Impact of crop year and nitrogen topdressing on the quantity and quality of wheat yield

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Abstract Impacts of N topdressing applications were studied in a field experiment to determine water availability grain yield and protein formation interrelations. Five winter wheat varieties and six nitrogen application levels were applied in two crop years representing different precipitation and temperature patterns to evaluate yield, yield components and quality manifestation. The results obtained suggest, that precipitation patterns in relation with the wheat development phenophases had profound influence on the grain yield and the protein formation of wheat crop. Varietal differences were determined regarding yield, protein values in relation with plant nutrition and crop year impacts. There were no, or minor differences only between varieties, however plant nutrition treatments induced significant differences in both crop years.

Keywords: N topdressing, wheat, grain yield, protein yield, crop year

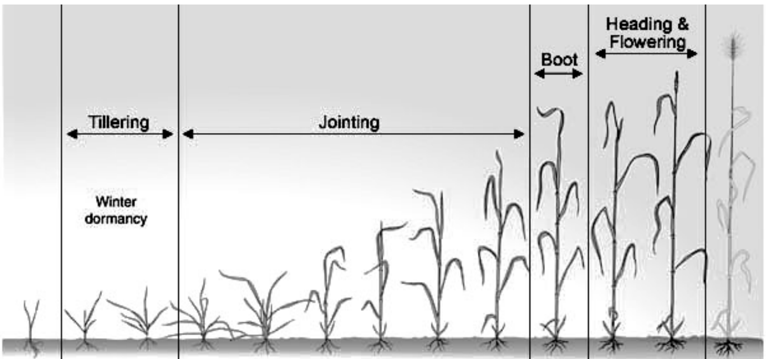
Introduction

Grain yield and yield quality of winter wheat *Triticum aestivum* L. is highly influenced by the meteorological conditions of the given crop year, especially the amount and distribution of precipitation and the actual temperature (Grimwade et al 1996, Győri 2008, Pepó 2010). Weather conditions are evaluated and labelled favourable or non-favourable in relation with the optimum requirements of the crops' phenophases (Lásztity 1999; Ványiné and Nagy 2012). Concerning precipitation, the most vulnerable periods during growth and development of winter wheat are the phenophases of heading and flowering (Feekes 10-10,5; Zadoks 51-70). In relation with temperature, two critical periods can be detected. One is the vernalisation, and the other is the ripening stage (Feekes 1-2 and 11; Zadoks 10-13 and 71-99), (Pollhamer 1981, Kismányoky and Ragasits 2003). Crop yield and grain quality can also be influenced by agronomic applications. Plant nutrition in general and N topdressing in particular should be considered as the most effective treatments within the technologies of winter wheat production. The amount of nitrogen and the timing and distribution of the application have an impact on wheat quality, especially on the protein production of the crop (Győri 2006, Pepó 2010, Vida et al 1996).

Materials and methods

A wide range of high milling and baking quality winter wheat *Triticum aestivum* L. varieties were examined under identical agronomic conditions in a long term field trial. The small plot trials were run at the Nagygombos experimental field of the Szent István University, Crop Production Institute, Hungary. Soil type of the experimental field is chernozem (calciustoll).Annual precipitation of the experimental site belongs to the 550-600 mm belt of the Northern edges of the Hungarian Great Plain. Experiments were conducted in a split-plot design with four replications. The size of each plot was 10 m^2. Plots were sown and harvested by plot machines (standard Wintersteiger cereal specific experimental plot machinery series). Various identical agronomic treatments were applied to plots. Plant nutrition applications were done in single and combined treatments. N topdressing variants were applied by single and repeated topdressings representing 6 levels:

