0.739) whereas, Lad *et al*. [28] reported positive direct effect of tillers per plant on yield. Similarly, negative values were obtained from its indirect effects through plant height (-0.011) and grains per spike (-0.130) whereas, positive indirect effects *via* days to heading (0.244), peduncle length (0.161), spike length (0.062) and 1000-grain weight (0.265) were found. Since the direct effect was negative, so the direct selection for this trait to improve yield will be undesirable.

Spike length showed positive direct effect on grain yield with value of 0.751 [10, 27]. The indirect effects *via* days to heading, plant height, tillers per plant, grains per spike and 1000-grain weight were recorded positive with values of 0.186, 0.029, 0.048, 0.096 and 0.065, respectively while, negative indirect effects only through peduncle length (0.068) was found. So, these results revealed that direct selection based on spike length should be considered to improve grain yield of wheat varieties/genotypes due to its positive direct and indirect effects on yield.

Grains per spike showed negative direct effect on yield with value of -0.318. In contrast, Akram *et al*. [12] reported positive direct effect of grains per spike on yield. The indirect negative effects were contributed through days to heading (-0.218), tillers per plant (-0.259) and 1000-grain weight (-0.314) whereas, traits like plant height (0.113), peduncle length (0.038) and spike length (0.349) were found indirect positive contributors. So, selection can be practiced for grains per spike through plant height, peduncle length and spike length.

The direct effect of 1000-grain weight on grain yield was positive (0.970) indicating it as suitable selection criteria for developing high yielding wheat genotypes for rainfed areas. The indirect negative effects via days to heading (-0.212) and tiller per plant (-0.135) were observed. However, positive indirect effects via plant height (0.153), peduncle length (0.066), spike length (0.104) and grains per spike (0.137) were found. Similar results had been reported by Dencic *et al.* [23] and Josm [26].

Although peduncle length and grains per spike had positive relationship with grain yield but these traits had negative direct effect on yield so, spike length and 1000-grain weight were important as contributing traits towards yield.

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