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The Study of Path Analysis for Durum Wheat (*Triticum durum* Desf.) Yield Components

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ABSTRACT

This study used 10 durum wheat (*Triticum durum* Desf.) genotypes based from Azerbijan and Iran for experient purposes with an RCB design with four replications under non-stress full-irrigation and drought stress conditions in Ardabil, Iran during the 2015-2016 crop year. The study measured and evaluated the following parameters related to performance traits after harvest: tiller number, plant height, fertile tillers, length of main spike, peduncle length, number of internodes, awn length, spike original weight, number of seeds per main spike, TDW and grain weight. The results of variance analysis indicated that genotypes and their interactions with the environment differ significantly. Since the genotypic interaction with the environment was more significant, this study used genotypic correlation to study the relationship between variables. The comes about of relationship examination for the execution of the hereditary characteristics of the remaining edge relapse show detailed that the gather record (Hello there) had the most noteworthy affect, meaning it might be the basis for accomplishing the most elevated execution. TGW was The greatest coordinate negative impact on execution was related to the TGW.

KEY WORDS: GENETIC DIVERSITY, PATH ANALYSIS, PERFORMANCE, DURUM WHEAT.

INTRODUCTION

The world has been counting on wheat as an critical source of nourishment for thousands of years (Gholamin and Khayatnezhad 2020). Still, wheat, a whole-grain cereal, plays a vital role in feeding the ever-increasing population of the world. (Feldman 2000). On the international markets, durum wheat is usually traded at significantly higher prices than bread wheat. Besides, its great agronomic adaptability has caught the attention of many farmers. Also, it is extensively cultivated on a global scale in areas with suitable conditions for wheat farming. Arguably, durum wheat is a critical agronomic product and its farms are found in almost all continents: in the Mediterranean basin of Western Asia, Northern Africa, and South Europe (Khayatnezhad 2012, Khan, Alam et al. 2013).

Famously, dishes with durum wheat dough extend beyond geographical borders, as the art of cuisine in many countries has developed delicious, exclusive ways of using the grain (Gholamin and Khayatnezhad 2020. For instance, countries in North Africa and the Middle East cook traditional dishes like 'couscous' or 'bulgur', flat, unleavened bread; and in India, durum is consumed as 'chapatis .' Therefore, with such extensive use worldwide, it is no surprise that about 50% of world's production of durum wheat is converted into pasta products. It requires sufficient information of the relationship between the surrender and its component characters to design and implement an effective breeding program based on the yield components.

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In this respect, identifying the correlation coefficients between component characters is vital for choosing suitable materials for breeding (Afroz, Sharif et al. 2004). The path coefficient analysis, on the contrary, has proved more helpful in expounding the component-specific, coordinate and roundabout impacts on grain abdicate. Therefore, this study attempts to identify the relationships between abdicate and its component characters by assist analyzing the components causing such relations (Khan, Alam et al. 2013).

Environmental sources of stress, such as dryness and its associated consequences are critical, hindering factors of crop production, like wheat, on the national and international levels. The importance of this issue becomes more prominent in areas with moderate or high environmental stress related to dryness. (Kirigwi, Van Ginkel et al. 2004). The gravity of this issue becomes more palpable when we realize that about more than 1/4 of areas on land have dry climates, and 1/3 of the world's arable land is currently facing water deficit stresses (Kirigwi, Van Ginkel et al. 2004).

Some parts of the Mediterranean do not offer optimal levels of moisture conditions, thus hinder the optimal production of wheat. Technically, plants undergoing stressful presentation to dry spell within the vegetative stage have discernable disorders, such as leaf wilting, plant height decline, reducing within the number and zone of leaves, and delay within the precision of buds and blossoms (Talebi, Fayaz et al. 2009). By definition, drought tolerance is a plant's ability to grow and produce under water-shortage stress. If drought is remaining for the long term, the impacts of the related stress on a plant's metabolism are associated with its growth stage, SWSC (soil retention capacity) and physiology. In a relevant research on seven wheat cultivars from 53 lines, Moghaddam et al. observed significant differences in growth and other quantitative traits (Moghaddam et al., 2010).

