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Durum Wheat (*Triticum durum* Desf.) Evaluation under Semi Arid Conditions in Eastern Algeria by Path Analysis

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Abstract

This study was aimed to characterize yield components and plant traits related to grain yield. Correlation and path analysis were carried out in durum wheat genotypes grown under irrigated and non-irrigated field conditions during two cropping seasons (2010/2011 and 2011/2012).

In the path coefficient analysis, grain yield represented the dependent variable and the number of spikes m^{-2}, number of grains $spike^{-1}$, kernel weight and number of grains m^{-2} were the independent ones. Grain yield showed positive phenotypic correlation with number of spikes m^{-2} and number of grains per m^{-2}under both conditions and during two cropping seasons.Path analysis revealed positive direct effect of 1000- kernels weight, number of spike m^{-2} and number of grains per spike on grain yield. These results indicated that the 1000- kernels weight and number of spikes m^{-2} followed by the number of grains per spike and number of grains per m^{-2} were the traits related to higher grain yield, under irrigated and late season water stress conditions.

Key words: Durum wheat, direct effect, indirect effect, correlation, grain yield.

Introduction

Among all cultivated wheats, *Triticum aestivum* and *Triticum durum* are the most important cereal crops in the world. Durum wheat is one of the most extensively cultivated crops under dryland conditions in the Mediterranean environments, where water stress and high temperature are the main constraints limiting productivity (Araus et al., 2002). Grain yield in durum wheat is the result of many developmental and physiological events occurring throughout the growing cycle. It is determined by three major components, namely, number of spikes per unit area, number of grains per spike and kernel weight. The importance of each one of these yield components to grain yield depends on the growth stage when water stress occurs (Hochman, 1982; Mcmaster et al., 1984). At jointing (stem extension), irrigation in dryland conditions affects yield components by increasing the number of spikes per plant, spikelet number per plant and number of kernels per plant, while at grain filling there is an increase in kernel weight (Mcmaster et al., 1984). The number of grains per spike is usually related to grain yield at all timings of water stress (Simane et al., 1993). Wheat plant is more sensitive to water stress between booting and grain filling than any other period (Fischer et al., 1977; Hochman, 1982).Yield components and plant trait contribution on grain yield may be important for breeding strategies. Simple correlation analysis that relates grain yield to a single variable may not provide a complete understanding of the importance of each component in determining grain yield (Dewey and Lu, 1959; Singh et al., 1970). Path coefficient analysis allows an effective means of partitioning correlation coefficients into unidirectional pathway and alternate pathways. This analysis permits a critical examination of specific factors that produce a given correlation and can be successfully employed in formulating an effective selection strategy. Throughcorrelation and path coefficient analysis, Kumar and Hunshal (1998) observed in durum wheat thatharvest index, total dry matter, effective tillers, number of grains per spike and grain weight per spike were the most important components of grain yield. With terminal moisture stress, longer grain-filling period, number of spikes m^{-2} and number of kernels per spike were traits associated with drought tolerance in durum wheat

(Simane et al., 1998). The objectives of this study were: (i) to evaluate associations between yield components and grain yield, (ii) to determine direct and indirect effects of yield components on grain yield in durum wheat genotypes grown under irrigated and non-irrigated conditions.

