Evaluation of seed yield of durum wheat (*Triticum durum*) under drought stress and determining correlation among some yield components using path coefficient analysis

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ABSTRACT: Water deficit can have negative effects on grain formation. I investigated the relationships between the characters of durum wheat (*Triticum durum*) and yield under drought stress and identified the most effective components of yield. I used 49 durum wheat genotypes (43 exotic and 6 local lines), in a lattice design (7×7) replicated twice, during tillering, stem elongation, anthesis and grain filling. There were positive correlations among harvest index (r=0,849), plant height (r=0,695), tillering (r=0,689), peduncle length (r=0,466) and grain yield. The number of seeds per spike (0,432), spike length (0,410) and 1 000 seed weight (0,385) had the highest direct effect on yield.

Key words: Correlation, drought stress, durum wheat, *Triticum*, path analysis

RESUMEN: Evaluación del rendimiento de semillas de trigo duro (*Triticum durum*) bajo estrés por sequía y determinación de la correlación entre algunos componentes del rendimiento utilizando el análisis de senderos. Los efectos del déficit hídrico pueden ser negativos en la formación del grano. Investigué las relaciones entre los caracteres del trigo duro (*Triticum durum*) y el rendimiento bajo estrés por sequía e identifiqué los componentes más efectivos del rendimiento. Utilicé 49 genotipos de trigo duro (43 exóticas y 6 locales), en un diseño de celosía (7×7) replicado dos veces, durante el macollamiento, elongación del tallo, antesis y relleno de grano. Hubo correlaciones positivas entre el índice de cosecha (r=0,849), la altura de la planta (r=0,695), número de macollas (r=0,689), la longitud del pedúnculo (r=0,466) y el rendimiento de grano. La cantidad de semillas por espiga (0,432), longitud de espiga (0,410) y 1 000 semillas de peso (0,385) tuvo el mayor efecto directo sobre el rendimiento.

Palabras clave: Correlación, estrés por sequía, trigo duro, *Triticum*, análisis de senderos

Water shortages are damaging and counting too heavily on production of agricultural yields throughout the world (Volaire, 2003; Yu & Setter, 2003). Wheat (*Triticum* spp.) is a strategic crop plant and is heavily relied upon to meet nutrient requirement by people. Therefore, breeding of wheat varieties resistant to drought is the need of time (Salemi & Afyuni, 2005; Abdmishani & Boushehri, 1997). The drought is generally caused by an imbalance or shortage of rainfall and high temperature. Tabriz (330,1mm), Iran receives an average of 252mm precipitation and is considered as one of the driest region in the area (Haydari, 2004).

Connies, John and John (1987) define drought as a situation, when precipitation is reduced and or no rainfall occurs for a long time making soil cultivation not feasible for a short or long time that hinders growth of plants and results in reduced economic yield.

The water deficit at different growth stages affect physiological activity of plants up to a certain threshold followed by negative effects on grain formation and lowers the yield. Plant breeders use relationships among characters by the correlation coefficient studies, but these coefficients determine the correlation(s) among independent characteristics only. Therefore, it is necessary to measure a relationship among correlation coefficients of these characteristics to improve the efficiency of selection work and yield. Therefore, to achieve success in the selection and breeding the researcher must know the pathway of their interrelationship that affect them (Tewari, 1975; Korkut, Baser & Bilir, 1993; Adak, Özkan & Güler, 1999).

Garcia Del Moral, Ramos, Garcia Del Moral and Jimenez-Tejada (1991) used path analysis method for durum wheat and barley (*Hordeum vulgare* L.) to determine grain yield of the direct and indirect effects of yield characters.

