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Comparative study of the Environmental impact on the nutritional quality of Durum Wheat (*Triticum durum* Desf.)

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ABSTRACT

In this study, we set out to assess the impact of environment (Khenchela vs. Constantine) on the nutritional qualities of two durum wheat genotypes grown extensively in Algeria (Waha vs. GTA- dur). Based on our results, the absence of an 'Environmental' effect upon the content of insoluble proteins, TKW (Thousand Kernel Weight), and in the absence of qualitative analysis of insoluble proteins (electrophoresis analysis), we concluded that these parameters are not very associated with culture conditions in both regions (soil type, farming practices, etc.), which does not seem to be stressful for the cultivation of wheat. However, the variation of the content of the wheat grains in soluble sugars and soluble proteins appear to reflect better the impact of changing environment upon the composition of the nutrient grains and therefore the quality of this preferred nutritional foodstuff of all Algerians in particular as couscous and porridge.

Key words: *Triticum durum Desf, Thousand kernel weight, Soluble proteins, Insoluble proteins, Soluble sugars.*

Introduction

Wheat grain yield and flour quality are influenced by the effects of environment during grain filling. Environmental variables such as temperature, water and fertilizer influence the rate and duration of wheat grain development, protein accumulation and starch deposition in unique ways, and by different mechanisms (Mureˆan *et al.,* 2020; Dupont and Altenbach, 2003).

Wheat is one of the most important food crops grown worldwide and the main source of calories and protein for a third of the world's population. Durum wheat (*Triticum durum*, Desf.) occupied more than 8% of the wheat area and grown on approximately 17 million hectares in the world and about half of the area is in developing countries (Nuttall *et al.,* 2017).

At all times, wheat has occupied a very important place in the Algerian diet. As an indication, 5.5 million tonnes of wheat were imported during the period 2006-2007 (Laino *et al.,* 2010).Given the diversity of needs and food-manufacturing processes made from wheat flour, knowledge of different disciplines is necessary. This includes knowledge about the physicochemical, biochemical characteristics of the fundamental properties of the paste.

Variation in genotypic performance generates the genotype x environment interaction, making it difficult to select and recommending performant genotypes (Bohorova *et al.,* 2001). Various approaches are valid for the assessment of the genetic diversity of plant genetic resources; biochemical and molecular markers such as reserve proteins were widely used.

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Currently, one of the main objectives of wheat improvement is determine specific varieties with high productivity and resistance to environmental factors.

The objective of this study was to evaluate the impact of the environment and the genotype* environment interaction on the nutritional quality of durum wheat.

Materials and Methods

Plant material

The plant material used in this study includes four varieties of durum wheat from two different growing areas, namely two varieties from the Khenchela area and two varieties from the Constantine area (WAHA, GTA/DUR).

The climate of the Khenchela area is continental in the North and almost Saharan in the South. The winters are very harsh and the summers hot and dry. In addition, it is characterized by high rates of evapotranspiration during the year.

Rainfall is less than 200 mm per year. March is the wettest month (receives the most rain) while July is the driest. In general, the spring rains are more important (an average of 60.33 mm) than those of the autumn, which have an average of 43.67 mm.

The climate of the Constantine area is continental. The temperature varies from 25 to 40° in summer and 0 to 12° in winter. The average rainfall varies from 500 mm to 700 mm per year.

Analyzed quality parameters

Four durum wheat quality parameters, namely: thousand kernel weight (TKW), soluble protein (SP), insoluble protein (IP) and soluble sugars (SS) were determined for both genotypes in each of the two environments.

Extraction and determination of soluble sugars

Extraction of soluble sugars followed the phenol method (Dubois *et al.*, 1956). To 50 mg of plant material, placed in clean test tubes, 3 ml of 80% ethanol was added. The tubes were left at room temperature for 48/h and then they were placed in water bath at 80/°C to remove the alcohol and then made to volume with distilled water. In new test tubes, 1/ml of this solution was mixed with 1/ml of phenol (5%) and 5/ml of sulfuric acid simultaneously. This mixture remained for 30 minutes and the absorbance measurements were taken at a wavelength of 485nm.

Extraction of soluble and insoluble proteins

50 mg of wheat grains was ground to a fine powder with the addition of 5 ml of distilled water. After centrifugation for 10 min at 2000 g, the supernatant containing soluble proteins was recovered and used for the estimation of soluble proteins. 5 ml of 5% trichloroacetic acid was added to the pellet (recovered during the extraction of soluble proteins) with thorough shaking for 30 min. after centrifugation (10 min at 2000× g), the pellet was recovered and mixed with 5 ml of 1N sodium hydroxide and placed in a water bath at 80°C for 30 minutes. The solution again centrifuged (2000×g) for 10 min. The supernatant was used for the estimation of insoluble proteins. The soluble and insoluble proteins were determined following Bradford assay (Bradford, 1976).