0, 80, 80+40, 120, 120+40 and 160 kg/ha N in single and split applications. All plots were sown with identical series of wheat varieties for studying their performance in relation with agronomic impacts. The recent study presents the performance and evaluations of six winter wheat varieties (Alföld-90, Mv Magdaléna, Mv Suba, Mv Toborzó and Mv Toldi) of the 2013 and 2014 crop years. Wheat grain quality parameters: protein, and wet gluten contents were determined from grain samples, as well as quality characteristics at the Research Laboratory of the SIU Crop Production Institute, and RET Regional Knowledge Centre laboratories according to Hungarian and EU standards (MSZ 1998; EK 2000). The protein figures were correlated with the treatments applied, and analyses were done by Microsoft Office 2003 statistical programmes (Horváth 2014). Figure 1 demonstrates the phenophases of winter wheat by the grading of two internationally used systems. Phenological phases have been evaluated in accordance with the monthly precipitation and temperature figures of the respective crop years by the methods of Pollhamer (1981) and Kismányoky and Ragasits (2003).



Feekes	1	2	3	4	5	6	7	8	9	10	10.1	10.5	11
Zadoks	10	21	26	30	30	31	32	37	39	45	50	60	90

Figure 1. Growth stages of winter wheat - Feekes and Zadoks values. (Source Kismányoky and Ragasits 2003).

Crop year conditions were evaluated in accordance with the monthly values of temperature and precipitation in favourable (2013) and non-favourable (2014) crop years during the vegetation period. The monthly periods are considered in accordance with the magnitude of deviation in relation with the long term mean temperature and precipitation values. A plus or minus 20 % of precipitation and 1 °C of temperature were applied as threshold values.

Results and discussion

Yield results of the trial are summarized in Figure 2 and 3. The total amount of grain yield (kg/ha) is indicated for the two respective crops years for all the wheat varieties examined.

The results obtained suggest, that the two crop years examined had different levels of grain yield regardless to varieties. In 2013 grain yield amounts ranged from 2,9 to 7,5 t/ha with definite differences between N applications, while in 2014 this turned to be 4,8 to 7,3 showing less variations between plant nutrition treatments. In both crop years minor varietal differences were detected only.

Quality information is provided by in Figure 4 and 5. The total amount of protein yield

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(kg/ha) is indicated for the two respective crops years by all the wheat varieties examined. The results obtained highlight three factors. The first of them is the difference between the

