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EFFECT OF MULTINUTRIENT COMPLEX FERTILIZERS ON TOTAL NITROGEN AND NITRATE(V) CONTENT IN THE TUBERS OF VERY EARLY POTATO CULTIVARS

WPŁYW WIELOSKŁADNIKOWYCH NAWOZÓW KOMPLEKSOWYCH NA ZAWARTOŚĆ AZOTU OGÓLNEGO I AZOTANÓW(V) W BULWACH BARDZO WCZESNYCH ODMIAN ZIEMNIAKA

Abstract: The paper presents the results of a three-year study on the effect of an application of the multinutrient complex fertilizers and singlenutrient fertilizers on total nitrogen and nitrate(V) contents in the tubers of very early potato cultivars.

It was found that an application of multinutrient complex fertilizers representing the nitrophoska group, that is Nitrophoska blue special and Viking 13, was followed by an increase in total nitrogen contents in tubers. In turn, an application of HydroComplex was associated with a total nitrogen content which was similar to singlenutrient fertilizers. Polimag S (amophoska group) increased total nitrogen content, compared with singlenutrient fertilizers, only in the year with a higher rainfall over the potato growing season. The present studies demonstrated that a significant increase in nitrate(V) content in tubers followed an application of the multinutrient complex fertilizer HydroComplex which contains most of magnesium and sulphur of all with the nitrophoska group.

Keywords: potato, fertilization, multinutrient complex fertilizers, total N, NO_3-N

Nitrogen compounds, converted to total protein (N × 6.25), account for 1.7 to 2.3 % potato tuber fresh matter. Nitrogen in the form of nitrates represents as little as 0.5 to 1.3 % total nitrogen. However, due to high consumption, potatoes are a source of quite high amounts of these compounds. Approximately 27 % nitrates in a daily diet are potato-derived ones [1, 2]. Accumulation of nitrogen compounds in potato tubers depends on environmental conditions, agronomical factors, cultivar properties and tuber physiological maturity [1, 3–5]. Nitrate concentration in tubers depends, to a large extent, on mineral fertilization. Results of studies indicate that there is a possibility of reducing nitrate contents in tubers due to an application of multinutrient fertilizers [6, 7].

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The aim of the study was to compare the effect of singlenutrient and multinutrient complex fertilizers on total nitrogen and nitrate(V) content in the tubers of very early potato cultivars.

Materials and methods

The effect of multinutrient complex fertilizers – HydroComplex (12 % N in this 5 % NO_3-N and 7 % NH_4-N, 11 % P_2O_5, 18 % K_2O, 2.6 % MgO, 8 % S, 0.015 % B, 0.02 % Mn, 0.02 % Zn and 0.35 % Fe), Nitrophoska blue special (12 % N in this 5.5 % NO_3-N and 6.5 % NH_4-N, 12 % P_2O_5, 17 % K_2O, 2 % MgO, 6 % S, 0.02 % B and 0.01 % Zn), Polimag S (10 % N in NO_3-N, 8 % P_2O_5, 15 % K_2O, 5 % MgO, 14 % S, 0.1 % B, 0.1 % Cu, 0.2 % Mn and 0.5 % Zn), Viking 13 (13 % N in this 5.3 % NO_3-N and 7.7 % NH_4-N, 13 % P_2O_5, 21 % K_2O, 1.2 % MgO, 4 % CaO and 1.4 % S), and singlenutrient fertilizers (ammonium nitrate, single superphosphate and potassium sulphate) on total nitrogen and nitrate(V) contents in the tubers of very early potato cultivars ('Aster', 'Fresco', 'Gloria') was investigated. The study was carried out in the years 2005–2007 on podzolic soil with a very high content of available phosphorus, mean to very high content of potassium, mean content of magnesium, and pH in 1 mol · dm^{-3} KCl 5.0–6.8. The field experiment was established in the split-plot design with three replications. The multinutrient complex fertilizers and singlenutrient fertilizers were applied in the amounts equivalent to recommended rates for the cultivars tested of 100 kg N · ha^{-1}. The remaining elements in the singlenutrient fertilizers were applied at the rates which guarantee an appropriate N:P:K proportion for edible potatoes, that is 1:1:1.5. Potatoes were harvested at the tuber physiological maturity stage. Laboratory studies were conducted on samples of 50 different-sized tubers taken from each treatment. The content of total nitrogen with Kjeldahl method and nitrate(V) with ionselective nitrate electrode were determined.

Only the growing season of 2007 was characterised by thermal and moisture conditions that were favourable for the cultivation of very early potato cultivars. In 2005 was drought from mid-June to the end of the growing period, and in 2006 was mild drought during the whole growing period.

Results and discussion

The content of total nitrogen in potato tubers ranged from 9.37 to 14.48 g · kg^{-1} d.m.; that of nitrate(V) varied from 66.67 to 94.67 mg · kg^{-1} f.m. Irrespective of the kind of fertilizer applied, most total nitrogen was accumulated by potato tubers in 2006, with the lowest rainfall over the growing season. By contrast, nitrate accumulation in tubers in this year was the lowest (Table 1). High temperature and temporary rainfall shortages during the growing season increase total nitrogen in tubers [1, 8], which was confirmed in the present study.