Material and methods

Field experiment was conducted during the 2010-2011 and 2011-2012 cropping seasons at the experimental field of Setif ITGC, Algeria (5°20'E, 36°8'N, 958 m above mean sea level). The statistical design employed was split plot based on a complete randomized block design (CRBD) with four replications. Ten durum wheat cultivars (Table 1) were used in this study, the seeds were sown using an experimental drill in 1.2 m x 2.5 m plots consisting of 6 rows with a 20 cm row space and the seeding rates for both experiments (irrigated and stressed) were about 300 seeds per m^2. All plots of the irrigation experiment were irrigated by using a Sprinklers system and the volume of water input for each plot was controlled. Two irrigation regimes were applied; the first irrigation (20 mm) was performed at the time of Elongation (30 zadoks cods) and the second irrigation (20 mm) was applied after heading (50 zadoks cods). The values of kernel weight, number of spikes, number of grains per spike, number of grains per m^2 and grain yield was determined from 1 linear m sample obtained in each subplot. Individual kernel weight was estimated using a subsample of 250 kernels. Number of spikes m^{-2} was determined by counting spikes in 1m of row. Number of grains per spike was determined by dividing grain yield by number of spikes and the result of this operation was divided by kernel weight, and grain yield was obtained by weighing the total grain weight of 1m row. Data were analyzed using analysis of variance and path coefficients procedure. Path analysis was performed using genotypic correlation considering grain yield as the response variable and number of spike m^{-2}, number of grains per spike, kernel weight, and number of grains per m^2 as predictor variables. Resulted data were subjected to analysis by Lazstats procedure and means of treatments were compared using Fisher's LSD multiple range tests in 0.05 percent.

Results and discussion

The combined analysis of variance was presented in Table 2 (Cropping season 2010/2011) and Table 3 (Cropping season 2011/2012). The results revealed the significant effects of conditions (irrigated and stressed) for all parameters except for TKW during two cropping season. The genotype effect was significant for all parameters except for TKW in stressed condition and during the second cropping season (2011/2012). Correlation coefficients calculated among studied traits are shown in Table 4. Positive and significant relationships were found between grain yield and number of spikes per m^2 (NS/m^2) and number of grains per m^2 (NG/m^2) under both irrigated and stressed conditions and during two cropping season. In these cases, direct selection for higher number of spike m^{-2} and/or larger number of grains per spike would be enough to increase grain yield. These results are similar to those obtained by Shamsuddin (1987) and Simane et al. (1998). The other positive correlations were indicated between NS/m^2 / NG/m^2 and NG/S / NG/m^2 under both conditions and during two cropping season, but during the second cropping season and under irrigated condition number of spike per m^2 are correlated positively with number of grains per spike. In this study, TKW correlated negatively with grain yield under stressed condition and during the first cropping season this results confirmed with the results of Ehdaie et al. (1988). The correlations were analyzed further by the path coefficient technique, which involves partitioning the correlation coefficients into direct and indirect effects via alternative characters or pathways. Grain yield was performed by the complex outcome of different characters considered to be the resultant variable and numbers of spikes, spike length, spikelet and grain numbers were casual variables. The direct and indirect effects of the 4 grain yield related traits are shown in Table 5. During first cropping season (2010/2011) and under irrigated condition, path coefficient analysis showed that the direct effect of TKW and NG/S on grain yield was significant and positive ($P_{TKW/GY}$= 1,203***, $P_{NG/S/GY}$= 1,612* respectively). Our results are in agreement with those reported by Khaliq et al. (2004) and Okuyama et al. (2004) who found that grains number per spike exerted direct positive effect on grain yield. In addition, number of spikes per meter square (NS/m^2) showed a significant and positive direct effect on grain yield under both conditions and during first cropping season. During second cropping season (2011/2012), the direct effect of TKW on grain yield under irrigated and stressed conditions was positive and significant ($P_{TKW/GY}$= 0,985***, $P_{TKW/GY}$= 1,062** respectively). All direct effect of TKW on grain yield during two cropping season (2010/2011 and 2011/2012) and under both condition were confirmed with many studies Ehdaie and Waines (1989) and Deshmukh et al. (1990). During two cropping seasons and under both conditions indirect effect of TKW on grain yield via NG/S was negative (Table 5). During first cropping season (2010/2011) and under irrigated and stressed conditions indirect effect of NG/m² on grain yield via NS/m² was positive and high (1,68 and 1,306 respectively).

Conclusion

The study of correlation they showed that the number of spikes and grains per meter square should be considered as selection criteria for wheat yield improvement under irrigated and stressed conditions. Path analysis revealed that for genotypes grown under optimum conditions and during first cropping season (2010/2011), there was significant effect of TKW, NS/m² and NG/S on grain yield, but under drought stress conditions,just NS/m² had more positive direct effect on grain yield.During second cropping season (2011/2012), TKW had positive direct effect on grain yield under stressed and irrigated conditions. It was concluded that grains number per spike, grains number per meter square and 1000 grain weight which were determined to have significant direct effects on grain yield could be major selection criteria for breeding studies under rainfed and irrigated conditions.

