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Connection of characters relevant for drought stress on the quality of 25 European winter wheat genotypes

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Abstract

In 2010 at three Austrian, two German and one Hungarian location 25 winter wheat genotypes were tested in characters relevant for drought stress and in quality parameters. The results showed that early heading and ripening varieties exhibited a lower protein yield than later ones even if their protein content is higher. Genotypes with a longer period of grain filling obtain a lower protein yield. Taller genotypes reach a higher protein quality and heavier kernels. The quality parameters are negatively influenced by the chlorophyll content. The stomatal conductance does not influence the selected quality parameters. Varieties with later leaf senescence achieve higher protein content, higher protein quality and higher hectolitre weight.

Keywords

Chlorophyll content, drought stress, leaf senescence, *Triticum aestivum*, wheat quality

Introduction

The worldwide climate change is influencing the agriculture in Central Europe. As extreme weather events like heat and persistent drought appear more regular especially the Pannonian regions suffer from water insufficiency. Nevertheless other regions in Central Europe have the same problems. Against this background the research project called *Winter wheat cultivars maintaining high yield under environmental stress* was set up in October 2009. One part of this project was the quality aspect of wheat under drought stress which is pointed out below.

Materials and methods

In 2010 at three Austrian locations in the Pannonian region (Breitstetten, Tattendorf and St. Andrä), at two German locations (Söllingen in Lower Saxony, Seligenstadt in Northern Bavaria) and at one Hungarian location (Szeged) 25 winter wheat varieties were cultivated. At two Austrian sites the trial was laid out in a rainfed and an irrigated variant. The varieties were selected for a wide range of end use quality. The nursery was made up by eight domestic genotypes from each participating country plus Capo as check variety. The field experiments were arranged in a randomized lattice design with three to four replications. Plot size differed among locations (Austria 8.0-13.5 m²; Germany 4.5-5.5 m²; Hungary 6.5 m²). The nitrogen application ranged in total from 129 to 140 kg N ha^{-1} in Austria, 170 to 190 kg N ha-1 in Germany and 68 kg N ha^{-1} in Hungary.

The following agronomic parameters were recorded: Heading date (BBCH 59), date of anthesis (BBCH 65), date of physiological grain maturity (BBCH 87) and plant height (cm) according to BFL (2002). Furthermore physiological parameters were evaluated: flag leaf senescence (BBCH 73-85 in % of discoloured leaf), flag leaf chlorophyll content (10 flag leaves from each plot at BBCH 59-65 using the SPAD-502 chlorophyll meter from Konica Minolta Sensing, Inc.), flag leaf stomatal conductance (three flag leaves of each plot at BBCH 65-71 using the leaf porometer from Decagon Devices, Inc.).

The following quality parameters were determined: thousand kernel weight (TKW, g, 86% d.m.), hectolitre weight (kg, ISO 7971-2), protein content (% d.m., Dumas combustion method, ICC Nr. 167; Nx5.7) and Zeleny sedimentation value (ml, ICC Nr. 116), kernels per ear (calculated from grain yield, TKW and number of ears per m²). Statistical analysis, i.e. correlation analysis, were carried out for the whole set of 25 varieties and separately also for two subsets of different baking quality. Therefor the varieties were divided in the three quality groups according to OBERFORSTER et al. (1994), i.e. 10 varieties of high baking quality, 12 varieties of medium baking quality, and 3 feeding wheat varieties. Due to the limited number of feeding wheats this group was not considered in the correlation analysis within quality groups.

Results and discussion

For all countries similar results were observed. Early heading varieties - with a longer period of grain filling - realised a lower protein yield than later ones. A negative tendency between growth stages (date of heading, anthesis and maturity) and the protein content, sedimentation value

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and hectolitre weight could have been observed (*Table 1*). However, only the negative correlation between physiological grain maturity and protein content was significant ($p \leq 0.05$). Early maturing genotypes seemed to have a higher hectolitre weight, protein content and protein quality. This corresponded with the found correlation between leaf senescence and hectolitre weight and protein content. Within the Austrian baking quality groups only positive (r=0.61* to 0.70*) correlations between heading time and time of anthesis with the protein yield were found. The period of grainfilling was significantly negatively correlated with the protein yield (r= -0.59* to -0.73* within the Austrian baking quality group and the whole set of varieties, respectively; *Figure 1*). This means that varieties with a longer period of grainfilling reached a lower protein yield within the baking quality group.

