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Correlation between agronomical and quality traits in durum wheat (*Triticum durum* Desf.) germplasm in semi arid environment

Abstract

The aim of this study was to determine the correlations between agronomic and quality traits in durum wheat. A field experiment was conducted during 2013/2014 and 2014/2015 cropping season at Siliana site in randomised completed block design. Ten durum wheat genotypes namely Maâli, Mahmoudi, Om rabiaa, Nasr, Salim, Maghrbi, Ben bechir, Souri, Agili glabre and Azizi were used. Morphological data on plant height, spike length, spiklet per spike, grain weight/spike, grain yield, biological yield and 1000 grain weight were recorded. Six quality traits were measured by Spectroscopic method NIRS: humidity, protein content, gluten content, strength wheat flour and sedimentation index (according to Zeleny). Results revealed that genotypical variance was found significant for all traits measured. The environment (year) variance was also found significant for all morphological and quality parameters. Genotype x environment interaction was significant for all traits except biological yield and 1000 grain weight. Analysis of Pearson's correlation showed that most agronomical traits are inversely correlated with quality parameters. Biplot analysis indicated that the first two PCs (principal components 1 and 2) explain 70.4 % (PC1=51.9 % and PC2=18.5 %) of the relationships between the genotypes and all of the traits. Gluten content, Zeleny sedimentation and strength wheat flour were grouped on the positive PC1 axis of the biplot, suggesting strong relationships among them. The genotypes Mahmoudi, Agili glabre, Azizi and Souri showed the best gluten content and Zeleny sedimentation and strength wheat flour with a stable behavior for the two years.

Keywords: Correlation, environment, grain yield, protein

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Introduction

Breeding programs aims to develop high yielding varieties with good quality, resistant to stresses. To enhance this tolerance to biotic and abiotic stresses, and adaptation to climate change, it is important to improve the yield and quality of the crop.[1] Agronomical traits especially grain yield and yield components are essential for varieties description. Plant and spike heights, spikelet and kernel numbers per spike, kernel weight per spike, harvest index and grain yield are generally the most used parameters in genotypic classification.[2] In addition of yield potential, to develop high quality wheat genotypes is still important. Cultivars are evaluated for high quality by protein content, zeleny sedimentation, energy value (W), water absorption and test weight.[3,4] For durum wheat, grain protein content, gluten strength, and yellow pigment content are the most important quality parameters.[5] Protein content have a great importance in durum wheat production and present the most important determinant of end-use quality, such as in pasta-making, in which high nutritional value and strong gluten are desirable.[6–8] Strong gluten allows an important firmness and stability to pasta after cooking, whereas pasta made with weak gluten semolina tends to deteriorate rapidly and become soft. Quality and agronomical parameters have been commonly used in breeding programs, but determining quality and agronomic traits in genotypes needs several measurements to tend available results, since they are greatly affected by environmental conditions.[2,9] This study aims to assess the agro-morphological and quality traits and their correlation for ten durum wheat varieties.

Material and methods

Vegetal material

Ten durum wheat varieties were used in the study: Maâli, Mahmoudi, Om rabiaa, Karim, Nasr, Salim, Maghrbi, Ben bechir, Souri, Agili glabre and Azizi. This work was conducted during 2013/2014 and 2014/2015 cropping season at Elgantra-Siliana site located in the North Ouest of Tunisia. Soil had a clay-loam texture with electrical conductivity=2.1 dsm^{-1} and having pH=7.91. Experimental design was in randomised completed block with three replications. Plot size was 6 m x 1.2 m (7.2 m^2). Plots received 100 kg ha-1 of Di-Ammonium Phosphate at sowing and 200 kg N (½ at sowing stage and ½ at tillering stage). An herbicide was applied as treatment for weed control. Meteorological data (rainfall) during vegetative and reproductive stage were recorded (Table 1).

