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Relationship between physico-chemical and molecular grain quality parameters for Tunisian durum wheat varieties (*triticum durum* L.) in different environments

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ABSTRACT

An experimentation using eight Tunisian durum wheat varieties (four landraces and four high yielding ones) was conducted in two different bioclimatic regions (semi-arid and sub-humid) during two growing years. Relationships between agronomic (grain yield), physico-chemical (total protein content, gluten content, gluten index) and molecular parameters (high molecular weight glutenin subunits (HMW-GS), low molecular weight glutenin subunits (LMW-GS) and their ratios) were investigated. The variability of protein content was significant in relation to environment (E), while the gluten index, indicating the gluten strength, was mainly controlled by genotypic factors (G). The quantification in relative percentages of HMW-GS y and x by CE LabChip90 and the estimation of HMW-GSy/HMW-GSx and of HMW-GS/LMW-GS showed that these fractions have varied in relation to E, G and to their interaction ($p < 0.05$). The correlation test showed significant associations between physico-chemical and molecular parameters, whereas these relationships varied significantly in relation to E and G. The Principle Component Analysis (PCA) has distinguished four different quality profiles, where a given variety produced very different qualities in different environments. These results highlight the importance of the evaluation of genotypes under different conditions and suggest that more investigations are requested to optimize the use and the recommendations of varieties.

Key words: durum wheat, landraces, quality, HMW-GS, environment.

INTRODUCTION

Strong Relationships between the high molecular weight glutenin subunits allelic composition and gluten strength for durum wheat were previously found (Sisson et al., 2005 and Ammar et al., 2000). Our previous studies showed that glutenin amounts varied significantly with environments and genotypes. Physico-chemical and technological durum wheat properties were influenced by the environmental, genotypic factors and the potential interactions among them (Daaloul Bouacha et al., 2014 and 2015). Many researchers considered that storage proteins are the responsible of the variation in physicochemical and technological durum wheat properties (Martinez et al., 2005 and Lerner et al., 2004), thereafter, the objective of this study was to investigate the relationship between physicochemical and molecular parameters for

different genotypes (landraces and high yielding ones) in different environments, in order to better understand their stability and the contribution of environment on their quality variation.

MATERIALS AND METHODS

Plant material and grain characteristics. Two field trials were grown in a sub-humid (SH) region (Bousalem) and in a semi-arid (SA) region (Kef) of Tunisia; each trial included four durum wheat landraces (Chili, Biskri, Mahmoudi and Inrat 69) and four high yielding durum wheat cultivars (Karim, Razzak, Om Rabiaa and Khiar). The experiment was laid out as a randomized block design with a factorial set of treatments that included eight durum wheat cultivars and four fertilizer combinations of nitrogen (N) and potassium (K), as described by Daaloul Bouacha et al. (2014).

Agronomic and physico-chemical characteristics. The quality parameters measured were: grain yield, thousand kernel weight, yellow berry, gluten content and gluten index. Near infrared spectroscopy using a Perten-Inframatic-8600 was used to estimate total grain protein content, sedimentation test, hardness of grains and water absorption.

Molecular characteristics. Glutenins extraction and quantitation of relative percentages of different fractions by microchip capillary electrophoresis-sodium dodecyl sulfate (microchip CE) platform, LabChip 90 were made as described by Rhazi et al. (2009).

Principle Component Analysis (PCA). In order to investigate the relationship between the physico-chemical and the molecular characteristics for the different genotypes (landraces and high yielding ones) in the different environments, Principle component analysis was carried out. Then elementary responses of each variety defined as a combination between one variety (C: Chili, B: Biskri, M: Mahmoudi, I: INRAT69, O: Omrabiaa, KA: Karim, R: Razzak, KH: Khiar), one environment (e1: sub-humid year 1, e2: sub-humid year 2, e3: semi-arid year 1, e4: semi-arid year) and one fertilizer treatment (f1: K0N0, f2: K0N1, f3: K1N0, f4: K1N1), were projected on the surface plan formed by the two components.

RESULTS AND DISCUSSION

The evaluation of the eight durum wheat varieties showed a significant variability for the examined quality parameters. Mean grain yield was 4777 kg/ha with a range according to environments, between 3081kg/ha and 6748 kg/ha. Total grain protein content showed significant variability in relation to environments with a range between 15.47% and 18.93%. The gluten index was mainly controlled by genotypic factors (G).

The principle component analysis has permitted to identify 3 linear combinations. Amongst these combinations, the principle component PC1, explaining 41.53 % of total variability, was correlated positively with protein content, sedimentation, hardness, water absorption and gluten content, and negatively with yellowberry. The second principal component PC2, explaining 20.10% of the total variability, is correlated positively with HMW-GS by LMW-GS ratio and HMW-GS y relative percentages and HMW-GSy by HMW-GSx ratio and negatively with HMW-GSx relative percentages.

Projection of the variables in the two components space (PC1 and PC2) (Fig. 1), explaining 61,63 % of the total variability, showed that among the technological parameters evaluated, the expression of hardness, sedimentation, water absorption and gluten was important when HMW-GS by LMW-GS and HMW-GSy by HMW-GSx ratios were the highest. In addition, this result was also confirmed when HMW-GSy relative percentages were higher than HMW-GSx relative percentages. This stipulates that HMW-GSy fractions could contribute to the improvement of technological quality parameters, since they carry most important disulfide bonds than HMW-GSx fractions (Shewry et al., 1992).

