4.7 Wheat grain proteins with impact on end-use quality and health attributes show significant responses on heat, drought and combined stresses

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Abstract

In the view of global climate change, heat and drought stress have become the most important limiting factors to crop productivity and food security. Beside this, there is some information about the effect of the elevated atmospheric CO_2 concentration to the yield, but not on the quality. These abiotic factors, like water deficits and high temperature generally occur at sensitive growth stages affecting functional properties of wheat. They are reflected in changes in the wheat yield; adversely affect the seed storage protein composition and the end-use quality. Wheat seed storage proteins are considered as key players in triggering different wheat related health disorders, containing immune responsive peptides (epitopes) that can cause immunological diseases. The main aim of our research is understand the shifts in the seed storage protein composition in different Hungarian bread wheat cultivars, caused by abiotic stress factors using proteomics and immunomics analyses. Performing climate chamber experiments and field trials we can evaluate the complex interpretation of specific heat- drought and combined abiotic-stress effects and monitoring the influence of elevated atmospheric CO_2 on the composition of these proteins. Characterisation of the protein content in the view of certain environmental conditions can provide a

powerful tool to predict the effect of climate change on the bread making quality and the accumulation of the harmful protein.

Introduction

In the past decades increased global temperature and climatic variability is resulting an increase of both the frequency and magnitude of extreme climate events [1]. Climate change can significantly affect environment, ecosystems, agriculture, and potentially affect crop production and quality [2]. Therefore cereals might have exposed to more than one stress event in the growing season [3].

With the rapidly changing climate combined abiotic stress factors can be detected, like high temperature, lack of water in the root zone, extreme transpiration and elevated atmospheric CO_2, which can cause significant changes in the yield, relative protein content, and composition of seed storage proteins, therefore affect the dough rheological parameters, and baking quality [4,5,6].

As one of the most important crops providing vegetal protein in human food, wheat plays a critical role in global food security. Storage proteins in wheat grain are the single greatest source of protein in the human diet. Maintaining grain quality under extreme climate conditions is crucial for human nutrition, end-use functional properties [7].

Wheat seed storage proteins represent 70-80 % of the full protein content, depends on species. They are key players in wheat-related diseases and health problems, like autoimmune reaction of coeliac patients. They form a typical protein profile of modern wheat genotypes, which confers to the dough its viscosity and elasticity. Bread quality is determined by the composition and molecular structure of gluten which turn controls the interaction of gluten subfractions during processing [8].

Abiotic stress factors and climatic extremities can cause changes in the protein profile of seed storage proteins, due to shifts in the composition and elimination of their balance.

The main purpose of the research was to observe the shifts and changes in the seed storage protein composition of preselected Hungarian bread wheat cultivars, in response to certain abiotic stress factors occurring at anthesis and post anthesis periods.

Climate chamber experiments and field trials were performed to evaluate the complex modelling of specific heat-, drought and combined abiotic stress effects and examine the impact of elevated atmospheric CO_2 on the wheat seed storage protein composition.

Interpretation of the protein content in response to certain environmental conditions can predict wheat acclimation, and effect of the climatic extremities on crop yield, relative protein content, bread making quality and accumulation of the harmful proteins in the future.

Performing field trials with experimental free air CO_2 enrichment (FACE) studies we can build up an accurate climate prediction model, which can underlies a specific breeding program.

Materials and Methods

Based on greenhouse heat and drought stress experiment out of 125 Hungarian bread wheat genotypes, derived from the Cereal Gene Bank of the Department of Plant Genetic Resources and Organic Breeding, Martonvásár, four wheat lines, a drought resistant, a drought sensitive, a heat resistant and a heat sensitive were selected.

Grain yield, and plant height were measured, thousand kernel weight of all samples were evaluated. Protein content was determined by near infrared spectroscopy (NIR) and Duma method. Grain samples were milled with Retsch Mixer Mill MM200.

SE-HPLC was performed to analyse the profile of seed storage proteins by determining the UPP% and Glutenin/Gliadin ratio. Harmful protein content was determined by using commercially available R5 (RIDASCREEN® Gliadin, R-Biopharm, AG, Darmstadt, Germany) and G12 (AgraQuant Gluten G12 Assay (4-200 ppm) ELISA assays.

Results and Discussion

In reference to the previously selected four bread wheat genotypes, according to the measured thousand kernel weight, combined drought and heat stress at anthesis and post anthesis period caused a significant reduction, 40-50 % kernel weight loss, in yield. However every genotypes shows increased protein content in response to combined stress effects, based on the UPP% and glutenin/gliadin ratio, due to changes in protein composition significant decrease can be found in quality of four of every genotypes (Fig. 1).

The results of commercially available R5 and G12 ELISA tests revealed that based on the climate chamber experiments characteristic changes occur in harmful protein content in response to drought stress and heat stress at anthesis and post anthesis period (data not shown). Further immunoanalyses are needed to evaluate different abiotic stress profiles.

Besides the selected bread wheat genotypes *Triticum monococcum* preliminary selected genotypes were examined by commercially available R5 and G12 ELISA assays as well. They show significant lower harmful protein content compare to the examined bread wheat genotypes.