They reported that while it took local cultivars longer to show the first indications of spike growth, they had higher heights and fewer grain seeds per spike and lower TGW, GY, and HI, compared with the newer cultivars. However, new cultivars and some local cultivars demonstrated similar yield traits. (Moghaddam, Ehdaie et al. 1997). A complicated quantitative trait, grain yield is impacted by several yield contributing characters (Xie 2015). The amount of genotypic diversity plays a vital role in developing enhanced crops with optimal yield traits under various agro-climatic conditions (Baye, Berihun et al. 2020). The correlations between genotypic and phenotypic traits are valuable indicators to determine the extent of the association of plants' various morpho-physiological properties with economic productivity. Despite not providing the relative significance of coordinate and circuitous impacts of growth and yield components, a correlation coefficient can be a useful tool in mapping the scope and heading of components' impact for the identification of main characters (Da Silva, Pedrozo et al. 2009).

Path analysis makes all that possible, with the introduction of the relationship coefficient for analyzed characteristics in the cultivars, the indirect and indirect impacts of those traits, and by presenting more authentic and reliable explanations of the causality between the studied traits. Relevant research studies refer to the positive relationship between grain abdicate and surrender component characteristics such as Hello there in wheat cultivars (Ghaderi, Zeinaali et al. 2009), biological yield (Kandic, Dodig et al. 2009), plant height (Leilah and Al-Khateeb 2005), grains per spike (Khan, Azam et al. 2010) and thousand kernels weight (Leilah and Al-Khateeb 2005). Recently, Ahmad et al., (2018) too talked about that grain yield's affiliations with the natural surrender, and the number of spikelets were genotypically and phenotypically positive and significantly noteworthy(Ahmad, Kumar et al. 2018). Path analysis calculates the quantitative direct and indirect impacts of component traits on grain yield (Rajput 2019).

Path analysis effectively divides the correlation coefficients into two main categories of direct and indirect impacts, explaining their associations in more details. (Majumder, Shamsuddin et al. 2008). Way investigation in this way licenses a basic examination of particular variables that deliver a given relationship and can be effectively utilized in defining an viable determination technique (Baye, Berihun et al. 2020). The aim of this research study is to investigate the genetic diversity in durum wheat cultivars, identify inherent traits beneficial for higher yields, and examine the correlation between these traits to select the best breed of durum wheat in terms of performance-related traits for cultivation under stress conditions, especially in Ardabil.

MATERIAL AND METHODS

For the sake of experiment, this study selected ten durum wheat Genotypes (Triticum durum Desf.) indigenous to Iran and the Azerbaijan due to their rumored contrasts in surrender execution beneath inundated and non-irrigated conditions (Table 1).

Table1. Name and Origon of used genotypes

Code	Genotype	Region
1	Hordeiforme (Miyaneh)	Iran
2	Leucurum (Qax)	Azerbaijan
3	Hordeiforme (Naxcivan)	Azerbaijan
4	leucumelan(Naxcivan)	Azerbaijan
5	Niloticum (Naxcivan)	Azerbaijan
6	Hordeiforme (Maragheh)	Iran
7	Leucurum (Sarab)	Iran
8	Leucurum (Tabriz)	Iran
9	Melanopus (Cheiltoxm)	Azerbaijan
10	Leucurum (Germi)	Iran

The study was conducted in the ARS at the Islamic Azad University of Ardabil in the 2015-2016 crop year. The university is located west of Ardabil, Iran. Based on the meteorological records in the last decade, the yearly precipitation is 310 mm and the normal annually temperature is 8.6°C within the try locale. Too, the normal least temperature is -22°C and the normal most extreme temperature is +30°C. The elevation is 1350 m over the sea-level. Seeds were hand bored and each genotype was sown in five lines of 1.5 m. The remove between the lines was 0.2m The test was conducted utilizing RCB plan with four replications. The Two levels of stretch medicines including: Full water system: characterized as assembly all the water needs of cultivars (100%) at distinctive development stages. Constrained water system: characterized as assembly water requests of the plant until the fertilization organize, and after that applying a organize water treatment until the terminal stage). Every line in 5 columns and 20 cm interims and 150 cm in width were planted. After manor, the try field was watered utilizing the spilling strategy to soak the soil and meet the water requests of cultivars and encourage germination.

The post-harvest performance-related measurements included the following traits and criteria: tiller number total, plant height, number of internodes, fertile tillers, awn length, peduncle length, spike original weight, length of main spike, TDW, number of seeds per main spike, and main spike, grain weight. The study used MATAT-C, SPSS 16, and PATH2 as data analysis tools. The study used the SMR method to conduct path analysis for performance based on the remaining characters. The collected data were analyzed in SPSS and the experiment used Duncan's MRT in 0.01% for comparing treatment means and the cluster method to divide the means into high and low yielding genotypes.

