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Performance of selected durum wheat genotypes under different environmental conditions in eastern Egypt

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SUMMARY – Twenty four durum wheat genotypes (provided by CIMMYT/ICARDA, Aleppo, Syria) and one local check durum cultivar (Sohag-2) were evaluated in RCBD trials grown in El-Salheia province and at the Eastern Better lakes in Sinai, Ismailia province, Egypt, for two successive growing seasons. The tested genotypes were evaluated for several agronomic and quality characteristics. The trials were fully irrigated throughout the growing seasons and the recommended cultural practices were applied. Significant differences between genotypes for most of the studied characters were observed. Heritability estimates in broad-sense were generally higher at El-Salheia site than at Sinai and were relatively higher for days to heading, days to maturity, yield components (number of spikes/m^2, number of grains/spike and 1000-kernel weight) and grain yield, but were relatively low for the quality characteristics including protein content, sedimentation test and flour color. The observed variations for grain yield and its components and for the phenological parameters, except for 1000-kernel weight were mainly affected by location. However, the protein content, sedimentation test, flour color, 1000-kernel weight and number of grains/spike were mainly affected by years. These results indicate that the difference in soil fertility between El-Salheia and Sinai sites was a major factor affecting grain yield and most of its components, whereas the temperature prevailing during the anthesis and maturing periods was the main factor affecting kernel weight and other grain quality characteristics.

Key words: Wheat, durum, variability, heritability.

RESUME – *"Performances de génotypes de blé dur sélectionnés sous différentes conditions environnementales dans l'Est de l'Egypte". Vingt-quatre génotypes de blé dur (apportés par CIMMYT/ICARDA, Aleppo, Syrie) et un cultivar local testeur (Sohag-2) ont été évalués dans des essais RCBD cultivés dans la province d'El-Salheia et dans la région des Eastern Better lakes au Sinaï, province d'Ismailia, Egypte, pendant deux campagnes successives. Les génotypes testés ont été évalués pour plusieurs caractéristiques agronomiques et de qualité. Les essais ont été pleinement irrigués tout au long des campagnes et on a appliqué les pratiques culturales recommandées. Des différences significatives furent observées entre génotypes pour la plupart des caractères étudiés. Les estimations d'héritabilité au sens large ont été généralement supérieures au site d'El-Salheia par rapport au Sinaï et elles ont été relativement plus élevées pour les jours jusqu'à l'épiaison, jours jusqu'à la maturité, composantes du rendement (nombre d'épis/m^2, nombre de grains/épi et poids de 1000 grains) et rendement en grains, mais elles ont été relativement faibles pour les caractéristiques de qualité y compris la teneur en protéine, le test de sédimentation et la couleur de la farine. Les variations observées pour le rendement en grains et ses composantes et pour les paramètres phénologiques, excepté pour le poids de 1000 grains, ont été principalement affectées par la localité. Néanmoins, la teneur en protéine, le test de sédimentation, la couleur de la farine, le poids de 1000 grains et le nombre de grains/épi ont été principalement affectés par les années. Ces résultats indiquent que la différence de fertilité du sol entre les sites d'El-Salheia et du Sinaï était un facteur majeur affectant le rendement en grains et la plupart de ses composantes ; tandis que la température prévalente durant l'anthèse et les périodes de maturation, était le principal facteur affectant le poids des grains et autres caractéristiques de qualité du grain.*

Mots-clés : *Blé dur, variabilité, héritabilité.*

Introduction

Wheat constitutes one of the five major cereal crops in the world. It has been used as a main source of food since the prehistoric times. Many of the crop's characteristics were probably well known 2000 years ago when it evidently was grown for food. Durum wheat (*Triticum turgidum* L. var. *durum*), sometimes called macaroni wheat, covers about 9% of the wheat area (FAO,1994). Modern durum wheat varieties yield as the highest yielding bread wheat varieties, and the kernels of durum wheat are typically larger, heavier, and harder than those of bread wheat. However, durum wheat dough is less elastic than that of bread wheat and, therefore, it is inferior for producing leavened loaves, but durum wheat is primarily used for making noodles and other pasta products such as macaroni and spaghetti. In the international trade, durum wheat of good quality generally commands a higher price than that of bread wheat. In Egypt, the cultivated area of durum wheat is limited. Continuous supply of improved germplasm is necessary for durum wheat improvement. The future improvements of this crop depend considerably on the availability and identification of more genetic resources as well as the development of desired traits that fit the different agro-ecological zones. The present study was designed to permit evaluation of the genetic performance of various durum wheat genotypes in two different locations of the Suez Canal region in Egypt.

