The effect of late application of foliar nutrition and supporting materials on the yield and the quality of barley grain

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Abstract: Within the small plot field trials, the effect was tested in 2014 of late application of K-gel, Yara Vita Kombiphos and Sunagreen on the yield and the quality of Bojos, the spring barley variety. Barley was grown at two levels of N-nutrition N1 = 84 and N2 = 104 kg N per hectare. The highest grain yield (9.268 t per hectare) was obtained after application of K-gel, the largest grain and one of the high mass density was harvested after fertilisation with Yara Vita Kombiphos at N1 nutrition and the highest starch content was supported at both of the N-nutrition levels by the application of Sunagreen (66.14%/65.93%). The higher dose of N generally decreased the yield and even worsened the grain quality.

Key-Words: barley, yield, foliar nutrition, Bojos, grain quality

Introduction

Malting barley is a crop that has high economic risk for farmers because of its high sensitivity to external growth factors. These are responsible for two of the physiological properties - the growth rate and the capability of nitrogen management [1]. In cereals, nitrogen is a key element for achieving consistently high yields and is involved in all the metabolic processes of plants. Since the nitrogen uptake rate and distribution in plants is largely determined by the needs and requirements of different stages of plant growth [2], nitrogen-based fertilisers are applied in a way to be able to meet the plant nitrogen requirements throughout the growing season, thereby maintaining the high yield while not worsening malting quality of the grain [3]. Uneven application of nitrogen causes stand irregularity during harvesting, increasing the share of green grain and pass-through rate [4]. Consequently, lack of nitrogen from the beginning of vegetation has the effect of reduced formation of structural and functional proteins, which negatively reflects in the growth and formation of all principal plant organs (roots, stalks and leaves) [5]. Achieving adequate grain yield in the desired malting quality often presents considerable challenges. A yield is dependent on the production potential and the capability of accumulation of assimilates in interaction with soil and climatic conditions [6]. Phosphorus and potassium play an important part in the energy metabolism of plants. They are important particularly for the young plants that need adequate amounts of the elements for offshoots and spikelets to develop [7], as well as in the second half of vegetation where they are involved in the grain-forming process. To achieve high yield and quality of spring barley, growth stimulants are used as auxiliary agents. They can reduce the negative effect of stressful periods during the growing season [8]. Of these, Sunagreen seems to be the most appropriate product [9]. It has gained popularity in recent years, particularly for its capability of stand balancing in a highly efficient manner and strengthening weaker fertile offshoots of barley, accompanied with effective but sensitive selection of weed offshoots. Applications of auxin stimulators are equal competitors, particularly in spring barley, with greater sensitivity to the crop, chiefly at higher temperatures at the time of application. During tillering, Sunagreen has a positive effect on the crude protein content of the grain [10]. The study aimed at identifying the effects of application of nitrogen, phosphorus and potassium foliar nutrition, and application of Sunagreen on the yield and quality of barley grains.

Materials and methods

The experiment was set up on the land owned by AGROSPOL Velká Bystřice Ltd. The Bojos variety of spring barley was sown on 12 March 2014 on plot size of 20.6 m^2, the seed rate being 3.7 millions of germinating seeds. Nitrogen was applied as part of pre-sowing treatment, the dosage being 54 kg of N per ha (CAN, 27-27% of N). On 5 May 2014, when the stand was at the early stage of stem elongation (BBCH 30), there was the second application of N fertilisers. Amounts of N applied per hectare as urea involved 30 kg as part of N1 and 50 kg as part of N2.

On 21 June 2014, at the stage of late flowering, there was the application of products as indicated in Table 1, with each variant repeated four times. The products comprised K-gel, a foliar fertiliser to support the processes of photosynthesis, particularly in the late vegetation stages, with a prolonged effect due to the gelling component; Yara Vita Kombiphos, a foliar fertiliser formulated for complementary phosphorus, potassium and magnesium nutrition; and Sunagreen, an agent stimulating the growth and development of plants and used to optimise the productive offshoots of cereals. The aim was to verify whether or not the products listed above influence the development, yield and the quality of grain.