Thousand-kernel-weight of durum wheat (TKW)

TKW was determined using an analytical balance.

Statistical analysis

Statistical analysis consisted of an analysis of variance (ANOVA) two-factor by using the Statgraphics Centurion 16 software. The experimental design used was a complete randomized design with three replicates.

Results and Discussion

The protein content of wheat seeds

The content of soluble and insoluble protein in wheat seeds was shown in the Figures 1 and 2.

The soluble protein content in wheat seeds

As shown in Figure 1, the soluble protein content

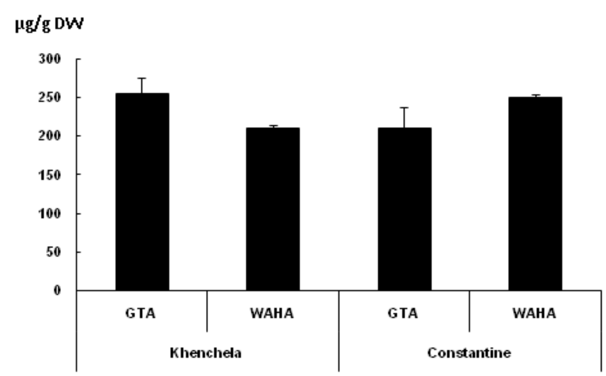

Fig. 1. Soluble protein content in wheat grains (µg/g DW)

Table 1. Analysis of variance for soluble proteins

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:Reg	13,0208	1	13,0208	0,04	0,8432
B:Var	13,4408	1	13,4408	0,04	0,8407
INTERACTIONS					
AB	5568,52	1	5568,52	17,85	0,0029
RESIDUAL	2495,37	8	311,921		
TOTAL	8090,35	11			

differs from cultivar to cultivar and from region to region. Genotype * environment interaction effect was significant (P<0.0029), which reflects the environment impact on this parameter.

The insoluble protein content in wheat grains

As shown in Figure 2, the insoluble protein content differs from cultivar to cultivar and appears to be similar from region to region. Indeed, statistical

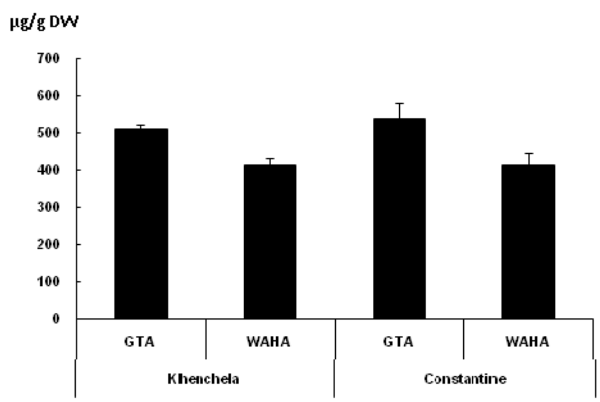

Fig. 2. Insoluble protein content in wheat grains (µg/g DW)

analysis confirmed this observation by revealing only a genotype effect (P<0.0002), which reflects the absence of environmental impact (study conditions) on this parameter.

Thousand-kernel-weight of durum wheat (TKW)

Thousand-kernel-weight is a varietal characteristic. Considering the classification of Godon and Williams (1998), the genotypes studied showed an average thousand kernel weight (medium wheat) except the GTA genotype of Khenchela area whose TKW less than 37g. The results showed that the values of Thousand-kernel-weight range from 36.9 to 42.8g around an average of 39.8g. Thousand kernel weight of WAHA genotype of Constantine area (42.8 g) was higher than those of Khenchela area while GTA genotype showed a slight difference between the two areas.

The soluble sugar content of wheat grains

As shown in Figure 4, the soluble sugar content of wheat grains seems to vary depending on the geno-

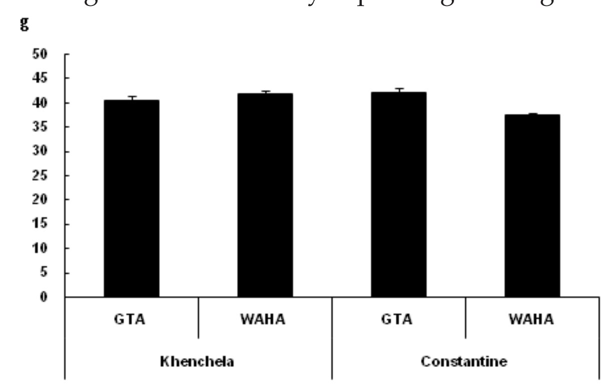

Fig. 3. Thousand-kernel-weight of durum wheat (TKW)

Table 2. Analysis of variance for insoluble proteins

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:Reg	691,601	1	691,601	0,75	0,4128
B:Var	36619,7	1	36619,7	39,51	0,0002
INTERACTIONS					
AB	575,468	1	575,468	0,62	0,4534
RESIDUAL	7415,22	8	926,902		
TOTAL	45302,0	11			

type and the region considered. Wheat grains with higher soluble sugar content are those derived from the Constantine region. The analysis of variance revealed a significant effect of the genotype, the environment and the interaction between the two (Table 3).