Materials and methods

Plant materials, experimental procedures and data collection

The genetic materials included in this study were and provided by the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, and included twenty three promising genotypes and the local check cultivar Sohag-2. These genotypes are widely diverse in their parentage and agronomic characters. Two field trials were carried out during the winter growing seasons of each of 1993-1994 and 1994-1995 at two locations. The locations represent two different governorates in eastern Egypt (El-Salheia and Eastern Better Lakes in Sinai). In the first season, the trials were hand sown on November 25th and on December 11th at El-Salheia and Eastern Better Lakes, respectively, while in the second season they were hand sown on November 30th at each of the above mentioned locations, respectively. The following agronomic and quality characters were recorded for each trial in each growing season: days to heading, days to maturing, number of spikes/m^2, number of grains/spike, 1000-kernel weight and grain yield. The following grain quality characteristics were measured at the ICARDA laboratories in Aleppo: protein content, sedimentation test, flour color.

All trials were carried out in a randomized complete block design (RCBD) with four replications. The data obtained from each trial in each location were statistically analyzed at the ICARDA Computer Center using Crop Research Statistical Package (CRSP) and the MSTAT-C system software package. Mean performance of the different characters was analyzed for each trial in each growing season and was also compared over years and locations. Parameters represent genetic components of the analysis of variance as described by Allard (1960).

Results and discussion

Mean performance and variability

Days to heading at Sinai were generally shorter than at El-Salheia in both seasons with around 7 days in the 1993-1994 season and 4 days in the 1994-1995 season. The month of January in 1993-1994 was relatively warmer than the same month in 1994-1995. However, the opposite occurs during the maturity stage (April) where it was cool in 1993-1994 and warm in 1994-1995. These environmental changes had, undoubtedly, affected heading date of the tested durum germplasm. The warm weather in January of 1993-1994 assisted genotypes to grow faster and to head earlier than in 1994-1995. These results are in agreement with these found by Porceddu (1976) and by Tripathi *et al.* (1973). Values of heritability in broad-sense and the genetic advance from selection for days to heading were significantly high and were higher at El-Salheia site than at Sinai (Table 1). These results indicate that this character is simply inherited and selection for this trait is possible. These results are in full agreement with results of several other researchers.

Days to maturity were generally lower at Sinai than at El-Salheia with a difference of 22.74 days in 1993-1994 and 11.4 days in 1994-1995 season, respectively. However, no difference in days to maturity was observed between trials grown at El-Salheia site in 1993-1994 and 1994-1995 seasons. The difference in maturing between Sinai and El-Salheia sites may be due to the low soil fertility at Sinai and to the high temperature occurred at the anthesis and maturity stages. The early maturing genotypes (Lagost-3 and Lagost-2) were approximately 11 days earlier in 1994-1995 than the late maturing genotypes (Genil-6). Heritability values in broad sense and the genetic advance from selection for days to maturity were relatively higher at El-Salheia than that at Sinai sites and indicate that selection for this trait is possible (Table 1).

Table 1. Mean, variability, heritability and expected genetic advance for durum wheat genotypes grown at El-Salheia and Sinai in two successive seasons (1993-1994 and 1994-1995)

