Effect of topdressing with nitrogen on the yield and quality of winter wheat grain

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ABSTRACT

Small-plot field experiments were established in the first decade of October at the Plant Breeding Station of Sládkovičovo-Nový dvor with winter wheat (*Triticum aestivum* L.), variety Astella. There was investigated an effect of topdressing with nitrogen on the yield of winter wheat grain and its quality characteristics in the experiment. Nitrogenous fertilizers were applied at the growth phase of the 6th leaf (Zadoks = 29). Soil of the experimental stand was analysed for inorganic nitrogen content (N_{an}) down to the depth of 0.6 m of soil profile. Productive nitrogen fertilizing rate was computed to ensure N_{an} content in soil on the level of 120 and 140 kg N/ha, respectively. Three various forms of fertilizers were examined, urea solution, ammonium nitrate with dolomite, and DAM-390. Different weather conditions statistically highly, significantly influenced grain yield in respective experimental years. Topdressing with nitrogen caused a statistically highly significant increase of grain yield in all fertilized variants ranging from +0.35 to +0.82 t/ha according to respective treatments. Average grain yield in unfertilised control variant represented 7.23 t/ha. Nitrogen nutrition showed a positive effect on the main macroelements offtake (N, P, K, Ca, Mg, S) by winter wheat grain in all fertilized variants. Nitrogen fertilizing to the level of 140 kg/ha N in soil positively influenced formation of wet gluten and crude protein with highest increment in variant 5 (solution of urea) representing +12.8 and +10.7%, respectively in comparison to control unfertilised variant as well as to variant 2 (solution of urea and fertilizing on the level of 120 kg N/ha) where increments represented +8.8 and 9.7%, respectively. Thousand-kernel weight, volume weight and portion of the first class grain were not markedly influenced by nitrogen fertilizing.

Keywords: winter wheat; topdressing with N; grain yield; grain quality

Nutrition in complexity with other agrotechnical measures markedly influences not only level of the yield, but also physical, mechanical, chemical and biochemical properties of grain (Ulmann 1991, Michalík 1992).

Results of many research works and practice knowledge confirm that yield and quality of winter wheat grain are decisively influenced by optimal supply of all biogenic elements in soil with dominant fertilizing effect of nitrogen (Tlustoš et al. 1997, Vaněk et al. 1997, Balík et al. 1999, Ewert and Honermeier 1999, Jimenez et al. 2002).

It is known and experimentally demonstrated that cereals crops actively take up nitrogen throughout the whole growing season. It is also a known fact that pre-anthesis nitrogen uptake in winter cereals represents 75–90% of total nitrogen in the plant at harvest (Heitholt et al. 1990). In conditions of high soil fertility even post-anthesis N uptake is important because it is positively correlated to kernel protein content (Guohua et al. 2000).

Winter wheat belongs among the crops for which the nitrogen rate optimalization methods are worked-out the most. Any method whether based on soil or plant analyses tries to optimalize nitrogen fertilizing and improve economical parameters of winter wheat grain production.

In submitted contribution we concentrated our effort for optimizing nitrogen rates and forms within topdressing winter wheat based on the information on N_{an} content in soil.

MATERIAL AND METHODS

Small-plot field experiments were established in the first decade of October 1999, 2000 and 2001, respectively at the Plant Breeding Station of Sládkovičovo-Nový dvor with winter wheat (*Triticum aestivum* L.), variety Astella which represents bread baking quality (B). The experiments were realized on loamy degraded chernozems and the plots (10 m^2 each) arranged in four repetitions using block pattern method. Seeding rate represented 4.5 millions of germinating grains per hectare under row distance of 0.125 m. As forecrop pea for grain was grown. Agrochemical characteristic of soil prior to experiment establishment is illustrated in Table 1. Average year atmospheric temperature of experimental site region was 10.46°C and annual sum of precipitation amounted 497.2 mm. The characteristics of weather conditions in 1998–2001 are represented: precipitation (% of long-term average) in Table 2 and temperatures (deviations from long-

Table 1. Agrochemical characteristics of soil to the depth of 0.3 m before experiment establishment

Soil analysis	1998/1999	1999/2000	2000/2001
pH/KCl	7.26	6.73	7.07
N_{an} (mg/kg)	18.1	24.7	15.2
N_{an}* (mg/kg) in depth of 0.0–0.6 m	10.9	11.6	9.8
P Mehlich II (mg/kg)	81.0	94.0	124.0
K Mehlich II (mg/kg)	210.0	224.0	268.0
Content of C_{ox} Tjurin (%)	1.28	1.56	1.24