Plant height was positively associated ($p \leq 0.05$ and $p \leq 0.01$) with sedimentation value, hectolitre weight and thousand kernel weight. Taller varieties showed higher protein quality, higher hectolitre weight and higher thousand kernel weight. The present findings are similar to those of KHAN et al. (2010), AKRAM et al. (2008), BELAY et al. (1993), EUNUS et al. (1986) and SANDHU and MANGAT (1985) who observed also a positive relationship between plant height and thousand kernel weight. A possible explanation is that tall cultivars obtain a loose grain arrangement on the ears. Therefore, grains reach a bigger size. Within the group of high baking quality wheat the correlation between plant high and hectolitre weight was positive (r=0.63*).

Kernels per ear were positively correlated ($p \leq 0.05$) with maturing date. Late maturing genotypes showed a higher number of kernels per ears. These results are in accordance

Table 1: **Intervarietal correlations between agronomic parameters, protein yield, protein quality and yield components (2010, 25 varieties)**

Parameter[1]	PRYLD	PROT	SEDI	HLW	TKW	KPE
HEAD	0.63**	-0.38	-0.11	-0.23	0.06	0.38
GRMAT	0.48*	-0.41*	-0.26	-0.36	-0.11	0.45*
GRFILL	-0.67**	0.29	-0.04	0.08	-0.19	-0.26
PH	0.38	0.17	0.49*	0.63**	0.57**	-0.13

[1] GRFILL, period of grain filling (days); GRMAT, physiological grain maturity (days from Jan 1); HEAD, heading date (days from Jan 1); HLW, hectolitre weight (kg); KPE, kernels per ear; PH, plant height (cm); PROT, protein content (%, d.m.); PRYLD, protein yield (t ha^{-1}); SEDI, sedimentation value (ml); TKW, thousand kernel weight (g, 86% d.m.)

with SUBHANI and CHOWDHRY (2000) but in contrast with KHAN et al. (2010). Due to the fact that these two traits are considered as variety characteristics, different genotypes used in the studies most probably led to the contradictory results.

In the core set a negative relationship between stomatal conductance and quality parameters was detected (*Table 2*). Within the quality wheat the negative correlation between stomatal conductance and hectolitre weight and sedimentation value was significant (r = -0.72* and -0.63*, respectively). Varieties with a high stomatal conductance showed lower test weights and lower protein quality. These findings are in contrast to the results of PINTO et al. (2008) who reported that genotypes with a high conductance can fill their grains more successfully. These contradictory results might occur through different measuring dates as well as through different environmental conditions (drought or irrigated conditions).