Parameters	El-Salheia		Sinai	
	1993-1994	1994-1995	1993-1994	1994-1995
Days to heading				
Mean	88.65	90.71	81.63	86.72
Coefficient of variability (CV)	3.70	2.10	2.54	1.77
Heritability	88.1	91.23	80.19	75.54
Phenotypic (CV)	5.36	3.55	2.85	1.79
Genotypic (CV)	5.03	3.39	2.55	1.56
Days to maturity				
Mean	147.59	146.64	124.85	135.24
Coefficient of variability (CV)	1.11	2.16	1.58	2.02
Heritability	71.82	81.94	70.82	50.80
Phenotypic (CV)	1.05	2.54	1.46	1.44
Genotypic (CV)	0.89	2.30	1.23	1.03
No. of spikes/m^2				
Mean	346.07	415.14	253.27	135.42
Coefficient of variability (CV)	9.14	9.68	20.08	12.49
Heritability	86.24	67.88	58.77	48.91
Phenotypic (CV)	12.32	8.24	15.63	8.74
Genotypic (CV)	11.38	7.04	11.98	6.11
No. of grains/spike				
Mean	35.83	30.98	23.97	17.82
Coefficient of variability (CV)	7.80	17.11	23.49	15.69
Heritability	78.52	51.72	59.18	80.52
Phenotypic (CV)	8.42	12.31	18.38	17.78
Genotypic (CV)	7.46	8.86	14.14	15.95
1000-kernel weight				
Mean	48.27	60.89	45.02	52.61
Coefficient of variability (CV)	7.09	7.28	10.84	9.53
Heritability	90.67	78.38	59.19	48.36
Phenotypic (CV)	11.61	7.83	8.48	6.63
Genotypic (CV)	11.06	6.93	6.53	4.61
Grain yield				
Mean	3.95	3.32	1.41	1.45
Coefficient of variability (CV)	16.51	7.92	12.17	14.68
Heritability	86.79	86.39	84.62	89.44
Phenotypic (CV)	22.71	10.71	15.61	22.49
Genotypic (CV)	21.16	9.96	14.36	21.27
Protein content %				
Mean	13.82	8.99	14.75	9.02
Coefficient of variability (CV)	5.76	10.29	9.60	7.33
Heritability	78.44	14.59	40.02	10.84
Phenotypic (CV)	6.20	5.56	6.20	3.88
Genotypic (CV)	5.49	2.13	3.92	1.28
Sedimentation test				
Mean	28.32	19.22	32.92	18.18
Coefficient of variability (CV)	11.33	22.25	12.71	18.09
Heritability	20.53	11.93	29.80	20.72
Phenotypic (CV)	26.78	11.86	7.59	10.16
Genotypic (CV)	12.16	4.09	4.14	4.62
Flour color				
Mean	5.19	2.99	4.27	3.73
Coefficient of variability (CV)	24.00	27.83	26.18	24.26
Heritability	32.47	16.37	19.29	32.06
Phenotypic (CV)	14.61	15.21	14.57	14.72
Genotypic (CV)	8.32	6.15	6.40	8.33

Spike fertility was found to be highly affected by terminal stresses, particularly heat (Nachit, 1992). Similar effects were observed for number of spikes/m^2, particularly at the Sinai site where terminal stress occurs. In contrast, El-Salheia site showed, by far, the highest values for number of grains/spike and number of spikes/unit area. Soil fertility at El-Salheia site and the relatively favorable temperature that prevailed during the vegetative period may have positive effect on plant development and growth rate which in return resulted in positive effect on performance of the tested genotypes. Broad-sense heritability for this trait was low in Sinai and relatively high at El-Salheia site (Table 1). The high heritability and genetic advance from selection for this character and its significant association with grain yield at El-Salheia location may lead to recommending the use of this trait as indirect selection criterion for improving grain yield, if the crop is grown under favorable conditions. These results are in agreement with those found by other workers (Adary and Qualset, 1978).

Soil fertility at El-Salheia site may also have positive effects on number of grains/spike. Values for number of grains/spike were higher at El-Salheia site over both seasons than at Sinai location, and were significantly higher in the 1993-1994 than in the 1994-1995. This seasonal difference may also be due to the variation in day and night temperature that prevailed during the anthesis period in each season. Heritability values and the genetic coefficient of variation were relatively low, especially in the 1993-1994 season at Sinai and in the 1994-1995 at El-Salheia. This low heritability and the significant genotype x environment interaction (Table 2) observed confirm that the number of grains/spike may not be a good character to use for indirect selection of grain yield under the condition of eastern Delta region in Egypt.