*content of N_{an} in soil analysed in the phase of 6^{th} leaf of winter wheat plants

term average) in Table 3 (Kožnarová and Klabzuba 2002). Effect of topdressing with nitrogen applied in the growth phase of the 6^{th} leaf (Zadoks = 29) on the yield of winter wheat grain and its qualitative characteristics was investigated. Soil of experimental site was analysed for N_{an} content down to the depth of 0.6 m of soil profile. The rate of nitrogen for topdressing was computed in the manner to reach the supply of 120 and 140 kg N/ha, respectively. As far as the forms of fertilizers are concerned the following ones were applied: solution of urea, ammonium nitrate with dolomite and DAM-390. The pattern of investigated experimental variants (treatments) is stated in Table 4. For good supply of phosphorus and potassium in soil, fertilization with these nutrients was omitted. Harvest of the crop was performed by small-plot combine. Soil and plant material analyses were accomplished by common analytical methods. The yields of grain were evaluated statistically using analyse of variance and differences within years and variants were tested by *LSD* procedure.

RESULTS AND DISCUSSION

Different weather conditions statistically high-significantly influenced yield of winter wheat grain in individual experimental years. The highest yield was obtained in the season 2000/2001 (average of all variants = 9.5 t/ha) when there was favourable distribution of precipitation in March and April with appropriate average temperature in March (6.9°C) comparing to long-term average (Tables 2 and 3). All this positively influenced production process. From the point of view of temperature and precipitation the season 1998/1999 was at the level of long-term average and average grain yield represented 6.96 t/ha. Marked yield depression happened in the season 1999/2000 (average yield = 6.47 t/ha) when low precipitation and high temperature in April and May negatively affected the final grain production (Table 4). Hubík (1995), Vrkoč et al. (1995) and Delogu et al. (1998) state a strong effect of weather conditions on winter wheat grain yield formation. To obtain high and high-quality yield the most suitable season would be that with sufficiency of precipitation in autumn, snow cover in winter and abundance of precipitation in spring up to the phase of flowering followed by higher air temperature without marked differences (Muchová 1992).

Applied nitrogen (variants 2 to 7) caused statistically high-significant increase of grain yield (from 0.35 t/ha in variant 7 to 0.82 t/ha in variant 5) in comparison with unfertilised control where achieved yield represented 7.23 t/ha on the average. There were found no statistical significant differences in yields between variants 6 and 7 (fertilized to the level of 140 kg N/ha based on N_{an} soil analysis) and variants 2 and 3 (fertilized to the level of 120 kg N/ha based on N_{an} in soil). However, when nitrogen was applied in the form of urea fertilizer solution the grain yield of variant 5 was by 3.3% higher than that one in variant 2 (Table 5). Dryšlová (2000) states that increase of nitrogen rate from 40 to 120 kg/ha increased winter wheat grain yield (variety Astella) by 0.6 t/ha on the average when the highest yields were obtained if the sowing was performed in optimal agrotechnical term which in our experiments fell on the first decade of October what is in accordance with the results stated by Muchová (1992).

Nitrogen application positively influenced offtake of main macroelements (N, P, K, Ca, Mg, S) by winter wheat grain in all investigated variants (Table 6). Baier et al. (2001) state that complete mineral nutrition of winter wheat caused higher offtake of potassium by 63.9% and magnesium by 17.5% in comparison with variant without fertilizers application.

Nitrogen nutrition showed positive effect on qualitative characteristics of grain. The highest portion of the first class grain was obtained in the variant 2 (+5.5% to variant 1). Fertilizing with nitrogen to the level of 140 kg N/ha positively

Table 2. The average monthly precipitation in 1998–2001 (the evaluation of precipitation normality of months according to the percentage of the long-term averages 1961–2001)

Month	Long-term average	1998		1999		2000		2001	
		precipitation (mm)	evaluation of normality	precipitation (mm)	evaluation of normality	precipitation (mm)	evaluation of normality	precipitation (mm)	evaluation of normality
1.	26.5	16.2	dry	14.0	dry	37.0	wet	11.0	very dry
2.	27.6	1.6	extraordinary dry	31.5	normal	23.9	normal	24.3	normal
3.	25.4	6.2	very dry	20.4	normal	76.3	extraordinary wet	64.0	very wet
4.	31.6	30.0	normal	54.9	very wet	12.7	dry	16.2	dry
5.	49.3	37.6	normal	34.5	normal	14.8	very dry	29.7	normal
6.	66.6	33.3	dry	106.4	wet	25.9	very dry	21.1	very dry
7.	57.5	64.1	normal	101.9	very wet	94.2	wet	83.4	wet
8.	56.6	40.3	normal	79.4	wet	37.4	dry	22.9	dry
9.	37.1	131.3	extraordinary wet	11.3	dry	31.6	normal	107.2	extraordinary wet
10.	34.9	80.3	very wet	28.6	normal	21.3	normal	17.4	normal
11.	48.6	34.4	normal	52.9	normal	66.9	wet	37.6	normal
12.	35.5	15.6	dry	61.8	wet	47.3	normal	27.3	normal