Mohammadi (1998) determined positive and significant correlation between 1000 grain weight with dry wheat grain yield, plant height, fertile tillering, correlation between the number of grains per spike and harvest index. Darvincel (1978) also found a positive and significant correlation between wheat grain yield and 1000 grain weight, number of grains per spike. As per path analysis on durum wheat genotypes; number of grains per spike, 1000 grain weight and and their effect on yield and direct and positive effect on number of fertile tillers and grain yield (Gebeyehou, Knott & Baker, 1982; Doting & Knight, 1992; Simane, Struit, Nachit & Peacock, 1993; Mondal, Sadhu & Sarkar, 1997).

This study was carried out to find direct and indirect relationship between drought on factors like plant height, spike length, tillering, grain number in spike and 1 000 kernel weight on grain yield under stress conditions.

MATERIALS AND METHODS

The study made use of 49 durum wheat genotypes; 6 lines among them were come from Iran and others had exotic origin. Present study was carried out at the experimental research station of the Islamic Azad University, Tabriz Iran during 2009- 2010. Lattice design experiment design was used with two replications as 7×7 format. Plot size was 0,6m^2 (1×0,6). Planting distance was 0,2m among three rows and 60 seeds were sown in each row of plot. The experiment was sown on 1 October 2006 and 3kg/da N was applied at the time of sowing time and 3kg/da N was applied at the time of stem elongation. Drought stress was employed at four different stages to determine the effects of tillering, stem elongation, flowering and grain formation on grain yield and yield components. Plants were watered regularly at weekly intervals except the periods aforementioned; to employ water stress on plants during these phases of growth. Harvesting of each plot was made by hand.

The data for each character was taken randomly by selecting six plants that represented the respective plot for plant height (cm), spike length (cm), number of fertile tillers, number of grains per spike and 1000-grain weight (g) that were transformed by computing their yield per hectare. The seed weight was calculated by weighing 20 (g) seeds followed by multiplication of this number to obtain 1000 seed weight (Verweij, Ahmed, Anton, Nemhauser & Shapiro, 2003). The resulting correlation and path analysis was performed out of the data using SPSS statistical software 10 and Path2 statistical software package.

RESULTS

Correlation coefficients for the pre specified characteristics were determined for 49 genotypes (43 exotic and 6 local lines) grown at the experimental station of the Islamic Azad University, Tabriz.

Most characters were positively correlated, while elation, 1 000 grain weight and spike length had a negative correlation (Table 1).

Direct and indirect effects of path analysis appear in Table 2. Seed yield had statistically significant direct

TABLE 1
Correlation coefficients among the characters under the water stress condition in the durum wheat.

Characters	Plant height (m)	Spike length (cm)	Peduncle length (cm)	Number of Fertile tillers	Harvest index	Number of seeds per spike	1 000 seed weight
Spike length (cm)	0,670**						
Peduncle length (cm)	0,714**	0,321*					
Number of fertile tillers	0,634**	0,746**	0,427**				
Harvest index	0,446**	0,365**	0,269	0,592**			
Number of seeds per spike	0,126	0,113	-0,150	0,128	0,586**		
1000 seed weight	-0,040	-0,478**	0,187	-0,252	0,068	-0,284*	
Grain yield	0,695**	0,591**	0,466**	0,689**	0,849**	0,387**	0,013

** and * Significant at the 1 and 5% levels of probability, respectively.

TABLE 2
Path analysis grain yield with its components for under stress drought condition durum wheat.

Characters	Direct	In Direct					
		Spike length (cm)	peduncle length (cm)	Number of Fertile tillers	Number of seeds per spike	1000 seed weight	correlation coefficient
Spike length (cm)	0,410**	–	0,057	0,261	0,048	- 0,185	0,591**
peduncle length (cm)	0,178**	0,13	–	0,149	- 0,065	0,072	0,465**
Number of Fertile tillers	0,352**	0,304	0,076	–	0,055	- 0,098	0,689**
Number of seeds per spike	0,432**	0,046	- 0,027	0,044	–	- 0,11	0,386**
1 000 seed weight	0,385**	- 0,195	0,033	- 0,089	- 0,123	–	0,013

** and * Significant at the 1 and 5% levels of probability, respectively.

effect on the spike length, peduncle length, number of fertile tillers number of spikes and 1 000 seed weight. Number of seeds per spike had direct positive effect (0,432), and showed high share on seed yield that in turn had indirect relationship on number of seeds per spike. The positive effect of spike length (0,046) and the number of fertile tillers (0,044), while indirect effects of other characters was detected in a negative way (Table. 2).