Table 1 Products applied as part of fertilising operations N1 and N2: application rates

N batch	Variant	Application rate
N1	Control	0
N1	K-gel	3 l per ha
N1	Yara Vita Kombiphos	3 l per ha
N1	Sunagreen	0.5 l per ha
N2	Control	0
N2	K-gel	3 l per ha
N2	Yara Vita Kombiphos	3 l per ha
N2	Sunagreen	0.5 l per ha

Note: Water supplied for spraying: 300 litres per hectare

Harvest as part of the trial was underway on 3 August 2014 using Wintersteiger - a small-scale plot harvester with an automatic scaling and sampling device. Grain yield was determined for each variant; in addition, grain sample analysis was carried out and involved identifying mass density (grain meter), the starch content (by Ewers), nitrogen substances (by Kjeldahl) and grain size fractions (Steinecker sifter).

The measured results were analysed statistically using STATISTICA 10 based on 2-factor analysis of variance.

Results and discussion

The effect of nitrogen batch considerably reflected in the barley grain yield (Table 2). The lower, all N1 variants average nitrogen dosage contributed to the increased grain yield (8.941 tonnes per hectare). Here, the yield was on average 0.591 tonnes per hectare higher than with the N2 variants, the relatively high level of lodging seen with the variants fertilised more intensely with nitrogen playing also its part. Should the N2 variant vegetation have been successfully retained in a non-lodged condition, the differences could well have been reverse. The higher grain yield seen in the N1 variants did not contribute to the reduced content of N-substances, which was on average higher in this case (12.33%) than with the N2 variants. The grain nitrogen level was not satisfactory in all the trial variants since currently, 10.8% is considered to be the optimal content of N-substances, while to ensure the production of quality malts, the limit of 12% should not be exceeded for barley. If the level is higher, the technological processes need to be modified by increasing the water content in steeping or germination time is extended [11]. The lower nitrogen supply and smaller level of lodging were favourable manifest in the grain formation and the final size. The N1 variants average grain above the 2.8 mm screen was c. 15% higher than with N2 application variants. Contrary to this, the percentage of grain above the 2.5 mm screen was higher with N2 variants, with however the level being only 9.63%, which was reflected in a higher pass-through rate, i.e. the quantity of grain useless for malting increased. Some authors [12] report that large grains generally provide higher starch content and lower protein content. For both of the N fertilisation levels, the starch content was balanced, with that of N1 being about 1% higher. Likewise, nitrogen dosage had not a significant influence on the difference in mass density. Nonetheless, it can be concluded that the lower nitrogen dosage not only promoted the increased yield, but also enhanced the grain technological quality.

Table 2 Nitrogen dosage effect on the technological parameters

Parameter	N1	N2
Yield (tonnes per ha)	8.94	8.35
N-substances (%)	12.33	12.10
2.8 mm	73.25	57.95
2.5 mm	2.,47	31.10
Pass-through rate %	5.11	10.91
Starch (%)	65.98	64.82
Mass density (kg per hl)	68.74	67.52

The yield and grain quality was influenced by not only nitrogen supply, but also the application of the tested products. The starch content is an important parameter, which is closely related to grain extract. The more starch in the grain, the better the beer production economy. The highest starch level was recorded after applying Sunagreen, within both of the N fertilisation level, confirming that the product has a positive effect on the deposition of storage substances in the grain (Fig. 1). Conversely, K-gel contributed to increased yield, particularly for the fertilisation intensity of N1 (9.268 tonnes per ha). This is in line with the findings of [13] who report increased yield of barley as a result of K-gel application as well (Fig. 2).