Table 3. The average monthly temperatures in 1998–2001 (the evaluation of air temperature normality of months according to the divergences from long-term averages 1961–2001)

Month	Long-term average	1998		1999		2000		2001	
		temperature (°C)	evaluation of normality	temperature (°C)	evaluation of normality	temperature (°C)	evaluation of normality	temperature (°C)	evaluation of normality
1.	–1.3	0.3	normal	–0.9	normal	–1.8	normal	0.6	normal
2.	1.2	3.5	normal	0.1	cold	2.5	normal	2.8	normal
3.	5.2	2.7	cold	6.8	normal	5.1	normal	6.9	normal
4.	11.2	10.9	normal	12.7	normal	15.2	extraordinary warm	10.7	normal
5.	16.4	15.1	normal	17.6	normal	19.4	very warm	17.3	normal
6.	19.3	20.0	normal	21.4	very warm	21.7	very warm	17.1	very cold
7.	21.1	21.5	normal	21.3	normal	21.3	normal	21.9	normal
8.	20.5	22.5	very warm	20.9	normal	21.6	warm	24.3	extraordinary warm
9.	16.1	15.9	normal	18.7	very warm	16.2	normal	14.9	cold
10.	10.6	12.8	very warm	10.1	normal	14.1	extraordinary warm	15.5	extraordinary warm
11.	4.5	2.9	cold	2.6	cold	8.6	extraordinary warm	3.5	normal
12.	0.8	–1.1	cold	–1.0	cold	2.3	normal	–4.3	extraordinary cold

Table 4. Variants of nutrition and average nitrogen rates for topdressing of winter wheat in years 1999 to 2001

Variant	Fertilization	Fertilizer	Rate of nitrogen for topdressing (kg/ha)		
			1999	2000	2001
1	unfertilized	–	–	–	–
2	fertilizing with nitrogen to the level of 120 kg/ha based on content of N_{an} in soil depth of 0.0–0.6 m	urea-solution	22	16	32
3		LAD[1]	22	16	32
4		DAM-390[2]	22	16	32
5	fertilizing with nitrogen to the level of 140 kg/ha based on content of N_{an} in soil depth of 0.0–0.6 m	urea-solution	42	36	52
6		LAD	42	36	52
7		DAM-390	42	36	52

[1]ammonium nitrate with dolomite, [2]ammonium nitrate and urea

Table 5. Effect of nitrogen fertilizing on the winter wheat grain yield (variety Astella)

Variant of nutrition		Grain yield (t/ha)				Relatively (%)
		1999	2000	2001	3-year average	
1		6.35	6.11	9.24	7.23	100.0
2		6.99	6.63	9.85	7.82	108.2
3		7.05	6.41	9.96	7.81	108.0
4		6.78	6.70	9.80	7.76	107.3
5		7.68	6.41	10.05	8.05	111.3
6		7.09	6.53	10.04	7.89	109.1
7		6.74	6.50	9.50	7.58	104.8
LSD variants	0.05				0.20^{+}	
	0.01				0.26^{+}	
Average		6.96	6.47	9.75		
LSD years	0.05				0.13^{+}	
	0.01				0.17^{++}	

Table 6. Effect of nitrogen fertilizing on the offtake of nutrients by winter wheat grain, variety Astella (Sládkovičovo, average of 1999–2001)

Variant of nutrition	Nutrient offtake by wheat grain (kg/ha)					
	N	P	K	Ca	Mg	S
1	128.4	21.6	22.8	8.9	7.2	10.3
2	140.7	27.1	27.9	8.7	9.8	11.7
3	136.1	27.1	27.8	10.6	10.0	15.8
4	137.8	28.7	28.4	9.5	9.3	16.7
5	157.3	28.9	29.5	10.0	9.9	18.2
6	146.7	28.6	29.6	10.7	9.4	13.1
7	136.6	27.7	27.8	8.5	8.7	18.6
Relatively (%)						
1	100	100	100	100	100	100
2	109.6	125.5	122.4	97.8	136.1	113.6
3	106.0	125.5	121.9	119.1	138.9	153.4
4	107.3	132.9	124.6	106.7	129.2	162.1
5	122.5	133.8	129.4	112.4	137.5	176.7
6	114.3	132.4	129.8	120.2	130.6	127.2
7	106.4	128.2	121.9	95.5	120.8	180.6