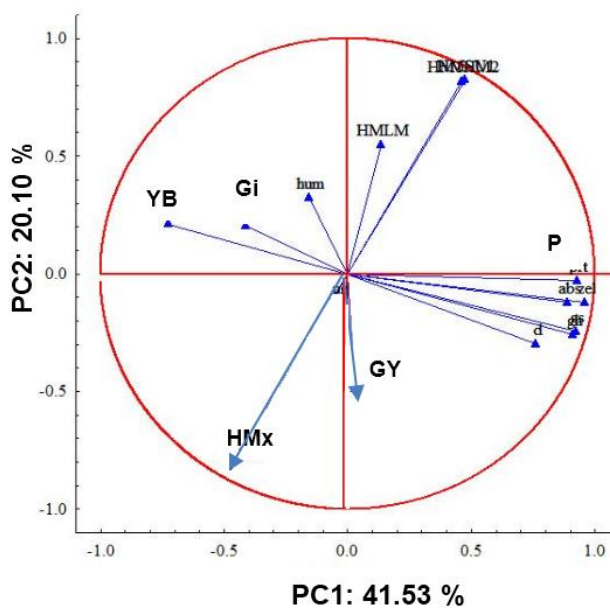


Figure 1. Projection of the variables in the two components space (PC1 and PC2) explaining 61.63% of total variability. P: protein content, Gi: gluten index, GY: grain yield, HMLM: HMW-GS by LMW-GS ratio; HMyHMx: HMW-GSy by HMW-GSx ratio, HMx: relative percentage of HPM- GSx, HM: relative percentages of HMW-GS

The responses of each variety projected on the surface plan formed by these two components showed that a given variety expressed very different quality profiles in different environments (Fig.2). Four different quality profiles were identified. A first group of quality profile defined by high levels of protein content, gluten content and sedimentation. Samples of this group carried out important HMW-GS relative percentages values and high HMW/LMW and HMW-GSy/HMW-GSx ratios, however, this group showed low grain yield means. Responses of this group corresponded on those of the landrace Biskri in the majority of the studied environments. A second group of quality profile defined by high levels of protein content, gluten content, sedimentation test and water absorption and low means of HMW/LMW ratios and with low relative percentages of HMW-GSx. However, grain yield was varying for this group. Varieties identified with this quality profile were principally landraces Chili and Mahmoudi in the majority of the environments. A third group of quality profile was defined by high gluten index and low grain yield means, low relative percentages of HMW-GSy and HMW-GSy/HMW-GSx ratios. This group was composed with high yielding

varieties in some favorable environments. A fourth group of quality profile defined by important HMW-GSx relative percentages, higher grain yield values and lower quality parameters (P, G..) values. This later group is composed of high yielding varieties in other environments.

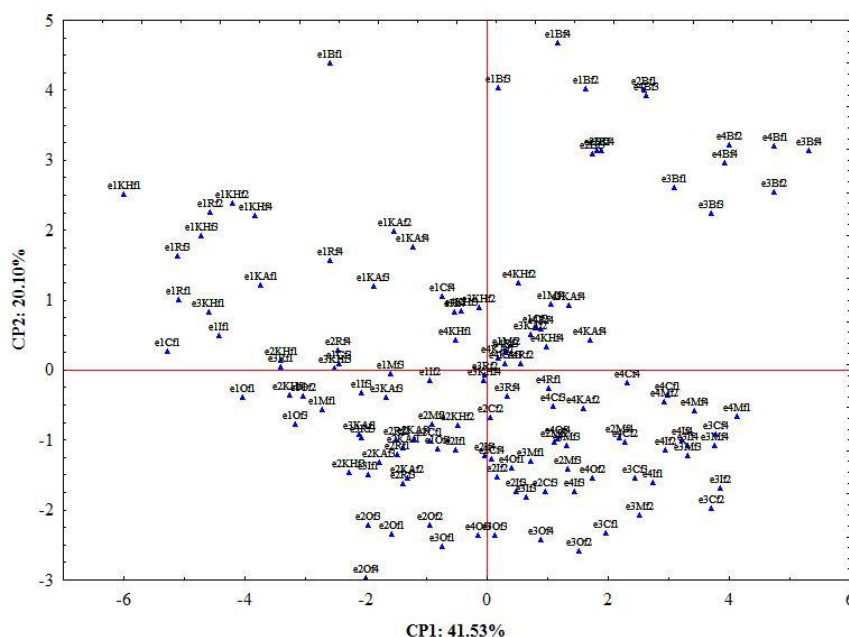


Figure 2. Projection of means of varieties' responses in the two components space (PC1 and PC2) explaining 61.63% of total variability. ▲ : elementary responses of each variety defined as a combination between one variety (C: Chili, B: Biskri, M: Mahmoudi, I: INRAT69, O: Omrabiaa, KA: Karim, R: Razzak, KH: Khiar), one environment (e1: sub-humid year 1, e2: sub-humid year 2, e3: semi-arid year 1, e4: semi-arid year) and one fertilizer treatment (f1: K0N0, f2: K0N1, f3: K1N0, f4: K1N1).

The relationship between Protein content and HMW-GS by LMW-GS ratio was influenced by cropping year conditions and fertilizer treatments. Indeed, Good management of nitrogen fertilizer use could improve the quality of high yielding cultivars in the sub-humid region during a standard rainfall conditions, however this relationship does not exist for the same region during an excessive rainfall condition.

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