References

[1]Araus, J.L., Slafer, M.P., Reynolds, M.P., Royo, C. (2002). Plant breeding and drought in C3 cereals: what should we breed for? Ann Bot., **89**: 925–940.

[2]Deshmukh, P.W., Atale, S.B., Korgade, P.W. and Vitkre, D.C.(1990). Evaluation of some yield contributing characters under rainfed and irrigated conditions in durum wheat. Ann Pl Physiol., **4**: 80-85.

[3]Dewey, D.R. and Lu, K.H.(1959). A correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agronomy Journal,**51**: 515–518.

[4]Ehdaei, B., Noormohammadi, G.H., Kajbaf, A. and Bozorgmehri, H. (1988).Genetic variation, heritability and correlation capabilities of agronomic traits of Khuzestan native hexaploid wheat cultivars. Ahwaz.Ag. J.,**12**: 17-27.

[5]Ehdaie, B. and Waines, J.G. (1989). Genetic variation, heritability and path-analysis in landraces of bread wheat from Southwestern Iran. Euphytica, **41**: 183–190.

[6]Fischer, R.A., Aguilar, I. and D.R. Laing, (1977).Post-anthesis sink size in a high-yieldingdwarf wheat: yield response to grain number. Aust. J. Agric. Res., **28**:165–175

[7]Hochman, Z. (1982).Effect of water stress with phasic development on yield of wheat grown in a semi-arid environment. Field Crops Research, **5**: 55–67.

[8]Kumar, A.B.N. and Hunshal, C.S. (1998). Correlation and path coefficient analysis in durum wheats (*Triticum durum* Desf.) under different planting dates. Crop Research Hisar, **16**: 358–361.

[9]Khaliq, I., Parveen, N. and Chowdhry, M.A. (2004). Correlation and path coefficient analyses in bread wheat. International Journal of Agriculture & Biology, **4**: 633–635.

[10]Mcmaster, G.C. et al. (1984).Irrigation and culm contribution to yield and yield components of winter wheat. Agronomy Journal, **86**:1123–1127.

[11]Okuyama, L.A., Federizzi, L.C. and Neto. J.F.B. (2004). Correlation and path analysis of yield and its components and plant traits in wheat.Cienc. Rural vol. 34 no.6 Santa Maria Nov./Dec.

[12]Shamsuddin, A.K.M. (1987). Path analysis in bread wheat.Indian Journal of Agricultural Sciences, **57**: 47- 49.

[13]Singh, B.P. (1970). Influence of seed size on field germination and seedling growthand yield of dwarf wheat. Madras Agric. J., **57**: 449-452.

[14]Simane B., Peacock J.M. and Struik P.C. (1993). Differences in developmental plasticity and growth rate among drought resistant and susceptible cultivars of durum wheat (*Triticum turgidum* L. var durum). Plant soil, **157**: 155–166.

[15]Simane B., Struik P.C. and Rabbinge R. (1998). Growth and yield component analysis of durum wheat as an index of selection to terminal moisture stress.Tropical Agriculture, **75**: 363–368.

Cultiva	Name	Origin	Cultivar	Name	Origin
1	Bousselem	Algeria	6	Altar	Mexico
2	Hoggar	Algeria	7	Dukem	Mexico
3	Oued Zenati	Algeria	8	Kucuk	Mexico
4	Polonicum	Algeria	9	Mexicali	Mexico
5	Waha	Algeria	10	Sooty	Mexico

