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Relationship Between Grain Yield and Some Agronomic Characters in Durum Wheat under Cold Dryland Conditions of Iran

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Abstract: The main breeding objective in drylands was drought resistance and used criterion was grain yield in the stress condition. Traits that were correlated with the grain yield may be useful for indirect selection. Negative significant correlation was obtained only between days to heading and thousand kernel weight in facultative types. In the spring types of durum wheat, days to maturity, grain filling period, plant height and days to heading were the most important traits for increasing grain yield, respectively. In the facultative types, days to maturity, plant height, grain filling period and days to heading were important but in winter types only numbers of days to maturity had positive significant correlation with grain yield. Path coefficient analysis revealed a strong direct effect of days to maturity on grain yield. However, higher DM with higher DH may interact with hot and dry weather during critical reproductive stage thus reduce grain yield of durum wheat under cold dryland condition.

Key words: Correlation, *Triticum turgidum*, high-lands, path analysis

INTRODUCTION

Durum wheat (*Triticum turgidum* L.) is cultivated in about 200-300 thousand hectares across arable lands in Iran from which, about 65% is under rainfed condition. This is about 5% of total areas devoted to bread wheat in the country[1]. In spite of low yield comparing to new varieties of breat wheat, durum wheat has special economic importance and also due to genetical resistance to rusts and bunt, durum wheat can increase the sustainability of farming systems by acting as disease break in rainfed area that is under wheat cultivation.

Selection of high performance durum lines is first step in breeding and development of new varieties in dry land condition. Direct selection in terms of grain yield is the simplest way but various agents affect on yield. Further more, heritability of grain yield is deminished under stress condition that makes genetic gain very low[2]. The genetic background of any pair of characteristics, whether yield, height or maturity is unlikely to be under totally separate control, mainly due to linkage or pleiotropy. For plant breeder it is therefore necessary to examine the relationships between pairs of characters in order to decide upon the appropriate selection criteria for a breeding program. Association between yield and yield-determining characteristics have been repeatedly analysed in durum wheat[2-5]. Traits that are correlated with the grain yield may be useful for indirect selection. The efficiency of using a trait as a selection criterion depends on its heritability and genetic correlation to plant performance[6]. We lack however, reports of these trait's heritability and genetic correlations to grain yield and therefore of their suitability as indirect selection criteria. More over, most previous studies measuring genetic variation and correlations in these traits have been conducted at only one location without stress condition and in many cases the reported correlations are highly dependent on the environment and on the material. In the other hand, sometimes, simple correlations are misleading and there is a necessity to decompositions of correlation into direct and indirect effects (i.e. path analysis). However, few investigations include path analysis on morpho-physiological traits and grain yield in durum wheat. The present study characterizes relationship between some agronomic traits in durum wheat with regard to direct and indirect effects on grain yield.

MATERIALS AND METHODS

One hundred and fifty one exotic and indigenous durum lines were evaluated in Dryland Agricultural Research Institute during 1998-2001 (Table 1). Trials were managed using standard agronomic practice for durum cultivation. Each genotype was planted in a row 3 m in length. The characters recorded on a row basis, were as following. Grain Yield (GY) in kg ha^{-1};

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Table 1: Location, elevation and meteorological data for the research site

Site	Location	Elevation (m)	Soil	Year	Prec. (mm)	Mean Abs. Max. T (°C)	Mean Abs. Min.T (°C)	Below 0°C days
Maragheh	37°15′ N, 46°20′ E	1720	Calcixerollic	1998-1999	270	12	0.1	132
			xerochrepts	1999-2000	320	14	0.5	118
				2000-2001	198	13	0.7	124

Prec.-Precipitation, Mean Abs. Max. T-Mean absolute maximum temperature, Mean Abs. Min. T-Mean absolute minimum temperature

Table 2: Correlation between agronomic characters in durum wheat

	Growth habit	Day to heading	Days to maturity	Plant height	Thousand kernel weight	Grain filling period
Day to heading	-0.3101**					
Days to maturity	-0.128	0.8985**				
Plant height	-0.1646*	0.7105**	0.7343**			
Tousand kernel weight	0.0388	-0.0166	0.0611	0.1257		
Grain filling period	0.2364**	0.2951**	0.6845**	0.4185**	0.1605*	
Yield	0.101	0.5128**	0.6501**	0.4743**	0.139	0.5634**

* Significant at $p<0.05$, ** Significant at $p<0.01$

Table 3: Coefficients of correlation between traits within winter type (W), facultative type (F) and spring type (S) durum genotypes

		Day to heading	Days to maturity	Plant height	Thousand kernel weight	Grain filling period
Days to maturity	W (n=41)	0.782**				
	F (n=24)	0.907**				
	S (n=77)	0.904**				
Plant height	W (n=41)	0.341*	0.279			
	F (n=24)	0.391	0.61**			
	S (n=77)	0.810**	0.798**			
Tousand kernel weight	W (n=41)	0.104	0.258	0.061		
	F (n=24)	-0.418*	-0.155	0.306		
	S (n=77)	0.237*	0.252*	0.232*		
Grain filling period	W (n=41)	0.370*	0.429**	-0.091	0.301	
	F (n=24)	0.587**	0.672**	0.657**	-0.076	
	S (n=77)	0.52**	0.651**	0.535**	0.259*	
Yield	W (n=41)	-0.065	0.570**	-0.003	0.276	0.199
	F (n=24)	0.465*	0.794**	0.718**	0.277	0.567**
	S (n=77)	0.275*	0.66**	0.370**	0.15	0.550**

*Significant at $p<0.05$, **Significant at $p<0.01$

Days to Heading (DH) as number of days from planting time (date of first effective rainfall-about 20 mm-after or just before sowing in the autumn) to 50% heading; Days to Maturity (DM) as number of days from planting time (date of first effective rainfall) to maturity; Grain Filling Period (GFP) as number of days from heading date to maturity; Plant Height (PH) in centimeter taken on ten randomly selected plant at the heading time and Thousand Kernels Weight (TKW) in gram. Determination of genotypes growth habit was according to used method in international Center for Agricultural Research in Dry Areas (ICARDA)[7-9]. Scale 1 was used for winter types and scale 10 for spring types. Statistical analysis was conducted using Genstat 5 Rel. 4.1[10].

