THE INFLUENCE OF NON-ROOT NUTRITION AND GROWING SEASON ON THE YIELD FORMATION PROCESS AND YIELD AMOUNT IN SPRING BARLEY

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Abstract

*Field polyfactorial trials were carried out in warm corn production area of Slovakia in 2002-2004 with three spring barley varieties (Annabell, Kompakt and Nitran) after sugar beet by the method of split blocks keeping randomness, in three repetitions. The size of experimental plots was 14 square meters. Four fertilization levels were evaluated: „**a**“ - control variant, „**b**“ - 50 kg N.ha^{-1} „**c**“ - 50 kg N.ha^{-1} + non-root nutrition, „**d**“- 80 kg N.ha^{-1} + non-root nutrition. The combination of non-root nutrition and increased level of N („**d**“) caused (in comparison to „**b**“ fertilization level) statistically significant increase of yield amount (for 0.37 tonnes/hectare) in all varieties, with economical efficiency value of 1.41 and 1.81. Confidence intervals have confirmed statistically significant differences caused by growing season in the number of plants, number of spikes, grain weight and the number of productive shoots. The difference in yield amount due to growing season ranged from 3.16 to 4.00 tonnes/hectare.*

Key words: spring barley, non-root nutrition, accumulation potential, grain yield

INTRODUCTION

The actual decrease of growing area in two important groups of field crops – sugar beet and legumes in the Slovak Republic faces to considerable changes in the crop production structure. These changes along with the lack of manure result in modification of soil fertility and call for changes in the nutrition and fertilization of some field crops. There are first of all those crops with close interconnection between the fore-crop value and successful cropping results. The spring barley is one of these crops concededly. It is an opportunity for the application of non-root nutrition in the fertilization of this important commodity. According to many authors the advantage of non-root nutrition consist in quick and immediate input of nutrients (lack of which limit the plant growth), in stimulation of biological processes during the yield formation and intake of nutrients by the root system, symptom elimination by lack of nutrients and overcoming of barriers scanting the plant nutrition through roots (drought, proportional coupling and soil nutrient antagonism) (1, 12, 9 and others).

In order to verify the influence of Campofort Fortestim – alfa a field semiindustrial trials with spring barley were started in the area of Znojmo. Thanks to the application of non-root nutrition the yield amount increased for 0.70 tonnes/hectare compare to the control variant. By using the combination of Fortestim - alfa, Campofort Special Zn, Campofort Garant P fertilizers an yield amount of 5.15 tonnes/hectare was achieved (increase for 1.01 tonnes/hectare compare to the control variant (8). By using the non-root nutrition it is possible to balance the inequality in nutrient intake, to strengthen the impact of N, Mg fertilizers, to stimulate the plant biosynthesis, and to improve the nutritional condition and stress resistance during vegetation (10). Nitrogen fertilization plays a key role in malting barley production and nutrition. Barley reacts very sensitive on available nutrient supply in the soil during the growing season. Larger soil nutrient content or raised from fertilizers secure higher yield stability, lower nitrogen rates induct yield decrease in all cases with exception of those years characterised by strong mineralization in the soil nitrogen. Lack of soil nitrogen decline the stand density, and the spike size thereby the number of grains per spike, defer the spike formation and conduce to premature "forced" ripeness wherewith abbreviate the period of grain formation and filling and decrease its weight (11).

In trials with spring barley established during 1999 – 2004 in the Institute of Agroecology in Vysoká nad Uhom several NPK rates ranged from 82.0 up to 142.0 kilogramme/hectare (pure nutrients NPK) were observed. Using higher nutrient doses higher yields were achieved and highly significant correlation between yield, growing season and fertilization was determined. Cold and rainy weather conditions in May 1999 have influenced positively the grain yield in malting barley (14).

The impact of weather conditions on the grain yield during and outside the growing season in spring barley (Sladko variety) was observed by authors Danilovič and Mati, (2) in 1994 and 1998 – 2000. Shortening of growth stages demonstrates itself in the formation of production and accumulation potential of stand where the dependence between the final yield amount and the number of grains per area unit was linear.

According to Kajdi (7) the best suited areas for spring barley production are wet ones with medium heavy soils. Barley demands an even distribution of precipitation during the growing season. It suits him gradual warming without bigger ups and downs after sowing. There is an increased demand for moisture from shooting to earning growth stage. During later growth stages there was observed a negative impact of higher temperatures and drought on the number and weight of kernels in the spike. Excessive precipitations during maturing growth stage are detrimental to barley and decrease its malting quality, too.