Fig. 1 The influence of N supply and fertilisation variant on starch content

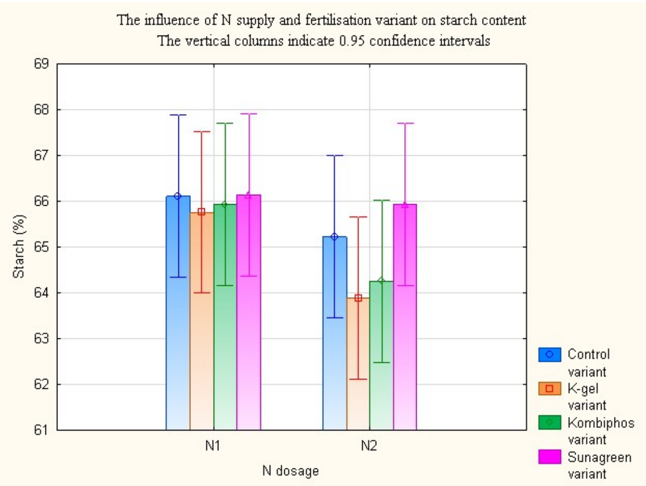
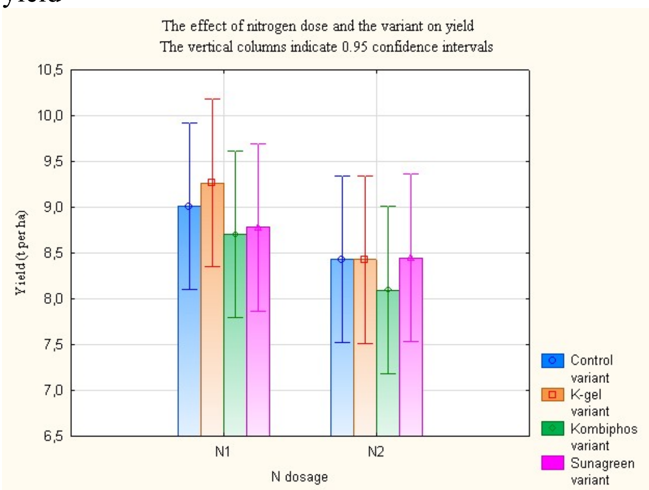
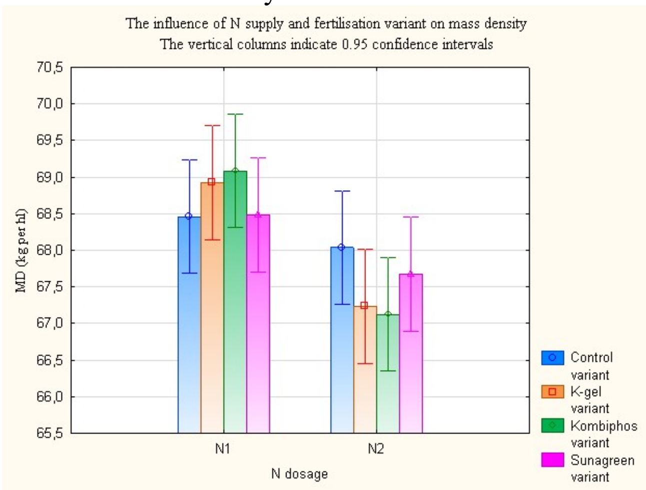


Fig. 2 The effect of nitrogen dose and the variant on yield



As is evident from Fig. 3, the lower nitrogen supply has a favourable effect on the grain mass density, with the best results recorded following the application of Yara Vita Kombiphos (69.09 kg per hl) and K-gel (68.93 kg per hl). The higher nitrogen fertilisation intensity along with lodging did not enable the products to show a positive effect. As a result, the highest levels were observed with the control variant. Mass density, as reported by [11], is directly linked to the malt extractability. From this aspect, the results found for nitrogen fertilisation intensity of N1 can be considered valuable.

Fig. 3 The influence of N supply and fertilisation variant on mass density



In terms of production and malting process, the percentage of grain that can be processed by malting industry out of the total yield, i.e. Σ 2.8 mm + 2.5 mm, is an important factor. The percentage of grain above the 2.8 mm/2.5 mm screen characterises the regularity and fullness of grain in the barley part since only size-uniform and regular grain of the given variety accepts water evenly in steeping, germinates uniformly and achieves the desired degree of cracking [11]. The lower nitrogen supply did increase the percentage of grain above the 2.8 mm screen after the application of each of the products, with however greatest increase being observed in Yara Vita Kombiphos (74.84%) and K-gel (74.21%). As with the evaluation of mass density, no effects were seen with the application of products at higher nitrogen fertilisation intensity (Fig. 4 and 5).