Table 2. Sum of squares for variety (V), location (L), year (Y) and their interactions for days to heading (HD), days to maturity (DM), spikes/m^2 (NS), kernels/spike (KS), 1000-kernel weight (KW), grain yield (YLD), protein content (PRO), sedimentation test (SDT), and flour color (FCOL), over the durum wheat trials

Character	V	L	Y	V x L	V x Y	L x Y	V x L x Y
HD	2269.5**	2909.5**	1229.1**	654.2**	551.6**	220.5**	273.7**
DM	1032.3**	27,965.4**	2132.9**	534.6**	258.2**	3088.3**	324**
NS	141,696**	333,145**	57,305.9**	85,606.9**	86,225.1**	838,976**	126,821**
KS	159,931**	924,141**	645,176**	194,821**	132,191**	107,803*	91,194.5*
KW	5263.8**	3196.5**	9796**	1047.9**	688 ns	605.8**	444.5**
YLD	33.5**	465.8**	8.2**	27.4**	23.2**	10.4**	15.8**
PRO	44**	21.5 ns	2679.2**	41.2*	50.6**	19.3 ns	43**
SDT	764**	302.8 ns	13,644.6**	490.1 ns	759.4**	762.2*	674.5*
FCOL	7701.2 ns	4036.5*	337,429*	6312 ns	8871.7 ns	3793.9 ns	5989.7 ns

*,**Significant at 5% and 1% respectively; ns = not significant.

1000-kernel weight was relatively lower in 1993-1994 than in 1994-1995 at both El-Salheia and Sinai sites. However the values at El-Salheia site were slightly higher than that at Sinai. Heritability values for 1000-kernel weight were relatively high at El-Salheia sites and low at Sinai site indicating that selection of plumb kernels needs to be made at favorable conditions such as those which prevailed at El-Salheia site (Table 1). These results are in agreement with results from other investigations made by Gill and Brar (1977), Adary and Qualset (1978) and Nachit and Ketata (1986).

Grain yield at El-Salheia was significantly higher over both the growing seasons than that at Sinai. The genotype number 11 (Heider/Mt/Ho) was the highest in grain yield over both seasons and sites. Other promising genotypes were number 14 (Omruf-3) in El-Salheia and number 20 (Korifla) in Sinai. These genotypes apparently have higher tolerance to terminal stress and possess good yield potential. The yield potential of (Heider/Mt/Ho), (Omruf-3) and their tolerance to terminal stress is confirmed by Nachit (1993, 1994). High heritability estimates in broad-sense were observed, but with a very low genetic advance from selection. This is mainly due to a higher significant genotype x environment interaction (Table 2).

Durum wheat quality is determined through measurement of several characteristics such as protein content, sedimentation test and flour color. In this study, significant differences in protein content were found between the tested genotypes in both locations and growing seasons (Tables 1 and 2). A difference of 4.83% was observed between the overall mean of the tested genotypes grown at El-Salheia in the

1993-1994 and 1994-1995 seasons and of 5.7% between the overall mean of the tested genotypes grown at Sinai site in the two successive seasons. However, the overall mean for protein content over the two locations was significantly higher in the 1993-1994 season than in the 1994-1995 season (5.29%). This large difference in protein content between the two growing seasons is mainly due to the moisture stress and relatively high temperature occurred during the vegetative growth period in the 1993-1994 season. The amount and frequency of irrigation was relatively higher in 1994-1995 season than in 1993-1994. Consequently, the vegetative growth in 1994-1995 was high and required more nitrogen for enhancing production of dry matter, which in turn had a negative effect on protein content in the grain. Similar results were found earlier (Gill and Brar, 1977). Large kernel size (1000-kernel weight) in 1994-1995 may also have contributed to lower protein content in this season. Heritability in broad-sense for protein content was generally low in all years and sites, except at El-Salheia at 1993-1994. High values of phenotypic coefficient of variation and the low values of genotypic coefficient of variation, coupled with a high genotype environment interaction indicate that this trait is highly influenced by environmental factors (Tables 1 and 2).

The highest values for sedimentation test occurred in the 1993-1994 and particularly, at Sinai site where moisture and heat stresses were relatively high during the vegetative growth period (Table 1). These results are in agreement with that reported by Adary and Qualset (1978). The values for flour color were generally low compared to the results reported by Nachit in 1994. This may be attributed to the relatively poor and sandy soils, particularly, at the Sinai site. However, strong variation along with the low heritability values indicate that this character is highly influenced by environmental variation.