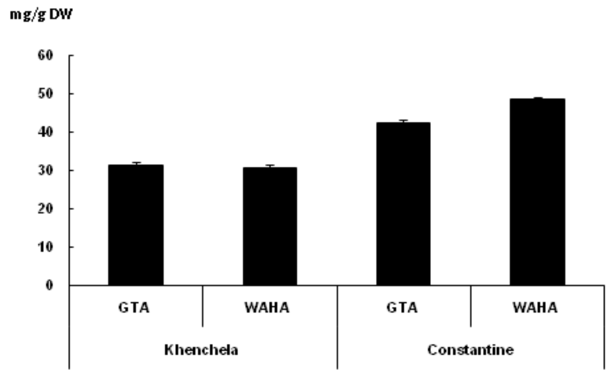

Fig. 4. Soluble sugar content in wheat grains (mg/g DW)

In the Algerian high plateaus, grain yield performance of durum wheat (*Triticum durum* Desf.) was highly influenced by abiotic stresses. The variation in yields, from year to year and from location to location, originates from the sensitivity of plant material to unpredictable fluctuations across growing seasons namely low winter temperatures, spring frost, hydric stress and high temperatures at the end of the crop cycle (Bahlouli *et al.,* 2005; Chennafi *et al.,* 2006).

The variation in genotypic performance generates the genotype x year interaction, making difficult the selection and recommendation of efficient genotypes (Bouzerzour *et al.,* 1995).

In order to assess the impact of climate on the nutritional qualities of durum wheat, we made a comparison between two different areas in the eastern Algeria, namely, the area of Khenchela, located in the semi-arid bioclimatic stage and the area of Constantine with a sub-humid climate. Furthermore, in order to evaluate the genetic part, we also used two different genotypes from each area.

The analysis was based on some biochemical parameters of wheat grain flour, namely, the content of soluble and insoluble protein, as well as, the soluble sugar content. This choice was not arbitrary, since it is known the importance of both proteins and sugars in determining the nutritional quality of wheat, as well as the impact of these elements on human health. On the other hand, 20% of the proteins in the diets of more than 4.5 billion people derived from wheat, in addition to many vitamins and minerals (Shiferaw *et al.*, 2013).

Environment generally has a significant influence on flour quality by its effects on relative quantity of specific proteins, protein subunits and protein groups, proportions of composition, concentration, polymerization and amount and size distribution of polymeric proteins. Temperature, water access and fertilizer are the most crucial environmental conditions (Zhang *et al.,* 2014). According to our results, Nachit *et al.,* (1992), when examining the impact of heat stress on soluble proteins (metabolic) of durum wheat grains (Italian), obtained similar results.

Environmental interactions during grain filling changes the rate of grain development and influence final grain weight (Figure 3), protein and starch contents (Altenbach *et al.,* 2003; Nuttall *et al.,* 2017; Farooq *et al.,* 2011). Protein quality in grain was also affected by the entanglements of the glutenin subunits into protein macromolecules which are influenced by the environment in which the wheat plant is cultivated (Jia et al., 1996).

In previous studies, wheat flour protein contents increase significantly under the influence of water deficit mainly due to higher rates of grain nitrogen (N) accumulation and lower rates of sugar accumulation (Panozzo and Eagles, 1999). Irrigation, on the other hand, may decrease flour protein content by dilution of nitrogen with carbohydrates (Ozturk and Aydin, 2004).

Table 3. Analysis of variance for soluble sugars

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:Reg	626,263	1	626,263	1358,39	0,0000
B:Var	23,213	1	23,213	50,35	0,0001
INTERACTIONS					
AB	35,5352	1	35,5352	77,08	0,0000
RESIDUAL	3,68827	8	0,461033		
TOTAL	688,699	11			

Conclusion

Given our results, absence of an 'environmental' effect on the insoluble protein content of durum wheat, TKW (Figs. 2 and 3), we can say that these parameters are not strongly associated with the growing conditions in the two areas (soil type, cropping practices, etc.), and, which does not appear to be stressful for growing wheat. In contrast, the variation in the soluble protein and soluble sugar content of wheat grains seems to better reflect the impact of the changing environment on the nutrient composition of the grains and, consequently, the nutritional quality of this favorite food of all Algerians (especially in the form of couscous and porridge).

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