Objective of the experiment was to determine the influence of non-root nutrition and those of the growing season on the accumulation potential indicators and the yield amount in spring barley.

MATERIAL AND METHOD

Field polyfactorial trials were carried out in warm corn production area of Slovakia in 2002-2004 with three spring barley varieties (Annabell, Kompakt and Nitran) after sugar beet by the method of split blocks randomly in three repetitions. The size of experimental plots was 14 square meters. Four fertilization levels were evaluated: „**a**“ - control variantô; „**b**“ - 50 kg N.ha^{-1} in DASA form (25 kg before sowing and 25 kg during the BBCH 12 – 13 growth stage) + P, K; „**c**“ - 50 kg N.ha^{-1} in DASA form (25 kg before sowing and 25 kg during the BBCH 12 – 13 growth stage) + foliar fertilizer CAMPOFORT Fortestim- alfa (in a rate of 7 l.ha^{-1} during the BBCH 23 – 25 growth stage) + P, K; „**d**“- 80 kg N.ha^{-1} (30 kg N in SA form before sowing, 25 kg N in DASA form during the BBCH 12 – 13 growth stage, 25 kg in DASA form during the BBCH 23 – 25 growth stage) + foliar fertilizer CAMPOFORT Fortestim- alfa (in a rate of 7 l.ha^{-1} during the BBCH 23 – 25 growth stage) + P, K. Soil samples for N_{an} were taken from the depth of 0.60 m and for P, K from the depth of 0.30 m. By calculation of P and K fertilization rates according to compensation system regarding the final yield amount of 7 tonnes/hectare we have started from nutrient consumption equivalent to 1 tonne of grain yield and the relative yield of straw 5 kg P and 20 kg K. Yield results were re-counted on the moisture level of 14%.

In order to evaluate the accumulation potential the samples of biological material during the BBCH 85 – 89 growth stages were picked up from the area of 1 square meter, from each variant in three repetitions. These indicators of the accumulation potential were observed: number of plants per 1 square meter (pieces.m^{-2}) before cutting, number of productive shoots per square meter (pieces.m^{-2}), an average number of productive shoots per one plant (pieces), number of spikes per 1 square meter (pieces.m^{-2}), number of grains in one spike (pieces) and the grain weight per one spike (g).

Experiment results were statistically processed using the Statgraphics and Statistica 6.1. software. Methods as follows were used: multifactor analysis of variance, multiple range tests, and the method of confidence intervals (the method of performance interval). In order to get more precise results observed factors regarding the grain yield in single years were tested by the analysis of variance and the Multiple range test – Tukey test on confidence levels of 95% and 99% (α= 0,05; α=0,01).

Experimental area was classed and characterised according to authors (13) as a warm macro area and very arid sub-area with an average precipitation total (1951 - 1980) of 561 mm, during the vegetation period

333 mm and an average temperature total of 9.7 °C (1951 - 1980), 16.3 °C during the vegetation period.

The soil conditions of experimental plot – brown soil and sloam. The soil was moderately supplied in P and very well in K. Humus content in the top soil is average (1.20 – 2.07%). The soil reaction is acidic to low acidic (pH active 5.9-6.5; pH substitute 5.0-5.5) (6)

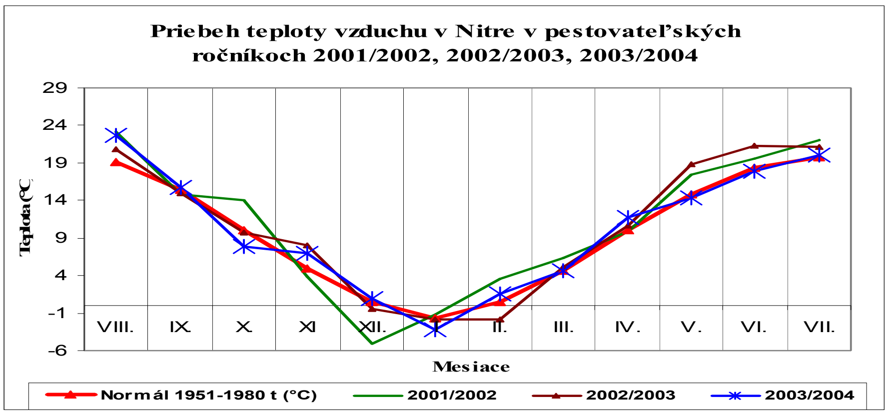


Figure 1**:** The air temperature course in Nitra during 2001/2002, 2002/2003, 2003/2004