Spike length, induced direct effect on seed yield (0,410). The highest direct and positive effect on grain yield between spike length and number of fertile tillers (0,261), the number of seeds per spike (0.048), and peduncle length (0.057) and negative effect on 1 000 seed weight (-0,185) was obvious (Table. 2). Spike length had direct positive effect (0,410) on grain yield, on number of fertile tillers (0,352). While there was positive and significant effect on, spike length (0.304) correlation with the seed yield and had indirect positive effect on the peduncle length (0,178) that affected seed yield directly and had positive effect. Number of fertile tillers (0,149) and spike length had indirect correlation on seed yield with correlation coefficient of (0,13). In the study, coefficient of determination (R^2=0,5) shows that the efficiency of the selected dependent variables affected characters other than five characters mentioned in this study as well. The highest direct grain yield effect on our study was determined for, spike length, number of seeds per spike and 1 000 seed weight respectively, i.e. increased seed yield is also affected positively.

DISCUSSION

The results of this study are in agreement with previous work in wheat and barley (Chaudhary, 1977; Sonmez, Ulker, Yılmaz, Ege, Bürün & Apak, 1999; Ataei, 2006; Bahari & HoseinpoUR, 2006; Kara & AkmAn, 2008); those studies found correlations for some grain yield and some yield components. Our results also match other work (e.g. Fonseca & Patterson, 1968; Solanki & Bakhshi 1973; Dashora, Rathore, Tikka & Sharman. 1977; Gebeyehou et al., 1982; Garcia Del Moral et al., 1991). Also Bhatt (1973) has pointed out that in cereals the efficiency of a single spike and 1000 seed weight has a higher direct effect on grain yield than the direct effect; therefore, during selection these characteristics are given priority. Similarly, Ataei (2006) found that barley grain yield was affected by number of grains such that number of spikes and 1 000 seed weight that has direct positive effects. Path analysis results showed that number of fertile tillers ranks fourth and increase in these characteristics has positive effects on grain yield (Tosun & Yurtman, 1973; Yürür, Tosun, Eser & Geçġt, 1981). In general, these may be due to the ecological characteristics of the resulting differences at trial sites, methods, and varieties/genotypes used in the study. Spike length had direct effect on seed yield (0,410) and other factors had indirect effect on it. The highest indirect effect of spike length on seed yield was on number of fertile tillers (0.261); while the number of seeds per spike (0,048), peduncle length (0.057) had positive and 1000-seed weight (-0,185) had negative effect (Table 2). 1000 seed weight had direct positive effect on seed yield (0,385). 1000 seed weight had effect on seed yield due to the effects of peduncle length (0,033) except all other characters with negative effect (Table. 2). Seed yield and number of fertile tillers had direct positive significant correlation (0,352), spike length had correlation coefficient of 0,304 and affected yield indirectly. Peduncle length and seed yield had direct positive correlation 0,178. Number of Fertile tillers (0,149) and seed yield (0,13) had indirect correlation. Tiller length and fertile tillers had indirect correlation with correlation coefficient of 0,13 and 0,149, respectively.

It was concluded that durum wheat plant height, harvest index, number of fertile tillering, spike length, peduncle length and number of grains per spike had positive and significant correlations with grain yield. According to the path analysis; grain yield had direct effects on number of grains per spike, which had positive and indirect effects on spike length, number of fertile tillers and 1000 seed weight features that must be given priority over other characteristics in breeding programs while making selection for drought stress.

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