As compared to environmental variation (Table 1), the genotypic variation was generally high for days to heading; intermediate to high for yield components (number of spike/m^2, number of grains/spike and 1000-kernel weight); and generally low for the quality traits. Surprisingly, heritability in broad-sense for grain yield was consistently high across years. It is interesting to note that, for most trials, heritability values for the characters determined from the durum wheat genotype grown at Sinai site were lower than that obtained from the trials carried out at El-Salheia site. This may indicate that selection response will be lower in stress areas similar to Sinai.

Studies of the genotypes, locations, seasons and their interactions

Highly significant variations were observed among the tested genotypes for all characters, except for flour color (Table 2). Significant to highly significant differences were observed among the two growing seasons. Nachit *et al.* (1992) analyzed genotype x environment interaction in durum wheat and concluded the importance of environmental variation on most of the studied traits. For the first order (two-factors) interaction, highly significant differences were observed for genotypes (V) and locations (L) for all the studies characters except for sedimentation values and flour color. Similary, the interaction between the tested genotypes (V) and years (Y) was highly significant for all characters, except for 1000-kernel weight and flour color, and the interactions between locations (L) and years (Y) were significant to highly significant for all characters, except for protein content and flour color. The second order (three-factors) interactions between the tested durum genotypes, locations and years showed significant to highly significant difference for all the studied characters, except for flour color. Both year and location effects were the most dominating variable and significantly affected the performance of the tested durum genotypes in both year and at both locations in El-Salheia and Sinai.

Conclusions

The results of the present study clearly show that the prevailing environmental conditions at both El-Salheia and Sinai sites and in both growing seasons had significant influence on most of the productivity and quality traits. The warm weather in January of the 1993-1994 season had conditioned the tested durum genotypes to grow faster and to head earlier than in the 1994-1995 season. The early genotypes headed almost one week earlier in 1993-1994 than in 1994-1995, particularly at Sinai. The highest values of number of spikes/m^2 and number of grains/spike were recorded at El-Salheia site. Good soil fertility of this site and the favorable temperature occurred during the vegetative period in the 1994-1995 season may have had positive effects on plant development and growth rate, which in return, had a positive effect on the performance of the tested durum genotypes. Values of 1000-kernel weight were relatively high and the recorded high values for protein content during the 1993-1994 season were mainly due to moisture stress that resulted from insufficient irrigation and the relative high temperature prevailing during the vegetative growth stage in this season. Similarly, the highest sedimentation test values were observed in the 1993-1994 season, where moisture, fertility and temperature stresses were relatively high during the vegetative growth period. The durum genotypes Heider/Mt/Ho and Omruf-3 showed the highest grain yield over both sites and seasons. These promising genotypes apparently have higher tolerance to terminal stress and also possess good yield potential.

References

Adary, A.H. and Qualset, C.O. (1978). *Genetic variability in landrace populations of durum wheat. Agronomy Abstracts,* 46.

Allard, R.W. (1960). *Principles of Plant Breeding.* John Willey and Sons, Inc., New York.

FAO (1994). *Production Yearbook.* FAO, Rome, Italy.

Gill, K.S. and Brar, G.S. (1977). Variability and correlation coefficients for grain quality and other economic traits in durum wheat. *Journal of Research, Punjab Agriculture University,* 14(4): 391-394.

Nachit, M.M. (1992). *Cereal Improvement Program, Annual Report*, pp. 74-111.

Nachit, M.M. (1993). *Cereal Improvement Program, Annual Report,* pp. 68-87.

Nachit, M.M. (1994). *Cereal Improvement Program, Annual Report,* pp. 99-139.

Nachit, M.M. and Ketata, H. (1986). Breeding strategy for improving durum wheat in Mediterranean rainfed areas. *Proc. Int. Wheat Conf.,* Rabat.

Nachit, M.M., Ketata, H., Gauch, H.G. Jr. and Zobel, R.N. (1992). Use of AMMI and linear regression models to analyze genotype-environment interaction in durum wheat. *Theoretical and Applied Genetics,* 83(5): 597-601.

Porceddu, E. (1976). Variability for agronomical trials in a world collection of durum wheat. *Zeitschrift fur Pflanzenzuchtung,* 77(4): 314-329.

Tripathi, R.S., Agrawal, K.B. and Khan, A.W. (1973). Estimates of variation and heritability of some quantitative characters in durum wheat. *Indian Journal of Agricultural Sciences,* 43(91): 842-854.