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HIGHER POST-ANTHESIS NITROGEN UPTAKE IDENTIFIED IN A SYNTHETIC HEXAPLOID WHEAT DERIVATIVE

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ABSTRACT

Two winter wheat cultivars were field tested at the National Agricultural Research and Development Institute Fundulea - Romania, and total plant Nitrogen was determined at anthesis and maturity. The winter wheat line Profund, bred at NARDI Fundulea and previously described as having high and stable positive grain protein deviation from the regression on grain yield, showed higher post-anthesis N uptake than cultivar Pitar, itself described as having a relatively high grain protein concentration. We suggest that the higher N post-anthesis uptake might have been inherited from the synthetic wheat derivative present in its genealogy.

Keywords: Nitrogen uptake, grain protein concentration (GPC), grain protein deviations (GPD), yield (GY), *Aegilops tauschii*, climate change.

INTRODUCTION

Global wheat production, which provides about 20% of the calories and is an important protein source for a large portion of the world's population, needs to increase in the upcoming decades to cover the rising demand for this grain (Hernández-Espinosa et al., 2018). Protein concentration is one of the main requirements for baking quality in wheat, so it is of economic importance to food manufacturers, and is also of economic importance for farmers since a premium is often paid for this attribute (Aguirrezábal et al., 2014).

The negative relationship between grain yield (GY) and grain protein concentration (GPC) (Simmonds, 1995; Triboi et al., 2006; Oury et al., 2007; Bogard et al., 2008; Marinciu and Săulescu, 2008, 2009) is a major obstacle to the simultaneous improvement of these two traits both in breeding programmes and on farms. The present trend to reduce fertilization due to the large economic and ecologic cost of excessive mineral fertilizer usage (Rothstein, 2007) causes an additional difficulty in obtaining high yields with the grain protein concentration required in bread making.

On the other hand, research has shown that elevated CO_2 concentrations in the atmosphere leads to a significant decline in grain protein concentration, reducing the wheat grain quality with potentially far-reaching impacts on the nutritional value and use for processing industry (Hőgy et al., 2009, Thompson et al., 2019). This means that in the context of climate changes, breeding for higher wheat grain protein concentration will become even more important.

A promising approach in solving the problem of the negative correlation between grain protein concentration and grain yield is the use of Grain Protein Deviations (GPD) (residuals from regression of grain protein concentration on grain yield) as selection criteria in wheat breeding programs to screen for increased grain protein concentration without a concurrent grain yield reduction (Monaghan et al., 2001). Several recent studies suggested that genotypes with positive GPD have an increased ability to uptake nitrogen (N) during the post-flowering period independently of the amount of N taken up before flowering, suggesting that genetic variability for N satiety could enable the breakage of the negative relationship

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(Bogard et al., 2010; Taulemesse et al., 2016).

The winter wheat line Profund, bred at NARDI Fundulea, showed high and relatively stable positive grain protein concentration in 25 yield trials performed in two consecutive years, in very different conditions. The grain protein concentration of this line was on average +1.24% and was positive in all trials. This unusual performance might be due to the presence of genes introgressed from *Aegilops tauschii*, possibly complemented with favourable genes present in the Romanian cultivar Pitar (Marinciu et al., 2018). The results presented in this paper are an attempt to find out if the high positive GPD of Profund is associated with higher N uptake after anthesis.

MATERIAL AND METHODS

The line Profund and the cultivar Pitar were tested in the field at the National Research and Development Institute Fundulea - Romania (44°30' N, 24°10' E) during 2016-2017 and 2017-2018, on chernozem soil (pH: 6.3-6.8; humus: 3%), using recommended crop management (preceding crop peas, 137 kg N ha^{-1}).