RESULTS AND DISCUSSION

As delineated in Table 2, the comes about of change examination shown that there were critical contrasts among the genotypes in terms of the larger part of characteristics, outlining their tall possibilities for breeding purposes. Since the characteristics were marginally and the environment moreover was noteworthy affect tradition, there this distinction was not startling (Manifesto, Schlatter et al. 2001).

Plant Height: As depicted in Table 2, the results of variance analysis demonstrated that the genotype, environment, and the interaction between them significantly impacted the plants' height (0.01). The mean comparison of the water treatment procedures revealed that full irrigation provided the best condition. As depicted in Table 3, Also, the mean comparison of genotypes concerning plant height indicated that 'genotype 4' had the highest and 'genotypes 2', and 'genotype 5' had the lowest height. Dividing the genotypes into different groups, the mean comparison of the interactions between the genotypes and the environment indicated that 'genotype 4' had the best interactive performance under stress conditions pointing to its optimal resistance in stress conditions. Conversely, 'genotype 2' had the worst interactive performance under similar harsh conditions. The results also appeared that genotypes with higher plant stature have a better push resistance compared to other genotypes. The results of the correlation analysis, presented in Table 4, reported the negative correlation (0.01) of the plant with HI, meaning an increase in the HI, caused the plant to decrease.

Main spike weight: Table 2 depicts the results of variance analysis, indicating that that the significant (0.01%) impact of genotype, environment, and the interaction between them for traits based on main spike weight. The cruel comparison demonstrated that full water system was the finest condition. Cruel comparison of genotypes based on primary spike weight shown that 'genotype 2' and 'genotype 7' had respectively the highest and lowest weight under full irrigation condition. The details are presented in Table 3. Also, 'genotype 7' had the lowest spike weight under stress conditions. Table 4 depicts the positive correlation between TGW, the number of grains per fundamental spike, and primary spike weight (0.01%).

Table 2. Analysis of variance results

S.O.V	df	Plant height	Main spike weight	1000 grain weight	Yield	Harvest index
Rep	3	397.26**	0.91	7.21	79.62	18.24
Condition	1	6458.26**	17.92**	501.26**	54.26	803.26**
Genotype	9	730.26**	2.01**	15.24*	224.26**	80.34**
C*G	9	280.19**	5.65**	13.24	217.25	57.25**
Error	57	101.26	1.54	33.28	413.25	8.65
CV	-	8.91	15.42	9.68	12.27	8.79

** (0.01) And * (0.05) significant levels

Table 3. Mean compression of traits

Genotypes	Treatments									
	PH		MSW		1000-W		Y		Hi	
	N	S	N	S	N	S	N	S	N	S
1	127	101	2.81	2.22	55.35	50.16	98.51	95.26	21.26	23.25
2	114	88	3.24	2.69	60.17	56.68	83.25	70.26	18.26	25.48
3	149	122	1.98	1.54	61.28	51.29	103.25	102.26	22.35	27.26
4	131	126	2.99	1.89	63.59	59.65	79.52	75.21	23.26	24.26
5	114	113	2.54	2.65	51.27	51.02	72.36	60.25	24.25	28.21
6	142	124	2.03	1.85	48.26	45.36	134.26	110.26	21.24	20.26
7	127	92	1.87	1.52	61.27	58.24	65.32	80.36	22.29	25.49
8	130	117	2.68	1.33	57.21	51.26	84.26	75.68	24.68	27.62
9	119	99	2.51	2.01	55.79	50.35	75.36	79.26	27.62	30.14
10	124	108	2.68	1.87	54.35	57.26	74.28	72.04	28.32	40.29

N: Normal, S: Stress, PH: Plant height, MSW: Main spike weight, 1000-w: 1000 grain weight, Y: Yield, Hi: Yield

TGW: As depicted in Table 2, the results of variance analysis indicated the following results concerning the significance of genotype impact for traits: critical in (0.05 percent level); inconsequential environment impact in 0.01 percent level and Genotype and environment interaction for TGW was non-Significant. The cruel comparison shown that full water system was the finest condition. The cruel comparison of genotypes based on TGW indicated that 'genotype 4' and 'genotype 6' had respectively the highest and lowest TGW in normal conditions. Also 'genotype 6' had the lowest TGW under stress condition, as depicted in Table 3. The results of correlation analysis are presented in Table 4, which reported the positive correlation between TGW and main spike weight.