Fig. 4 The effect of N supply and variants on grain above the 2.8 mm screen

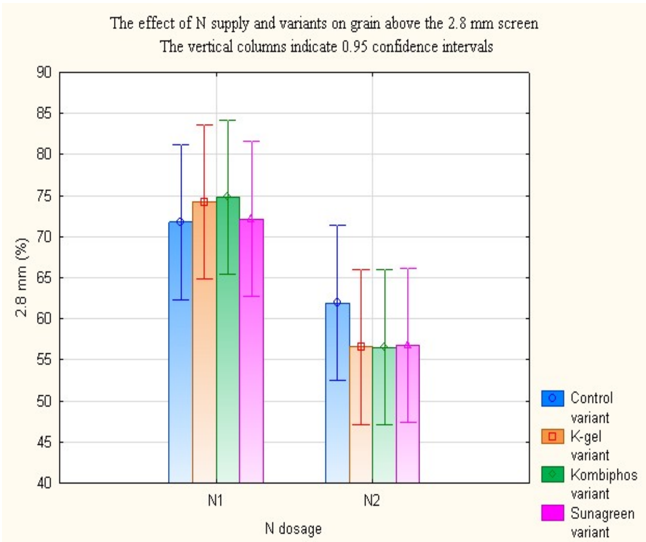
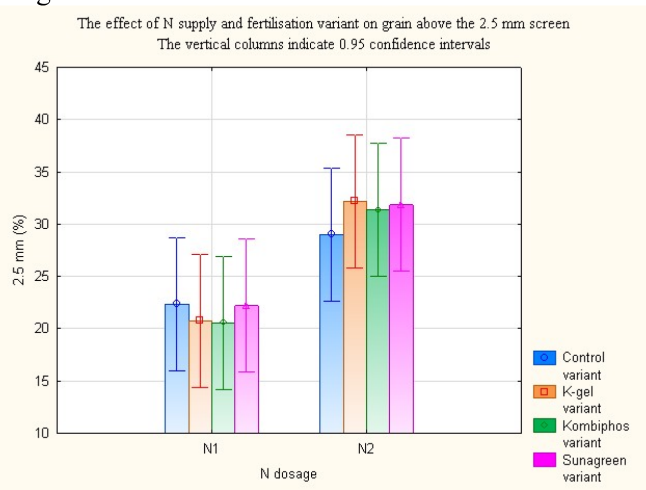
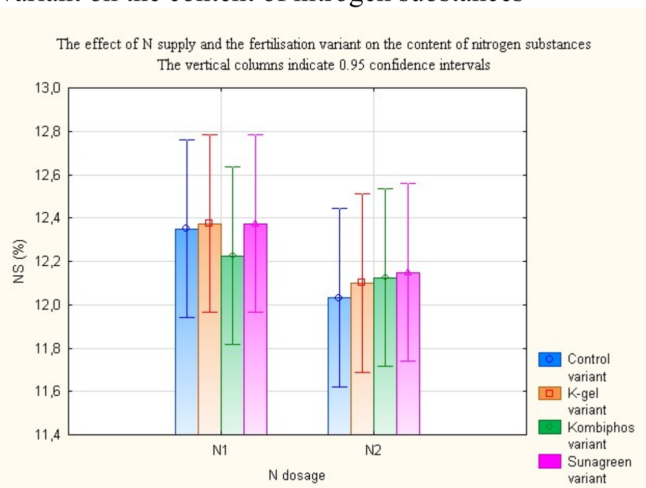


Fig. 5 The effect of N supply and fertilisation variant on grain above the 2.5 mm screen



As already mentioned, the lower nitrogen supply contributed to the higher level of N-substances in barley grain as a result of non-lodging vegetation. Here, the application of Yara Vita Kombiphos had the greatest effect – one that contributed to a decreased level of N-substances unlike with other variants (Fig. 6).