RESULTS AND DISCUSSION

As expected a strong relationship was obtained between DH and DM. It is found a significant positive correlation between DH, DM and GFP (Table 2). However, Dakheel *et al.*[2] and Amin *et al.*[11] have reported a negative correlation between DH, DM and GFP. This may be resulted from different conditions in grain filling period of plant in regions. Results of correlation between grain yield and its components under non-favorable conditions are different from optimum condition. There was significant positive correlation between grain yield and DH, DM, PLH and GFP with values ranging from 0.47 to 0.65 (Table 2). Kumar and Chowdhury[12] reported that in non-favorable condition there was not significant correlation between grain yield of durum wheat and DH, PLH and TKW. Refer to association between grain yield and PLH in the bread wheat, Innes *et al.*[13] reported that there were not differences between grain yield of genotypes with different PLH under favorable condition. However, the taller genotypes had significantly higher grain yield comparing with dwarf genotypes under non-favorable condition. PLH is a trait that relate to potential plant growth especially in dry environments[2]. The positive correlation between grain yield and PLH in this study agree with other studies[13,14]. Correlation between DM and DH in one hand and GFP with DM in the other hand are common results in every condition[14]. A negative or zero association was observed for TKW with GH, DH and DM. This was expected, since these traits represent competitive sinks. Kernel weight was lower in longer cycle genotypes that suffered late season heat stress.

Table 4: Decomposition of correlation into direct and indirect effects on grain yield

	Growth habit	Day to heading	Days to maturity	Plant height (cm)	Thousand kernel weight (g)	Grain filling period (days)
Growth habit	0.1456	0.0623	-0.1058	-0.004	0.003	0
Day to heading	-0.0451	-0.2008	0.7427	0.0173	-0.0013	0
Days to maturity	-0.0186	-0.1804	0.8266	0.0179	0.0047	0
Plant height	-0.024	-0.1426	0.607	0.0243	0.0096	0
Thousand kernel weight	0.0057	0.0033	0.0505	0.0031	0.0765	0
Grain filling period	0.0344	-0.0593	0.5658	0.0102	0.0123	0

Table 5: Contribution of direct and indirect effects on grain yield variability

	Growth habit	Day to heading	Days to maturity	Plant height (cm)	Thousand kernel weight (g)	Grain filling period (days)
Growth habit	0.02119	0.01813	-0.03081	-0.00117	0.00086	0
Day to heading		0.04031	-0.29823	-0.00694	0.00051	0
Days to maturity			0.68323	0.02953	0.00772	0
Plant height				0.00059	0.00047	0
Thousand kernel weight					0.00585	0
Grain filling period					0	0

There are mainly two reasons for correlation studies to be of interest to plant breeder: (1): traits that are correlated with the main breeding objectives may be useful for indirect selection and (2) when selecting for various traits simultaneously, a correlation between them may restrict the response to selection. The most interesting trait for use as an indirect selection for yield is TKW, because this character is a yield component, is more easy to determine than yield itself and generally has a high heritability. In present experiment, the correlation between TKW and grain yield was positive but it was not significant.

Negative significant correlation was obtained only between DH and TKW in facultative types (Table 3). It was evident that in spring types of durum wheat, DM, GFP, PLH and DH were the most important traits for increasing grain yield, respectively (Table 3). In the facultative types, DM, PLH, GFP and DH were important but in winter genotypes only DM had positive significant correlation with grain yield indicating that DM is very important trait in breeding of winter type durum (Table 3). It seems that with increasing the plant growth duration and subsequently assimilates enhancement in grains, the grain yield should be increased[15].

A path coefficient analysis was performed to identify direct and indirect effects of traits on grain yield (Table 4). Direct path coefficients are included in diameter of Table 4 indicating that DM has the highest (b = 0.8266) and GFP had the lowest value (b = 0.00). Misleading of simple correlation was evident here. According to Table 2, GFP has a significant positive correlation with grain yield (0.32) and may be used as indirect criterion for selecting high performance genotypes but adversely, its path coefficient is too low to use as selection criterion. GFP had no direct effect on grain yield, but it had a positive indirect effect through DM (Table 4). DM had a strong direct effect on grain yield, though it also had a negative indirect effect on DH and GH, which reduced the final values of the correlation. GH also had a fair positive direct effect on grain yield. Nevertheless, the negative indirect effects on DM greatly decreased the final values of the correlation between these traits.

Negative path coefficient in case of DH and insignificant values for PLH and TKW were another surprises (Table 4). Negative association between DH and grain yield may be abnormal result in without-stress condition but it is more expected in dryland condition due to severe drought stress in the end season. Larger DH result to coincidence of heading stage with drought and heat stress in highlands, which diminish grain yield.

The highest contribution is devoted to DM in direct effect (0.68) and negative indirect effect of DM through DH (-0.298) as well (Table 5).

It is concluded that a selection for large TKW can not be expected to be effective in increasing grain yield. Higher DM is a good index for selection in durum wheat. However, higher DM with higher DH may interact with hot and dry weather during critical reproductive stage thus reduce grain yield under cold dryland condition.

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