Table 1. Name and origin of the ten genotypes used in the study

	Cropping season 2010/2011									
	GY		TKW		NS/m ²		NG/m ²		NG/S	
Genotypes	IR	ST	IR	ST	IR	ST	IR	ST	IR	ST
Oued Zenati	57,45b	52,2b	53,71ab	54,29b	289,16b	241,65e	9330,86c	9615,58c	37,97cd	39,8cd
Altar	69,14ab	55,94ab	54,66ab	56,88a	339,16ab	266,65de	12001,94bc	9839,01c	40,41bcd	36,91de
Sooty	75,55a	63,14ab	47,97c	45,44e	364,58a	313,75bc	13625,32ab	13933,24ab	46,25a	44,19ab
Polonucum	60,18ab	56,47ab	51,96b	52,75c	290b	237,75e	11185,88bc	10659,49c	44,88ab	44,66ab
Waha	65,94ab	64,63a	52,94b	48,73d	359,16a	344,13a	12642,12abc	13263,7b	40,08bcd	38,58cd
Dukem	72,70ab	63,94ab	42,99d	41,9f	374,58a	331,66ab	15641,34a	15263,7a	46,8a	46,05a
Mexicali	63,44ab	59,64ab	51,95b	51,03cd	337,08ab	293,32cd	12548,42abc	11689,89c	41,83abc	39,83cd
Kucuk	73,53a	53,96ab	52,31b	50,3d	378,33a	293,32cd	12883abc	10724,04c	37,27cd	36,55de
Hoggar	62,36a	60,05ab	54,51ab	54,09b	320,83ab	268,33de	10755,18bc	11107,96c	39,83bcd	41,41bc
Bousselem	67,75ab	55,01ab	56,85a	57,07a	331,25b	283,32ed	10035,96bc	9639,16c	34,88d	34,02e
Mean	66,80	58,50	51,99	51,25	338,41	287,39	12065,00	11573,58	41,02	40,20
Min	57,45	52,20	42,99	41,90	289,16	237,75	9330,86	9615,58	34,88	34,02
Max	75,55	64,63	56,85	57,07	378,33	344,13	15641,34	15263,70	46,80	46,05
LSD 5%	11,64	8,06	2,63	1,97	62,10	25,08	2321,40	1547,80	4,12	3,12
Genotype effect	***	***	***	***	***	***	***	***	***	***
Irrigation effect	***		ns		***		*		***	
Interaction effect	ns		ns		ns		*		ns	

Table 2. Analysis of variance for grain yield (GY), 1000-kernel weight (TKW), no. spike m^{-2} (NS/m^2), no. grains m^{-2} (NG/m^2) and no. grains $spike^{-1}$ (NG/S) during 2010/2011 cropping season.

:** significant at 5%; **:** significant at 0,1% and **ns:** non significant.

Table 3. Analysis of variance for grain yield (GY), 1000-kernel weight (TKW), no. spike m^{-2} (NS/m^2), no. grains m^{-2} (NG/m^2) and no. grains $spike^{-1}$ (NG/S) during 2011/2012 cropping season.

	Cropping season 2011/2012									
	GY		TKW		NS/m ²		NG/m ²		NG/S	
Genotypes	IR	ST	IR	ST	IR	ST	IR	ST	IR	ST
Oued Zenati	25,9b	22,12a	44,3a	43,15a	181,6b	156,6b	5844,6b	5157,3c	32c	34,7c
Altar	43,04ab	24,86a	37,3cd	35,04bc	291,6ab	200ab	11415,3ab	7138,3bc	38,93ab	43ab
Sooty	42,04ab	29,33a	32,6e	27,7d	290ab	206,6ab	13084,6ab	10829,3ab	43,7a	45,66a
Polonucum	44,82ab	32,68a	43,7a	41,9a	285ab	231,6ab	10309,6ab	7785,3abc	36,06bc	38,00abc
Waha	47,78ab	36,57a	31,8e	31,4cd	326ab	281,6a	14763a	11682,6a	45a	43,2ab
Dukem	32,34b	31,08a	27,88f	27,4d	280ab	271,6a	11468ab	11322,3ab	41,26ab	39,06abc
Mexicali	45,8ab	32,9a	39,12bc	36,6abc	291ab	246,6ab	11772,6ab	8617,6abc	40ab	36,33bc
Kucuk	46,42ab	37,54a	32,27e	33,2bcd	351,6a	286,6a	14394,6a	11400,3ab	40,9ab	36,2bc
Hoggar	58,23a	30,57a	34,6de	32,1cd	373a	223,3ab	16887,3a	9485,6ab	44,26a	39,41abc
Bousselem	45,99ab	37,54a	41,27ab	39,82ab	300ab	251,6ab	11141,6ab	9404,3abc	36,6bc	30,06c
Mean	43,24	31,52	36,50	34,85	297,16	235,60	12108,16	9282,33	39,88	38,86
Min	25,95	22,12	27,80	27,42	181,60	156,60	5844,60	5157,33	32,00	33,06
Max	58,23	37,54	44,33	43,15	373,30	286,60	16887,30	11682,60	45,00	45,66
LSD 5%	25,73	15,66	3,42	6,85	145,17	106,09	7463,35	4315,49	6,69	7,68
Genotype effect	***	ns	***	***	***	***	***	***	***	***
Irrigation effect	***		ns		***		*		***	
Interaction effect	ns		ns		ns		*		ns	