Based on these findings further abiotic stress analysis and detailed examination of the immunogen protein content will be needed to determine the stability of the lower toxic protein content of the investigated einkorn genotypes.

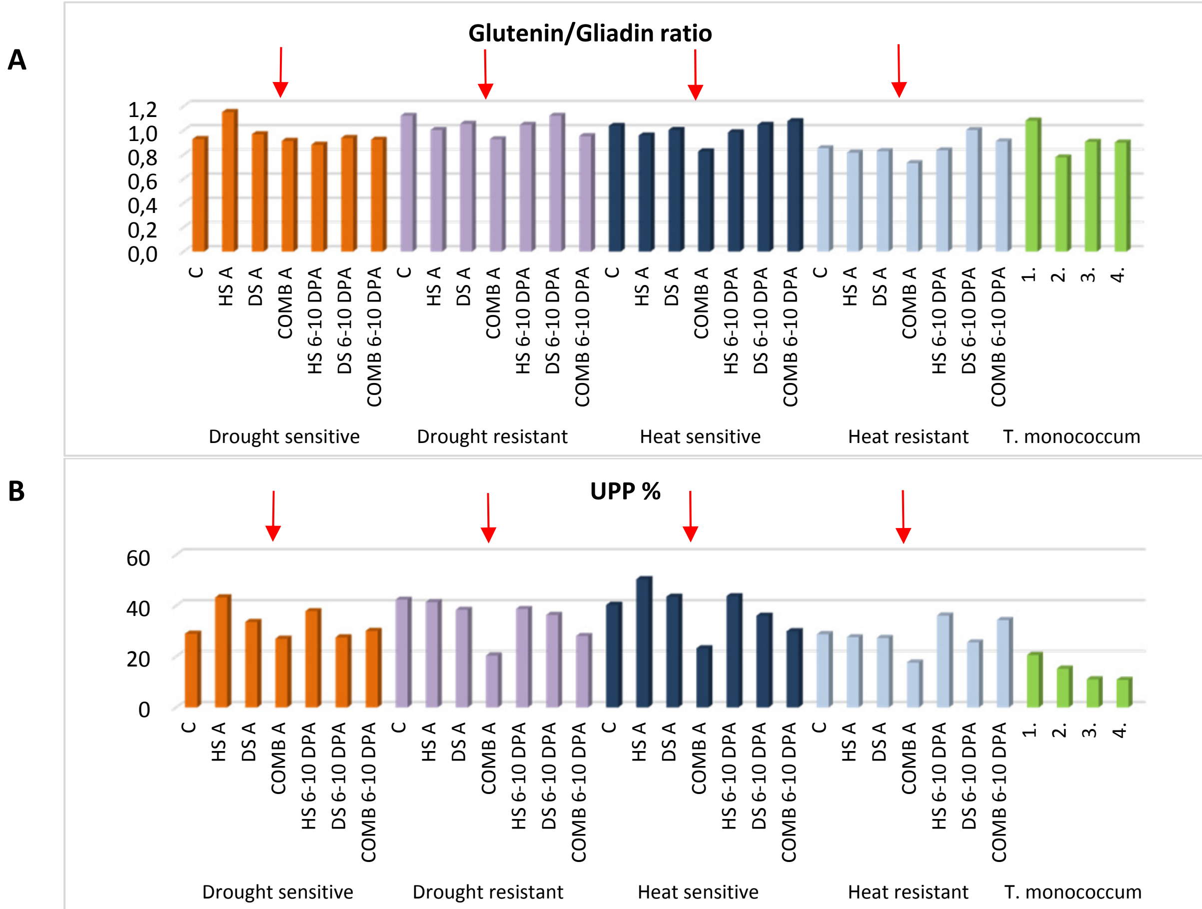

Figure 1. *Measured glutenin/gliadin ratio and UPP% (unextractable polymeric glutenin proteins) of four Hungarian bread wheat and preselected Triticum monococcum genotypes. C – control, DS A – drought stress at anthesis, HS A – heat stress at anthesis, DS 6-10 DPA – drought stress at 6-10 DPA, HS 6-10 DPA – heat stress at 6-10 DPA, COMB A – combined drought and heat stress at anthesis, COMB 6-10 DPA – combined drought and heat stress at 6-10 DPA*

Conclusion

Due to the increasing impact of climate change, abiotic stress factors such as higher temperature, lack of water, and elevated atmospheric CO_2 can cause significant changes in composition of seed storage proteins, therefore affect the dough rheological parameters, and baking quality.

Performing climate chamber experiments and field trials complex interpretation of specific heat, drought and combined abiotic stress effects can be evaluated, and the influence of elevated atmospheric CO_2 on the composition of these proteins can be monitored.

Observation of the influence of abiotic stress factors on protein quality and composition, and characterisation of the accumulation of harmful proteins provides us a powerful tool to predict the effect of climate change on wheat end use properties, and stability on response to certain environmental extremities. The results will lead us to