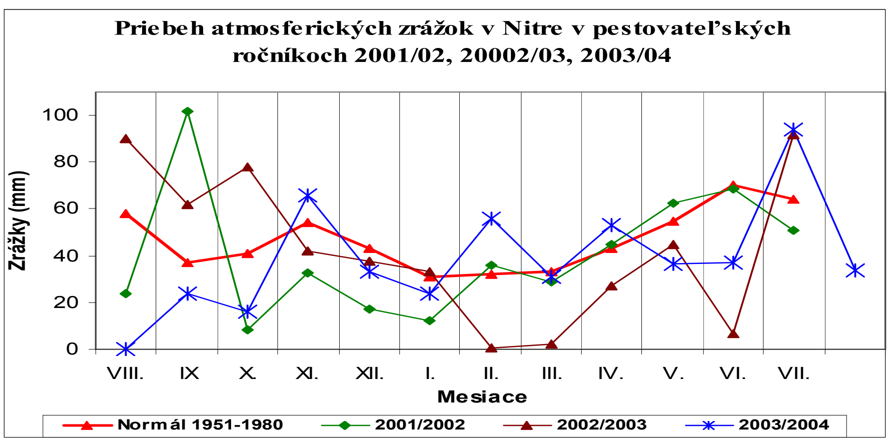


Figure 2**:** The atmospheric precipitation course in Nitra during 2001/2002, 2002/2003, 2003/2004

RESULTS AND DISCUSSION

Grain yield and the accumulation potential depending on evaluated parameters

•Fertilization levels

There was observed a statistically highly significant impact of fertilization levels on the yield amount during three experimental years (Figure 3). As for the results of non-root nutrition impact follows that the reaction of observed varieties on its application was positive. Non-root nutrition in combination with increased rate of N ("d" level) results (compare to "b" level) in statistically significant yield average increase (0.37 tonnes/hectare) in all observed varieties. Šoltysová - Danilovič (14) have confirmed the high dependence of malting barley yield amount on the growing season and fertilization level. The application of non-root nutrition (compare to the control variant) results in yield increase for 0.14 tonnes/hectare („c" level) up to 0.27 tonnes/hectare („d" level). Mráz (8) mentioned a yield increase up to 0.70 tonnes/hectare due to the application of Campofort Fostretim- alfa.

By the method of confidence intervals was not confirmed a statistically significant influence of non-root nutrition on yield formation elements.

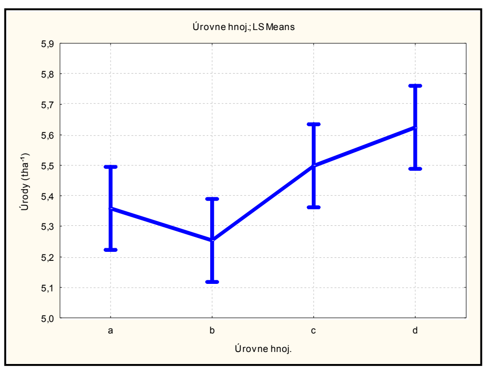


Figure 3: Average grain yield depending on the fertilization level
Averages and 95% confidence intervals

The importance of sufficient N nutrition was emphasized by authors (11) who during the spring barley experiments by N deficiency have determined a decrease in stand density, spike length thereby the number of grains per spike. Shifting of earning phase conduce to premature "forced" ripeness wherewith abbreviate the period of grain formation and filling with negative impact on the grain weight per spike.

Fertilization levels during the growing season 2004 have had statistically highly significant impact in the yield amount; in 2002 and 2003 this was statistically significant. . Ehrenbergerová et al. (4, 5) have achieved for 0.30 tonnes/hectare higher yield in fertilized variants compare to non-fertilized system (in 7 lines of naked and 2 husky barley varieties and in average for three years).

Results have confirmed appositive impact of non-root nutrition from economical point of view, too. The value of economic efficiency of evaluated varieties due to application of non-root nutrition along with 50 kg $N.ha^{-1}$ in DASA form („c“ level of fertilization) was 1.41 and 1.81 in 2002 and 2003 (Figure 4).