Yield: As depicted in Table 2, the results of variance analysis indicated that the genotype had a significant impact on yield (0.01). Besides, the findings suggested that the impact of the environment and the interaction between genotype and the environment were non-significant. The cruel comparison demonstrated that full water system was the leading condition. The cruel comparison of genotypes based on abdicate appeared that 'genotype 6' had the highest yield and 'genotype 7' the lowest yield in normal condition. Also 'genotypes 5' represented the lowest yield under stress condition (Table 3). The findings of this study indicated a positive correlation between yield, total plant weight, TGW, and HI. Most researchers consider yield as a fundamental trait and put it at the focus of their research studies in the search for the optimal cultivar (Table 4).

Harvest index: The comes about of examination of change (Table 2) appeared that the impact of genotype, environment, and genotype and environment interaction for characteristics in terms of collect list was critical (0.01). The mean comparison indicated that the stress condition was the best condition. The mean comparison of genotypes based on HI showed that, under normal condition, 'genotype 10' had the highest and 'genotype 2' the lowest level of HI; Also, 'genotype 6' had the lowest HI value under stress condition, as represented by Table 3. As depicted in Table 4, the results of the correlation analysis indicated the positive correlation between HI and GY.

Table 4. Correlation between traits

	Plant height	Main spike weight	1000 grain weight	Harvest index	Yield
Plant height	1	0.42	0.048	-0.64**	-0.68
Main spike weight		1	0.412**	0.019	0.41
1000 grain weight			1	-0.078	0.27
Harvest index				1	0.801**
Yield					1

Table 5. Correlation coefficient analysis with direct and indirect effects for yield

Trait name	Direct effect	Indirect effects			
		Plant height	Main spike weight	1000grain weight	Harvest index
Plant height	0.17	1	-0.001	-0.001	-0.489
Main spike weight	0.031	0.006	1	-0.001	0.018
1000 grain weight	-0.003	0.009	-0.007	1	-0.051
Harvest index	0.804	-0.121	-0.002	0	1

Effects remain: 0.077

Table 4. correlation between traits In similar studies evaluating methods' performance characteristics, the cause and effect model of interpretation was used to discuss and analyze the relationship between yield traits. This study used this model to analyze the correlation between yield and yield components' traits and identify the direct and indirect impacts of those traits. Table 5 presents the results of the path analysis. The result indicated that HI had the highest direct positive impact on GY while TGW had the highest negative impact. Also, most indirect effects by harvest index on plant height were applied.

Based on observations, day to complete heading was lower in tall plants, which meant a prolonged reproductive phase and more dense accumulation of photosynthates in the grains. Thus, the findings stated that plant height (PH) and grain yield (GY) were highly, significantly, and positively correlated. Similarly, the findings of relevant studies confirm such reports stating that GY was more considerable in taller plants as the number and size of grain in tall plants were higher. Plant height, on the other hand, though, had remarkable negative impacts on maturity days (Shamsuddin and Ali 1989), further confirming the findings of other studies (Subhashchandra, Lohithaswa et al. 2009).

Among all traits, the only trait with considerably negative perceived correlation with other traits was the 'days to maturity' trait. Other than, significant negative relationships were moreover watched for heading days with all the characteristics but development days, proposing a shorter vegetative stage together with a longer regenerative stage would contribute to higher grain surrender. Grain abdicate was emphatically related with plant tallness, the number of spikes/m2, and 1000-grain weight both at genotypic and phenotypic levels but critical as it were at the genotypic level. This result is also in line with the findings of Dogan (Dogan 2009) and Gashaw et al. (Gashaw, Mohammed et al. 2007).

They reported the correlation between GY and TGW was significant and positive. Besides, it was observed that GY and TGW did not have a significant genotypic and phenotypic correlation with days to heading and days to maturity, however, their correlations were remarkably high and negative. The findings of similar studies confirm the non-significant and negative association of GY and maturity days. (Subhashchandra, Lohithaswa et al. 2009) . It is stated that due to the prolonging of the vegetative phase, it wasn't to fixate photosynthesis translocate it to the developing grain, which significantly damaged GY and GS (grain size). The number of grains/spike negatively correlated with GY and TGW at the genotypic level. Their correlation wasn't significant, indicating that higher grain number negatively impacted grain size and in the end, damaged (decreased) grain yield.

CONCLUSION

The results indicated the relative resistance power of the genotypes studied in the experiment under drought stress conditions. Moreover, the observed high levels of TGW and main spike weight were indicators of their influence on the total yield. Therefore, this study states that investigating the impacts of such traits not only boosts the potential drought resistance of plants it will also improve yields. The findings and observations of this research study concerning the optimal genotypes combined with relevant data pave the way for other breeders and researchers in their attempts to find the best cultivars and improve yields in wheat durum wheat farms.

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