The line Profund was selected from the hybrid combination Murga/03124G//Pitar. Murga was selected as parent in crosses mainly based on its "stay green" trait and foliar disease resistance. According to Genetic Resources Information System for Wheat and Triticale (GRIS), the pedigree of the CIMMYT line Murga (sin. CMSS-93-B00686-S) is MUNIA/ALTAR-84//AMSEL. However, CIMMYT breeders suspect this pedigree might be wrong because Murga has many traits similar with *Aegilops tauschii* derivatives and therefore this line is probably a synthetic wheat derivative (Ravi Singh, personal communication).

Pitar is a recently released cultivar, selected from the cross Litera/F00099GP2 and described as high quality and relatively high protein wheat (Marinciu et al., 2015).

Plant samples were harvested from 3 replicates of 30 linear centimetres at anthesis and maturity. Samples were divided into leaves, stems and spikes at anthesis and leaves, stems, grains and chaff at maturity, were oven dried, weighed and analysed for N content using Kjeldahl method, and results were used to calculate total plant Nitrogen at anthesis and maturity. The difference between total N at maturity and at anthesis was considered an estimate of N uptake after anthesis.

Weather conditions in 2017 and 2018 were generally favourable for wheat, with average yields of 7-8 t ha^{-1} in 2017 and 5-6 t ha^{-1} in 2018 in yield trials at Fundulea. Timely rains of more than 100 mm during autumn allowed good stand establishment, while temperatures and rainfall favoured vegetative growth. Higher than average temperatures during grain filling affected yields, which were however higher than average. Very high rainfall during June 2018 (>120 mm i.e. about 40 mm more than average) may have caused N leaching, reducing the potential N uptake after anthesis.

RESULTS AND DISCUSSION

ANOVA shows that cultivars did not have a significant effect on N content at anthesis, but significantly influenced the N content at maturity and the post-anthesis N uptake (Table 1). Years had significant effects on all analysed parameters, and the interaction between cultivars and years were only significant at maturity.

These results suggest that the difference between the analysed cultivars were not significantly manifested at anthesis, but became evident at maturity, as a result of different post-anthesis N uptake. Weather conditions significantly influenced N accumulation, but this had a relatively small influence on differential cultivar performance.

Table 1. ANOVA for total N content at anthesis and maturity, as well as for the estimated post-anthesis N uptake

		At anthesis	At maturity	Post-anthesis N uptake
Source of Variation	df	F	F	F
Cultivar	1	$3.79^{n.s.}$	18.62***	12.39**
Year	1	11.10*	61.71***	7.88*
Interaction	1	$1.23^{n.s.}$	7.99*	$4.92^{n.s.}$
Within	8			
Total	11			

The total plant N was a little, but not significantly, larger in Pitar than in Profund at anthesis, but was larger in Profund at maturity in 2017 and on average. This could be explained as a result of higher post-anthesis N uptake (Table 2).

Table 2. Total plant N content (g m^{-2}) at anthesis and maturity

		2017	2018	Average
Profund	Anthesis	23.7	20.1	21.9
	Maturity	44.5	24.8	34.7
	Post-anthesis uptake	20.7	4.8	12.8
Pitar	Anthesis	28.8	21.4	25.1
	Maturity	31.3	22.1	26.7
	Post-anthesis uptake	2.5	0.7	1.6

We suggest that the outstanding performance of Profund regarding grain protein deviations (Marinciu et al., 2018) could be explained by the fact that Profund accumulates more Nitrogen after anthesis than other cultivars. This might be due to genes inherited from *Aegilops tauschii* via the supposed synthetic wheat derivative Murga. The contribution of genes transferred from *Aegilops* to improved grain protein concentration could be another example of using interspecific hybridization and synthetic hexaploid wheat as sources of variation for wheat grain quality improvement (Lage et al., 2006; Alvarez and Guzmán, 2017).

CONCLUSIONS

The winter wheat line Profund, bred at NARDI Fundulea, and previously described as having high and relatively stable positive grain protein deviation from the regression on grain yield, showed higher post-anthesis N uptake. We suggest that this trait might be inherited from the synthetic wheat derivative present in its genealogy.

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