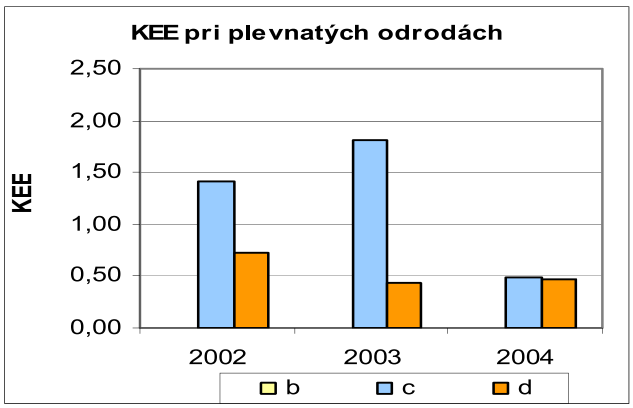


Figure 4: The coefficient of economic efficiency due to the application of non-root nutrition in all observed varieties in comparison to the “b” fertilization level

•Growing season

Results have confirmed statistically high variability of yield amounts owing to the growing season (Figure 5). An average grain yield amount for the whole experiment period achieved 5.87 tonnes/hectare and the difference among growing seasons was 3.16 to 4.00 tonnes/hectare .

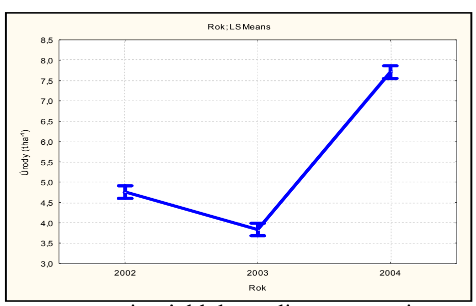


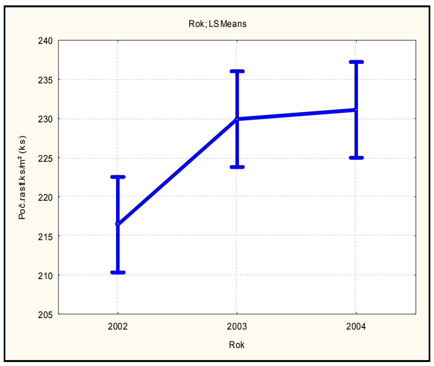
Figure 5: An average grain yield depending on growing season
Averages and 99% confidence intervals

The growing season of 2002 according to precipitation total (302.50 mm) can be characterized as normal (92.23% CN) and according to average temperature (9.70 °C) as warm (+116.87% CN) (Figure 1 and 2). Uneven precipitation distribution after barley sowing (there were only 9.30 mm precipitation from March 22. to April 12.) have extended the first critical period (sowing – emergence period) with the view of plant number formation as the basic yield formation element and with negative effect on the field emergence rate. Another dry period in May (lasting from May 6. to 24., 2002; precipitation total of 6.20 mm) have had a negative impact on the formation of productive shoots. Šoltysová - Danilovič (14) refer that colder and damper weather in May has a positive influence on the yield amount in malting barley because for the yield and grain quality formation are about 14°C May temperatures of great importance. During the period of barley maturing (from June 12. to 30.) high temperatures (up to 26.50 °C) and low precipitation total (7.70 mm) have caused decrease in GW - 1000 grains weight (41.5 g). The decrease of final yield amount (5.10 tonnes/hectare) comparing to the best growing season of 2004 (for 3.16 tonnes/hectare) was caused by lower number of spikes (for 83 pieces.m^{-2}) and lower GW (for 3.2 g). Differences in basic yield formation elements in single growing seasons were statistically highly significant (Figure 6, 7, 8, 9). Danilovič - Mati, (2) after studying the influence of weather condition on the grain yield formation during and outside the vegetation period of spring barley came to the conclusion that the shortening of growth stages effects the formation of stand production and accumulation potential whereas the dependence between the final yield amount and the number of grains per area unit is almost linear.