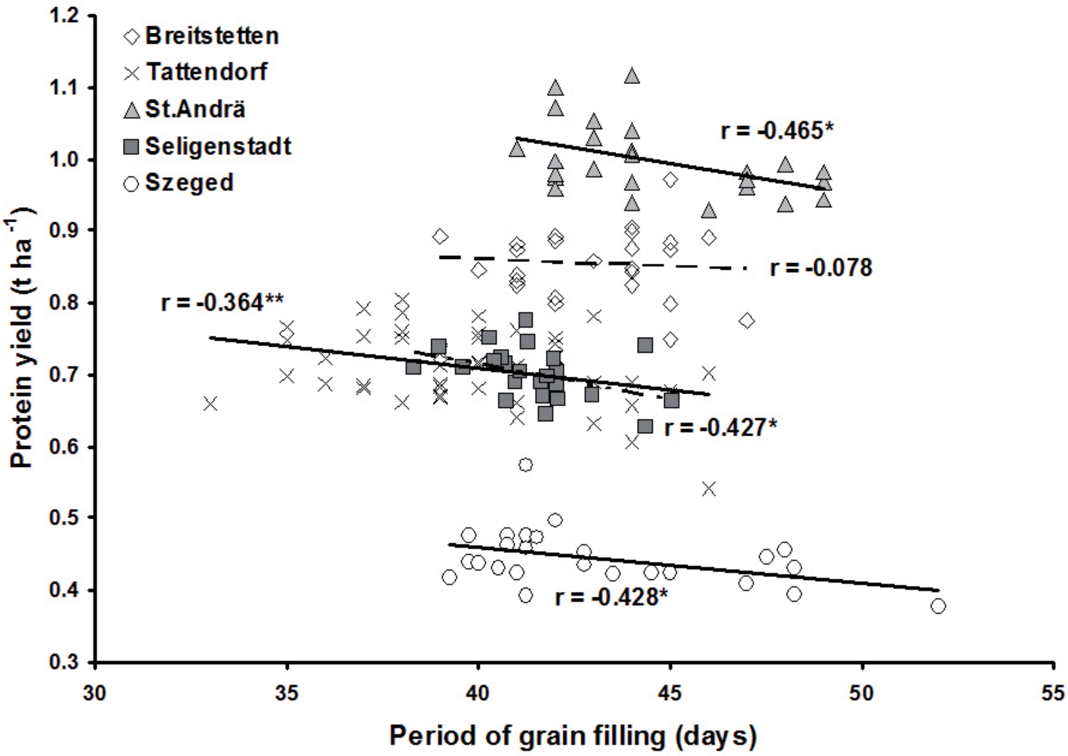

Figure 1: **Intervarietal correlations between period of grain filling and protein yield (2010, 25 varieties, in Tattendorf two water supply systems)**

Table 2: **Intervarietal correlations between physiological parameters, protein yield, protein quality and yield components (2010, 25 varieties)**

Parameter[1]	PRYLD	PROT	SEDI	HLW	TKW	KPE
Chlorophyll content (SPAD values)	-0.09	-0.54**	-0.43*	-0.49*	-0.32	0.37
Stomatal conductance (mmol m^{-2} s^{-1})	-0.13	-0.21	-0.21	-0.35	-0.04	0.00
Leaf senescence (%)	-0.39	0.64**	0.50*	0.59**	0.36	-0.62**

[1] abbreviations see *Table 1*

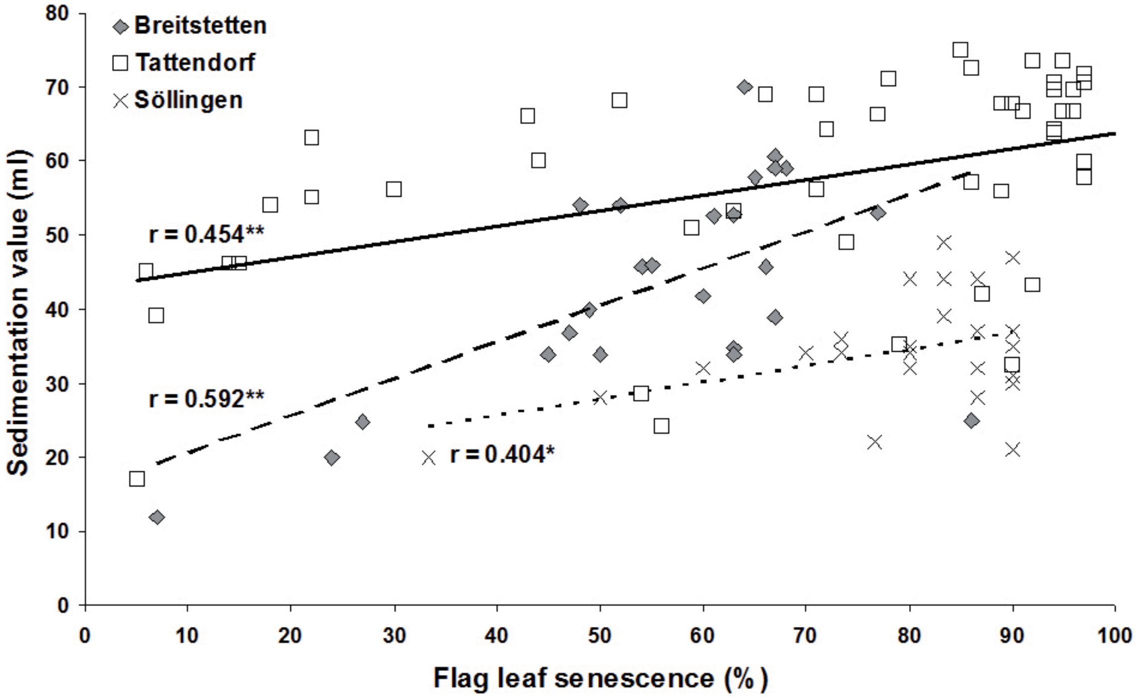

Figure 2: **Intervarietal correlations between flag leaf senescence and sedimentation value (2010, 25 varieties, in Tattendorf two water supply systems)**