Table 1 Mean rainfall (mm) in Elgantra-Sliana site during 2013/2014 and 2014/ 2015 cropping season

Months		October	November	December	January	February	March	April
Rainfall (mm)	2013/2014	8.5	102.7	35.6	39	43	43.2	27
	2014/2015	0	2.6	25.2	43.9	64.8	60.8	0

Measurements

Agro-morphological data on plant height (cm), spike length (cm), spiklet per spike, grain weight/spike (g), grain yield (kg), biological yield (kg) and 1000 grain weight (g) were recorded from five plants which had been randomly chosen in each row. The mean of quantitative data sets were used for analysis. Six quality traits were measured by Spectroscopic method (NIRS) that uses the near-infrared region of the electromagnetic spectrum (from about 800 nm to 2500 nm). The NIRS provide scorings for humidity, protein, gluten content, strength wheat flour and sedimentation index (according to Zeleny).

Statistical analysis

Variance (ANOVA), Pearson's correlation and biplot analyses, of different agronomical and quality traits, were statistically analyzed, at the 0.05 and 0.01 level, with SPSS software ver. 16.0 (IBM SPSS Statistics; SPSS Inc., SPSS for Windows, 2007, Chicago, USA) software.

Results and discussion

During the 2013/2014 and 2014/2015 cropping season, morphological traits and quality characteristics of ten durum wheat varieties were investigated at Elgantra-Siliana site. The results of variance components determined from the means of two years are given in Table 2. Genotypical variance was found significant for all traits measured. The environment (year) variance was also found significant for all morphological and quality parameters. Genotype x environment interaction was found significant for all traits except biological yield and 1000 grain weight. The ratio of genotype x environment variance in phenotypical variance was found as 99.8%, 99.5%, 99.3% and 98.9% for strength wheat flour, Zeleny sedimentation, protein content and gluten content respectively. According Yagdi & Sozen,[10] genotypical variance is important for spike length, number of spikelet per spike and test weight and the useful selections could be made with respect to these traits in durum wheat. Environmental variance was found important for seed number per spike, seed weight per spike and thousand kernel weight, while the variance component of genotype x environment was found important for seed yield, gluten content and protein content.

Results showed a marked influence of climatically conditions of different years on the durum wheat varieties grain yield and quality characteristics (humidity, protein, gluten content, strength wheat flour, sedimentation index according to Zeleny). When the growing conditions were rather dry and warmer (2014/15) and characterized by an uneven distribution of rainfall and shortage of rain particularly in April and May, grain yield was the poorest but grain quality was the best. The varieties 'Om rabiaa' and 'Nasr' and 'Salim' combined high yield with stability across the two years. In this context, Cesevičienė et al.[11] showed that grain yield and quality parameters of ten winter wheat varieties strongly depends on the experimental year's weather conditions, but the genotype had some impact on the variation. Similarly, according to Tarakanovas & Ruzgas,[12] grain yield was most affected by the year factor (38.7%), but variety and year-variety interaction had a lower influence of 6.6% and 4.3% respectively for 13 genotypes of winter wheat tested in 4 environments and 2 years.

Table 2 Analysis of variance (F test) for 13 traits of ten durum wheat genotypes for 02 years

Variation sources	df	Plant height	Spike length	Spiklet per spike	Seed per spike	Grain weight/ spike	Grain yield	Biological yield	1000 grain weight	Humidity	Protein	Gluten	Zeleny	strength wheat flour
Genotype	9	567.07**	2.07**	8.58**	160.71**	0.49**	305183.30**	2.23**	64.97**	0.85**	60.87**	602.87**	1474.74**	114155.48**
Year	1	114.27**	72.66**	33.19**	24.01**	7.59**	57.94**	97.17**	8.69**	251.55**	421.38**	313.87**	171.55**	828.64**
Genotype x year	9	131.70**	0.39**	5.00**	42.02**	0.65*	23065.46**	0.37ns	16.02ns	0.22**	0.81**	5.54**	10.18**	1138.85**
R^2		0.89	0.82	0.82	0.63	0.87	0.8	0.76	0.39	0.91	0.99	0.98	0.99	0.99

Df, degree freedom; ns: no significant; *, significant at the 0.05 level; **, significant at the 0.01 level