The growing season of 2003 was least favourable for the spring barley production from all evaluated seasons. According to precipitation total it can be characterized as very dry (62.80% CN) and as for the average temperature as warm (110.54% CN). Extremely dry were March with precipitation total of 2.3 mm (6.97% CN), April and June with precipitation total of 27 mm, resp. 6.5 mm (62.79% to 9.29 % CN). Comparing to the best growing season (2004) the number of spikes decrease for 30 pieces.m^{-2} and the lowest grain weight per spike (0.62 g) from all evaluated growing seasons what resulted in the lowest average yield amount from all evaluated seasons (4.26 tonnes/hectare). The yield amount decrease (compare to growing seasons 2002 and 2004) for 0.84 up to 4.00 tonnes/hectare (i.e. 16.5 % to 48.4 %).

During the third evaluated growing season of 2004 the temperatures were in conformity to the 30 year normal level, according to precipitation totalsMarch and June were wet. The precipitation total achieved 160% resp. 134% CN. During this growing season the highest grain yield amount was achieved – 8.26 tonnes/hectare in average for the whole experiment period. The yield increase compare to seasons 2002 and 2003 was 161.96 % to

193.9 %. Favourable weather course have had a positive impact on the formation of productive shoots (Figure 8) and after all on the final grain yield amount, too. The number of plants and number of spikes in 2004 and 2003 seasons was quite well-balanced (Figure 6, 7). Kajdi (7) recorded from experiments with spring barley an increased demand for moisture during shooting up to earning growth stage. High temperatures and drought induced the decrease in number and weight of grains per spike.



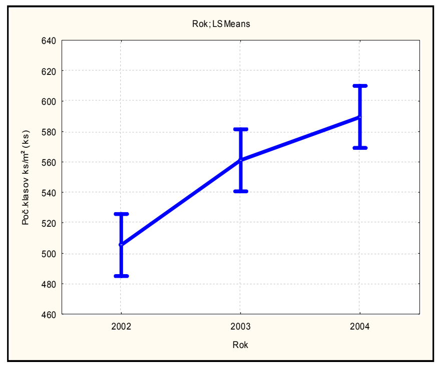
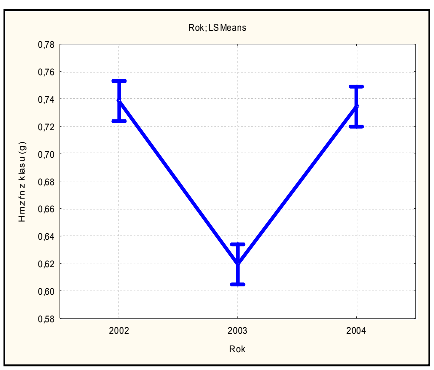


Figure 6, 7: Number of plants and number spikes depending on the growing period

Averages and 95% confidence intervals Averages and 99% confidence intervals



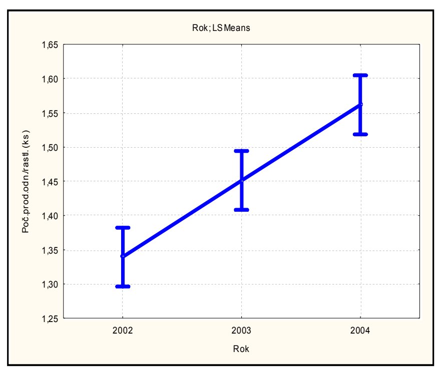


Figure 8,9: Weight of grain in the spike and the number of shoots depending on the growing seasons

Averages and 95% confidence intervals Averages and 99% confidence intervals

By the method of confidence intervals were statistically confirmed differences due to growing season in the number of plants, number of spikes, GW and the number of productive shoots (Figure 6, 7, 8, 9).

Statistically significant differences in the number of grains per spike due to the growing season were not confirmed.

CONCLUSION

Objective of the paper was to determine the influence of non-root nutrition and those of the growing season on the accumulation potential indicators and the yield amount in spring barley. By application of non-root nutrition in comparison to the control variant the yield amount increased for 0.14 tonnes/hectare („c“ fertilization level) up to 0.27 tonnes/hectare („d“ fertilization level) and compare to the „b“ fertilization level for 0.37 tonnes/hectare. Due to the application of non-root nutrition along with 50 kg $N.ha^{-1}$ in DASA form („c“ fertilization level) were achieved an economic efficiency value of 1.41 and 1.81 in all evaluated varieties in seasons 2002 and 2003. By the method of confidence intervals were confirmed statistically significant differences due to the growing season, number of plants, number of spikes, grain weight per spike and the number of productive shoots. The difference in yield amount due to growing season ranged from 3.16 to 4.00 tonnes/hectare.

Acknowledgments

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