Leaf senescence was in negative association (p ≤0.01) with kernels per ear. These results are substantiated with those of KANDIĆ et al. (2009). A low senescence rate maintains a higher transpiration efficiency resulting in prolonged assimilation. Leaf senescence was positively correlated (p ≤0.01) to quality parameters (*Figure 2*). These findings are in disagreement with GELANG et al. (2000), RICHARDS et al. (2002) and SPANO et al. (2003). According to these authors only an extended duration of grain filling (low senescence rate) will result in high quality and larger grains. The positive correlation within this study could be approved by the negative correlation between growth stages and quality parameters. Early maturing genotypes reached a higher quality and these varieties showed a higher leaf senescence rate.

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References

AKRAM Z, AJMAL S, MUNIR M, 2008: Estimation of correlation coefficient among some yield parameters of wheat under rainfed conditions. Pakistan J. Bot. 40, 4, 1777-1781.

BELAY G, TESEMMA T, MITIKU D, 1993: Variability and correlation studies in durum wheat in Alem-Tena, Ethiopia. Rachis 12, 38-41.

BFL, 2002: Methoden für Saatgut und Sorten: Richtlinien für die Sortenprüfung. Schriftenreihe 59/2002. Bundesamt und Forschungszentrum für Landwirtschaft, Wien.

EUNUS M, SARKER DC, KHAN ZA, SARKER AU, 1986: Interrelationships among some quantitative characters of wheat. Bangladesh J. Agric. Res. 11, 91-94.

GELANG J, PLEIJEL H, SILD E, DANIELSSON H, YOUNIS S, SELLDÉN G, 2000: Rate and duration of grain filling in relation to flag leaf senescence and grain yield in spring wheat (*Triticum aestivum*) exposed to different concentrations of ozone. Physiol. Plant. 110, 366-375.

KANDIĆ V, DODIG D, JOVIĆ M, NIKOLIĆ B, PRODANOVIĆ S, 2009: The importance of physiological traits in wheat breeding under irrigation and drought stress. Genetika 41, 11-20.

KHAN AJ, AZAM F, ALI A, 2010: Relationship of morphological traits and grain yield in recombinant inbred wheat lines grown under drought conditions. Pakistan J. Bot. 42, 259-267.

OBERFORSTER M. SCHMIDT L, WERTEKER M, 1994: Bewertungsschema `94 der technologischen Qualität von Weizensorten (Weichweizen). Jahrbuch 1993, 257-280. Bundesanstalt für Pflanzenbau, Wien.

PINTO S, CHAPMAN SC, MCINTYRE CL, SHORTER R, REYNOLDS M, 2008: QTL for canopy temperature response related to yield in both heat and drought environments. In: Appels R, Eastwood R, Lagudah E, Langridge P, Mackay M, McIntyre L, Sharp P (Ed.), Proc. 11th Int. Wheat Genet. Symp., 24-28 Aug, Brisbane, Australia. Sydney University Press, Sydney. [Available online: http://hdl.handle.net/2123/3351; accessed 4 Feb 2011].

RICHARDS RA, REBETZKE GJ, CONDON AG, VAN HERWAARDEN AF, 2002: Breeding opportunities for increasing the efficiency of water use and crop yield in temperate cereals. Crop Sci. 42, 111-121.

SANDHU BS, MANGAT NS, 1985: Interrelationships in some quantitative traits in wheat. Indian J. Agric. Res. 19, 98-102.

SPANO G, DI FONZO N, PERROTTA C, PLATANI C, RONGA G, LAWLOR DW, NAPIER JA, SHEWRY PR, 2003: Physiological characterization of ‘stay green’ mutants in durum wheat. J. Exp. Bot. 54, 1415-1420.

SUBHANI GM, CHOWDHRY MA, 2000: Correlation and path coefficient analysis in bread wheat under drought stress and normal conditions. Pakistan J. Biol. Sci. 3, 72-77.