Correlations coefficients calculated for determining the relations between morphological and quality parameters are given in Table 3. Negative correlations were found between grain yield, protein content, gluten content, Zeleny and strength wheat flour (r=-0. 36**), but grain yield has a significant positive correlation with biological yield (r =0.38**) and grain weight/spike (r=0.43**). A statistically significant positive correlation was found between protein content, plant height, spike length and spiklet per spike (r=0.45**, 0.39**, 0.43**). The correlation coefficient between the plant height, spike length (0.43**), spiklet per spike (0.57**), 1000 grain weight (0.32*), humidity, protein content, gluten (0.44**), Zeleny (0.46**) and strength wheat flour (0.47**) were found significant. No significant correlation with grain yield was noted. In contrary, Dokuyucu et al.[13] and Kashif & Khaliq[14] suggested that plant height is one of the most important traits determining the yield. The gluten content was determined to be negatively correlated with seed number per spike (r=-0.36*) and grain yield (r=-0.36**). This trait was positively and significantly correlated only with plant height (r=0.44**), spike length (r= 0.39**), spiklet per spike (0.47**) and protein content (r=0.94**). Similarly, sedimentation value exhibited positive significant correlation with plant height (r=0.46**), spike length (r=0.53**), spiklet per spike (0.53**), protein content (r=0.86**) and gluten content (r=0.84**). As for strength wheat flour, a significant positive correlation was determined with plant height (r=0.47**), spike length (r=0.44**), spiklet per spike (r=0.51**), protein content (r=0.95**), gluten content (r=0.95**) and Zeleny value (r=0.89**). These results show that most agronomical traits are inversely correlated with quality charactistics. A similar finding was also reported by Barnard et al.[15] and Yagdi & Sozen.[10] Chung et al.[16] found a negative correlation between protein content and yield contrarily to the positive correlation coefficient between these two traits observed by Yagdi & Sozen.[10] Our results showed a positive correlation between gluten content and protein content. Similary, Yağdı[17] determined a positive correlation between the two traits and recommended that the resarcher take these components in consideration. Biplot analysis was used to examine the relationships between the genotypes and agronomical and quality traits together (Figure 1). The first two PCs (principal components 1 and 2) explain 70.4 % (PC1=51.9 % and PC2=18.5%) of the relationships between the genotypes and all of the traits. Gluten content, Zeleny sedimentation and strength wheat flour were grouped on the positive PC1 axis of the biplot, suggesting strong relationships among them. Therefore, they were called protein related traits. The

genotypes Mahmoudi, Agili glabre, Azizi and Souri were also grouped on the positive PC1 axis. These genotypes showed similar responses for gluten content, Zeleny sedimentation and strength wheat flour in the two years. Grain weight/spike, biological yield and seed per spike were grouped on the negative PC1 axis of the biplot, suggesting strong relationships among them. Thus, they were called yield related traits. The genotypes Maâli, Om rabiaa, Nasr, Salim, Maghrbi and Ben bechir were also grouped on the negative PC1 axis. These genotypes showed similar responses for grain weight/spike, biological yield and seed per spike across years. The biplot analysis indicated that the parameters measured were clustered into two groups. Gluten content, Zeleny sedimentation and protein content were grouped on the same group. Same results were obtained by Kaya & Akcura[18] on 20 bread wheat genotypes tested across three environments. These results are in agreement also with those of Saint Pierre et al.,[19] which indicated that the grouping of genotypes in the biplot showed that the genotypes within the quality groups reacted similarly to the combinations of the quality traits.

Table 3 Correlations between agronomical and quality traits for ten durum wheat genotypes