*: significant at 5%; ***: significant at 0,1% and **ns**: non significant.

Table 4. Correlations matrix under stressed and irrigated conditions and during two cropping seasons (2010/2011 and 2011/2012).

	Cropping season 2010/2011					Cropping season 2011/2012					
	GY i GY s	TKW i TKW s	NS/m ²i NS/m ²s	NG/m ²i NG/m ²s	NG/S i NG/S s		GY i GY s	TKW i TKW s	NS/m ²i NS/m ²s	NG/m ²i NG/m ²s	NG/S i NG/S s
GY i	1					GY i	1				
GY s	1					GY s	1				
TKW i	-0,48	1				TKW i	0,016	1			
TKW s	-0,73	1				TKW s	-0,17	1			
NS/m ²i	**0,89**	-0,49	1			NS/m ²i	**0,79**	-0,52	1		
NS/m ²s	**0,79**	**-0,72**	1			NS/m ²s	**0,89**	-0,42	1		
NG/m ²i	**0,73**	**-0,85**	**0,81**	1		NG/m ²i	**0,73**	**-0,65**	**0,95**	1	
NG/m ²s	**0,9**	**-0,94**	**0,8**	1		NG/m ²s	**0,71**	**-0,79**	**0,82**	1	
NG/S i	0,25	**-0,82**	0,17	**0,68**	1	NG/S i	0,47	**-0,82**	**0,76**	**0,9**	1
NG/S s	0,52	**-0,67**	0,09	**0,65**	1	NG/S s	0,39	**-0,87**	0,52	**0,8**	1

Number in bold: significant at 5%.

Table 5. Direct and indirect effects of factors influencing grain yield in durum wheat genotypes under irrigated and stressed conditions during two cropping seasons (2010/2011 and 2011/2012).

Season	Trait	Condition	Direct effect	Indirect effect: TKW	NS/m ²	NG/m ²	NG/s
Cropping season 2010/2011	TKW	Irrigated	1,203***		-0,589	-1,022	-0,986
		Stressed	-0,109		-0,078	0,102	0,073
	NS/m ²	Irrigated	2,083*	-1,02		1,68	0,354
		Stressed	1,633*	-1,17		1,306	0,146
	NG/m ²	Irrigated	-0,706	0,6	-0,571		-0,48
		Stressed	-1,11	1,04	-0,888		-0,721
	NG/S	Irrigated	1,612*	-1,32	0,274	1,096	
		Stressed	0,626	-0,42	0,056	0,406	
Cropping season 2011/2012	TKW	Irrigated	0,985***		-0,512	-0,64	-0,807
		Stressed	1,062**		-0,446	-0,838	-0,923
	NS/m ²	Irrigated	0,405	-0,21		0,384	0,307
		Stressed	0,290*	-0,121		0,237	0,15
	NG/m ²	Irrigated	0,573	-0,372	0,544		0,515
		Stressed	1,096**	-0,865	0,898		0,876
	NG/S	Irrigated	0,28	-0,229	0,212	0,252	
		Stressed	0,464	-0,403	0,241	0,371	

*; **; *** significant direct effects at: 5, 1 and 0,1% respectively.