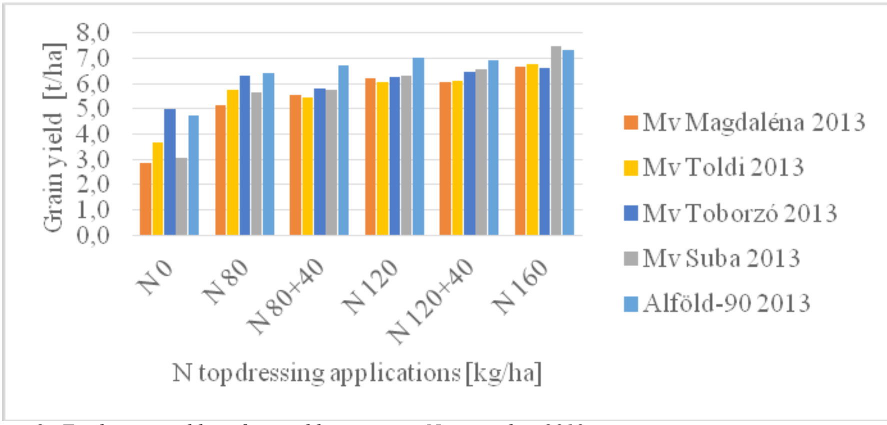

Figure 2. Total grain yields in favourable crop year. Nagygombos 2013

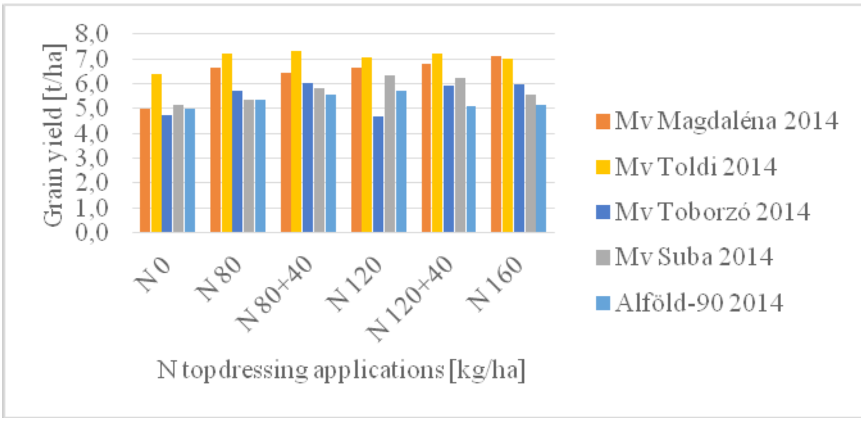

Figure 3. Total grain yields in non-favourable crop year. Nagygombos 2014

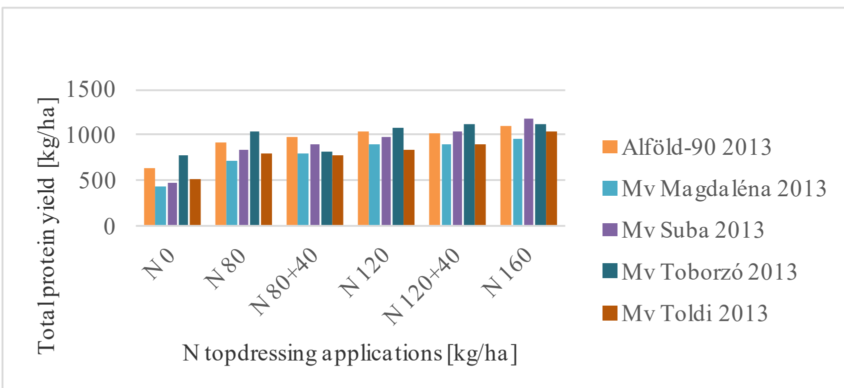

Figure 4. Total protein yields in the favourable crop year. Nagygombos 2013

amounts of protein yield. In 2013 the range of total amount of protein was between 412 and 1187 kg/ha. In 2014, a non favourable crop year resulted in 513 and 988 kg/ha protein yield values. The second is the consequent differences between the impacts of N application levels. These differences were significantly bigger in the favourable crop year in comparison with those of the non-favourable vintage. The reason of such deviation was due to the amount of precipitation during the phenophases of flowering and grain filling of the respective crop years.

The third factor detected was the performance of varieties. From among the five varieties examined three cultivars – Mv Suba, Mv Toborzó and Mv Toldi proved to be the most efficient regarding the amount of total protein yield production. The highest protein yields were obtained by Mv Toborzó in 2013, while in 2014 the Mv Toldi cultivar produced

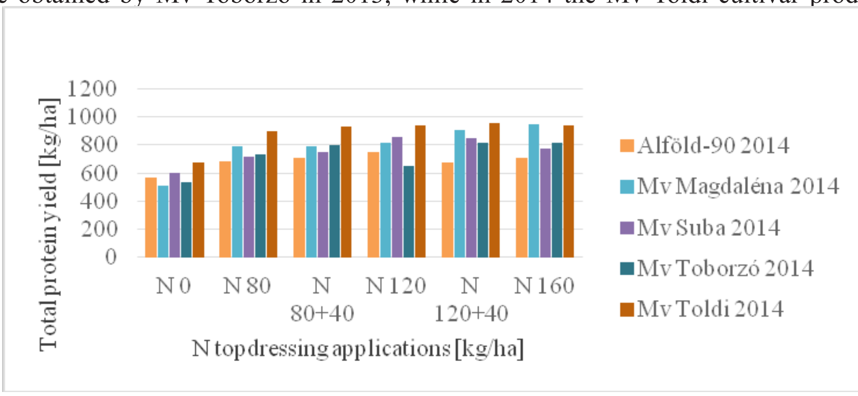

Figure 5. Total protein yields in the non-favourable crop year. Nagygombos 2014

superior figures. Tables 1 and 2 present correlation figures of experimental variants for both crop years. For better understanding, the tables show data on further interrelations not discussed in this paper, but which may provide information on the protein formation performance. These are the following apart from protein values: grain yield, hectolitre weight, thousand grain weight, gluten and Zeleny figures. The results obtained suggest that the strongest correlation was detected between the total amount of protein and the experimental treatments, regardless to the impact of crop years' weather in accordance with the findings of Győri (2008) and Pepó (2010).