	Plant height	Spike length	Spiklet per spike	Seed per spike	Grain weight/ spike	Biological yield	Grain yield	1000 grain weight	Humidity	Protein	Gluten	Zeleny	Strength wheat flour
Plant height	1	0.43**	0.57**	-0.38**	-0.09	0.65**	-0.19	0.32*	0.25*	0.45**	0.44**	0.46**	0.47**
Spike length		1	0.55**	-0.29*	-0.09	0.14	-0.23	-0.15	0.01	0.39**	0.39**	0.53**	0.44**
Spiklet per spike			1	-0.15	0.25*	0.37**	-0.18	0.03	-0.04	0.43**	0.47**	0.53**	0.51**
Seed per spike				1	0.23	-0.31*	0.11	-0.26*	-0.17	-0.43**	-0.36**	-0.31*	-0.39**
Grain weight/spike					1	0.07	0.43**	0.12	0.15	-0.25	-0.12	-0.28*	-0.24
Biological yield						1	0.38**	0.59**	0.43**	0.19	0.22	0.06	0.19
Grain yield							1	0.24	0.45**	-0.36**	-0.32*	-0.57**	-0.42**
1000 grain weight								1	0.40**	-0.04	-0.007	-0.16	-0.04
Humidity									1	-0.35**	-0.32*	-0.46**	-0.40**
Protein										1	0.94**	0.86**	0.95**
Gluten											1	0.84**	0.95**
Zeleny												1	0.89**
Strength wheat flour													1

*, Correlation is significant at the 0.05 level; **, Correlation is significant at the 0.01 level

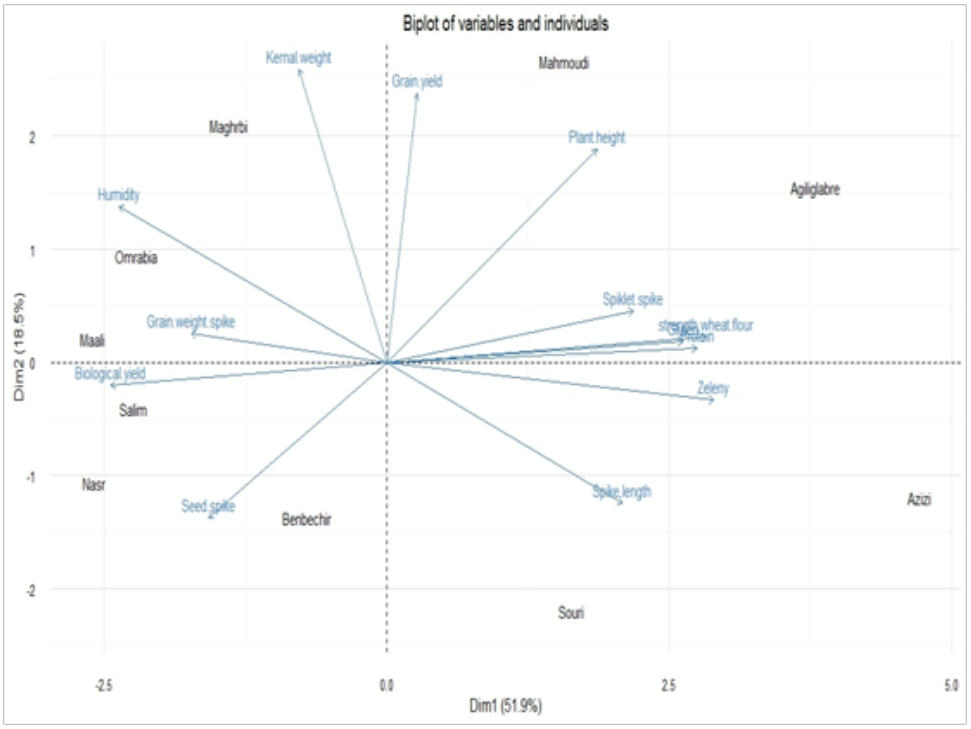

Figure 1 Biplot analysis for grain yield and quality traits for ten durum wheat varieties.

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From quality parameters, a higher variability was noted in our study for gluten content, Zeleny sedimentation and strength wheat flour, but similar variation in separate years showed that this quality parameter was most stable over years. Varieties Mahmoudi, Agili glabre, Azizi and Souri showed the best quality and were more stable concerning these parameters. These genotypes could be source of quality for breeding programs for improving pasta quality.

Conclusion

The present study showed that grain yield, its components and quality traits were influenced by environment (year). Thus, negative association between high yield and good quality should be major concern for plant breeder, for increased grain yield and grain quality of durum wheat.

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None.

Conflicts of interest

Author declares that there is none of the Conflicts.

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