Table 7. Effect of nitrogen fertilizing on some quality parameters of winter wheat grain, variety Astella (Sládkovičovo, average of 1999–2001)

Variant of nutrition	Crude protein (%)	Wet gluten (%)	Thousand kernel weight (g)	Volume weight (g/l)	Portion of the first class grain (%)
1	10.3	22.6	36.6	747.2	72.4
2	10.4	23.5	37.8	753.3	76.4
3	10.1	23.1	37.2	747.8	72.7
4	10.3	23.5	37.6	743.7	75.8
5	11.4	25.5	36.9	747.8	73.6
6	10.8	24.3	36.9	752.3	72.7
7	10.4	23.8	38.6	754.7	74.4
Relatively (%)					
1	100	100	100	100	100
2	101.0	104.0	103.3	100.8	105.5
3	98.1	102.2	101.6	100.1	100.4
4	100.0	104.0	102.7	99.5	104.7
5	110.7	112.8	100.8	100.1	101.7
6	104.9	107.5	100.8	100.7	100.4
7	101.0	105.3	105.5	101.0	102.8

influenced wet gluten and crude protein formation with the highest increment in the variant 5 (nitrogen applied in the form of urea solution) which represented +12.8 and +10.7%, respectively in comparison to variant 1 and +8.8 and +9.7%, respectively comparing to variant 2 (nitrogen applied in the form of urea solution) fertilized to the level of 120 kg N/ha. Thousand-kernel weight, volume weight and portion of the first class grain were not influenced markedly under the application of nitrogen nutrition (Table 7).

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ABSTRAKT

Vliv přihnojení dusíkem na výnos a kvalitu zrna ozimé pšenice

V maloparcelkovém výživářském pokusu jsme sledovali vliv přihnojení ozimé pšenice (*Triticum aestivum* L., odrůda Astella) dusíkem, který byl aplikován ve fázi 6. listu (Zadoks = 29), na výnos zrna a jeho kvalitativní parametry. Půdu pokusného stanoviště jsme analyzovali na obsah N_{an} ($N\text{-}NO_3^-$ + $N\text{-}NH_4^+$) do hloubky 0,6 m a dávku produkčního hnojení dusíkem jsme vypočítali tak, aby byl zabezpečen obsah N_{an} v půdě na úrovni 120, resp. 140 kg N/ha. Použili jsme roztok močoviny, ledek amonný s dolomitem a DAM-390. Rozdílné povětrnostní podmínky v jednotlivých pokusných letech ovlivnily statisticky vysoce průkazně výnos zrna ozimé pšenice. Nejvyššího výnosu bylo dosaženo v pokusném roce 2000/2001 (průměr za všechny varianty byl 9,5 t/ha). Výrazný pokles výnosu nastal v pokusném roce 1999/2000 (průměrný výnos byl 6,47 t/ha), kdy výslednou produkci zrna negativně ovlivnily nízké srážky a vysoká teplota v dubnu a květnu. Aplikovaný dusík způsobil ve všech variantách 2 až 7 statisticky vysoce průkazné zvýšení výnosu zrna ozimé pšenice (v průměru od 0,35 t/ha ve variantě s dusíkem aplikovaným ve formě DAM-390 na hladinu 140 kg N/ha do 0,82 t/ha ve variantě s dusíkem aplikovaným ve formě roztoku močoviny na hladinu 140 kg N/ha) v porovnání s nehnojenou kontrolou, u níž bylo dosaženo průměrného výnosu 7,23 t/ha. Přihnojení dusíkem na hladinu 140 kg/ha pozitivně ovlivnilo tvorbu mokrého lepku a hrubého proteinu s nejvyšším přírůstkem ve variantě 5 (dusík aplikovaný ve formě roztoku močoviny), a to o 12,8 %, resp. o 10,7 % v porovnání s nehnojenou variantou a o 8,8 %, resp. o 9,7% v porovnání s variantou 2 (dusík aplikovaný ve formě roztoku močoviny), ve které bylo dusíkem přihnojováno na hladinu 120 kg/ha.

Klíčová slova: ozimá pšenice; přihnojení dusíkem; výnos zrna; kvalita zrna

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