Fig. 6 The effect of N supply and the fertilisation variant on the content of nitrogen substances



Conclusion

As it results from the outcome of the single-year small-plot field trial, the nitrogen dosage plays a very important part in barley grain yield and quality, with the condition in which the vegetation is maintained until harvest being a critical factor. If lodging occurs, then there is a considerable decrease in the grain yield and quality. One should also take into account the fact that application of products beyond the framework of routine nutrition interventions will not pay off. If, however, a good condition of the crop is ensured until harvested, then the application can reflect to a considerable extent, which was reconfirmed in this study. The largest yield was seen after application of K-gel. In the event of Yara Vita Kombiphos, grain of the largest size and with the best mass density was harvested at the level of N1 nutrition. For Sunagreen, it increased the starch content at both of the N nutrition levels. A conclusion is thus possible that lower nitrogen doses stimulate the effects of products in the event of application of K-gel, Yara Vita Kombiphos and Sunagreen, thus providing better technological parameters, while higher doses of nitrogen inhibit the effect of these compounds.

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References

[1] Potarzycki J, Grzebisz, W, Effect of phosphoric fertilizers as a source of sulphur on malt barley total and technological grain yields. *Plant, Soil and Environment - UZPI (Czech Republic)*, 53(9), 2007, 395-402.

[2] Delogu G, Cattivelli L, Pecchioni N, De Falcis D, Maggiore T, Stanca AM, Uptake and agronomic efficiency of nitrogen in winter barley and winter wheat. *European Journal of Agronomy* 9(1), 1998, 11-20.

[3] Baethgen WE, Christianson CB, Lamothe AG, Nitrogen fertilizer effects on growth, grain yield, and yield components of malting barely. *Field Crops Research* 43(2-3), 1995, 87-99.

[4] Polák B, Váňová M, Onderka M, Základy pěstování sladovnického ječmene. Vyd. 1. Praha: Institut výchovy a vzdělávání Ministerstva zemědělství ČR, 1993, 27 s. ISBN 80-7105-042-3.

[5] Zimolka J, Ječmen - formy a užitkové směry v České republice. 1. vyd. Praha: Profi Press, 2006, 200 s. ISBN 80-86726-18-5.

[6] Hřivna L, The effect of a fungicide application on the yield and quality of barley grain and malt. *PLANT SOIL AND ENVIRONMENT* 49(10), 2003, 451-456.

[7] Römer W, Schenk H, Influence of genotype on phosphate uptake and utilization efficiencies in spring barley. *European Journal of Agronomy* 8(3-4), 1997, 215 - 224.

[8] Černý L, *Jarní sladovnický ječmen: pěstitelský rádce*. Vyd. 1. Praha, 2007, 39 s. ISBN 978-80-87111-04-8.

[9] Křováček J, Kvapil R, Černý L, Hájek M, Zvyšování výnosů jarního ječmene stimulátory. *Sladovnický ječmen-přiměřená ekonomika, vysoký výnos a kvalita zrna – KOMPENDIUM 2010 (sborník z konference)*: 53-56.
[10] Šamalík J, Sunagreen jako součást systému morforegulace jarního ječmene. *Sladovnický ječmen-přiměřená ekonomika, vysoký výnos a kvalita zrna – KOMPENDIUM 2010 (sborník z konference)*: 57-58.
[11] Kosař K, Procházka S, Technologie výroby sladu a piva. 1. vyd. Praha: Výzkumný ústav pivovarský a sladařský, 2000, 398 s. ISBN 80-902658-6-3.
[12] Fox GP, Kelly A, Poulsen D, Inkerman A, Henry R, Selecting for increased barley grain size. *Journal of Cereal Science* 43(2), 2006, 198-208.
[13] Hřivna L, Kotková B, Dostálová Y, Burešová I, Srovnání využití tuhých a kapalných N-hnojiv a jejich vliv na výnos a kvalitu sladovnického ječmene. *Technologie slad. ječmene – ječmen na rozcestí – KOMPENDIUM 2014 (sborník z konference)*: 31-33.