Table 1. Correlation between plant nutrition (control vs treatments), yield and protein yield by respective varieties. Nagygombos 2013

Wheat varieties	Yield [t/ha]	Hecto-litre weight [kg/hl]	Thousand grain weight [g]	NIR analysis data			
				Protein content [%]	Total amount of protein [kg/ha]	Gluten [%]	Zeleny number [ml]
r (Alföld-90)	0.9837	0.9979	0.5640	0.9962	0.9909	0.9931	0.9806
r (Mv Magdaléna)	0.9883	0.9750	0.9563	0.4003	0.9901	0.2015	0.8071
r (Mv Suba)	0.9936	0.9144	0.9432	0.1305	0.9990	0.1414	0.8023
r (Mv Toborzó)	0.9452	0.7715	0.4595	0.9509	0.9661	0.9220	0.9124
r (Mv Toldi)	0.9802	0.9556	0.7422	0.6782	0.9863	0.6306	0.7531

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Yield figures of the cultivars were in close correlation with plant nutrition with a few exceptions only. However this correlation proved to be stronger and at the same time more balanced in the favourable crop year.

Table 2.. Correlation between plant nutrition (control vs treatments), yield and protein yield by respective varieties. Nagygombos 2014

Wheat varieties	Yield [t/ha]	Hectolitre weight [kg/hl]	Thousand grain weight [g]	NIR analysis data			
				Protein content [%]	Total amount of protein [kg/ha]	Gluten [%]	Zeleny number [ml]
r (Alföld-90)	0.4578	0.7055	0.3952	0.9877	0.8826	0.9924	0.9974
r (Mv Magdaléna)	0.9463	0.9174	0.0151	0.9954	0.9828	0.9917	0.9753
r (Mv Suba)	0.5977	0.8952	0.7827	0.9463	0.8592	0.9405	0.9513
r (Mv Toborzó)	0.5716	0.6887	0.8961	0.9536	0.8645	0.9453	0.9662
r (Mv Toldi)	0.7506	0.7831	0.8343	0.9729	0.9308	0.9757	0.9838

The correlations of crop yield components were much weaker in both crop years in comparison with those of yield and protein values. The most vulnerable phenological periods of winter wheat were the stages of heading and flowering in relation with precipitation and vernalisation and ripening concerning temperature performance in accordance with the results of Pollhamer (1981) and that of Kismányoky and Ragasits (2003).

Conclusions

Precipitation and temperature data were studied in a long term field experiment to determine water availability and plant nutrition impacts on yield quantity and quality. The aim of the study was to evaluate favourable and non-favourable crop year conditions for winter wheat *Triticum aestivum* L. Five winter wheat varieties and six nitrogen topdressing application levels were applied in two consecutive crop years representing different precipitation and temperature patterns to evaluate yield, yield components and quality manifestation. The results of the experiment suggest that precipitation patterns in relation with the wheat development phenophases had profound influence on the yield and the protein formation of the crop. From among phenophases flowering and grain filling periods proved to be the most influential stages. The two crop years resulted in different amounts of protein yield. The favourable one significantly increased the total amount of protein in comparison with that of the non-favourable vintage. There were detectable differences in the protein yield of the wheat varieties studied. However the efficiency of the respective varieties also differed in the two crop years. Strong correlation was detected between the total amount of protein and the experimental treatments in both years. Yield figures of the wheat varieties were in close correlation with plant nutrition in general. Correlations of crop yield components were lower in both crop years in comparison with those of yield and protein values.

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