The singlenutrient fertilizers applied in the experiment did not affect significantly total nitrogen content in tubers (Table 1). An application of the multinutrient complex fertilizers HydroComplex, Nitrophoska blue special and Viking 13 (nitrophoska group)

resulted in a similar or higher total nitrogen content in tubers compared with singlenutrient fertilizers. The highest total nitrogen content was determined in the tubers of potato fertilized with Nitrophoska blue special and Viking 13. The respective increases in total nitrogen content amounted to 0.55 and 0.45 g · kg^{-1} d.m. as compared with singlenutrient fertilizers. The highest increase in total nitrogen content as result of fertilization with Nitrophoska blue special and Viking 13 was obtained, respectively, in 2006 with mild drought over the growing season of potato, and in 2007 which was moderately wet. Compared with singlenutrient fertilizers, an application of Polimag S (amophoska group) increased total nitrogen content, on average by 1.44 g · kg^{-1} d.m. only in 2007 with most rainfall in the growing period of potato. By contrast, in the years characterised by rainfall shortages, total nitrogen content in tubers was lower following an application of Polimag S. Studies by other authors demonstrated an increase in nitrogen content in tomato friut as result of fertilization with Polimag S [9].

Table 1

Total N [g · kg^{-1} d.m.] and NO_3-N [mg · kg^{-1} f.m.] content in tubers in relation to the kind of fertilizer and year of cultivation

Kind of fertilizer	N-total				NO_3-N			
	2005	2006	2007	mean	2005	2006	2007	mean
Without fertilizer	10.77	12.66	12.17	11.86	72.56	72.89	81.11	75.52
Singlenutrient fertilizers	11.58	12.75	11.42	11.91	89.00	80.67	79.56	83.07
HydroComplex	10.81	13.19	11.70	11.90	90.78	88.44	82.11	87.11
Nitrophoska blue special	12.06	13,91	11.41	12.46	81.56	76.33	79.67	79.18
Polimag S	10.38	10.92	12.14	11.15	81.56	78.33	82.22	80.70
Viking 13	10.96	13.27	12.86	12.36	84.00	78.00	80.22	80.74
Mean	11.09	12.78	11.95	11.94	83.24	79.11	80.81	80.81
$LSD_{0.05}$:								
Years	0.19				1.88			
kind of fertilizer	0.33				3.29			
years × kind of fertilizer	0.56				5.70			

Nitrate content in plants depends mainly on level of nitrogen fertilization and form of nitrogen. The ammonium and urea forms of nitrogen stimulates the nitrate reductase activity [10, 11]. Compared with cultivation without mineral fertilization, nitrate(V) contents associated with an application of singlenutrient fertilizers and multinutrient complex fertilizers were increased on average by 7.55 mg NO_3 · kg^{-1} f.m., and 3.66 to 11.59 mg NO_3 · kg^{-1} f.m. (Table 1). However, in no cases did it exceed the permissible content of 200 mg NO_3 · kg^{-1} f.m. The smaller was the differences associated with an application of Nitrophoska blue special, Polimag S and Viking 13, than with HydroComplex application. Studies by Jablonski [12] did not show a significant effect of Nitrophoska 12 special on nitrate(V) content in potato tubers. Of the multinutrient complex fertilizers applied, only HydroComplex significantly increased nitrate(V) content compared with singlenutrient fertilizers, the total nitrogen content in tuber dry

matter being similar. Following an application of HydroComplex nitrate(V) content was on average by 4.04 mg $NO_3 \cdot kg^{-1}$ f.m higher. Nitrate content in plants depends not only on nitrogen fertilization but also on sustainable fertilization with remaining macro- and microelements [3, 5, 13, 14]. Nitrates accumulate in plants when their uptake is greater than possibility of reduction. Of the multinutrient complex fertilizers with the nitrophoska group applied, HydroComplex contains most of magnesium and sulphur. Increase amount of magnesium in plant fertilization can contribute to increase of nitrate concentration by decrease in nitrate reductase activity [15]. In turn, increase of sulphates decrease in considerable degree uptake of molybdenum by plants, which is component of nitrate reductase [16]. In carrot fertilized with HydroComplex there was observed a reduction in nitrate(V) content. The beneficial influence of Hydro-Complex on the nitrate content in the carrot roots can be explained by the pace of nitrogen release from this fertilizer, adapted to the nutrition requirements of the plants [17]. Other authors reported that total nitrogen as well as nitrate(V) contents in potato tubers decreased following an application of the fertilizers Kemira solanum and Agro solanum [6, 7].

Table 2

Total N [$g \cdot kg^{-1}$ d.m.] and NO_3-N [$mg \cdot kg^{-1}$ f.m.] content in tubers in relation to the kind of fertilizer and cultivar

Kind of fertilizer	Total N				NO_3-N			
	'Aster'	'Fresco'	'Gloria'	mean	'Aster'	'Fresco'	'Gloria'	mean
Without fertilizer	11.81	12.98	10.81	11.86	77.22	75.67	73.67	75.52
Singlenutrient fertilizers	10.94	13.23	11.57	11.91	84.89	80.22	84.11	83.07
HydroComplex	12.06	12.62	11.02	11.90	86.11	85.67	89.56	87.11
Nitrophoska blue special	12.13	13.25	11.99	12.46	78.78	80.56	78.22	79.18
Polimag S	10.82	11.40	11.23	11.15	77.78	87.33	77.00	80.70
Viking 13	11.67	12.56	12.86	12.36	79.00	83.22	80.00	80.74
Mean	11.57	12.67	11.58	11.94	80.63	82.11	80.42	81.06
$LSD_{0.05}$:								
kind of fertilizer	0.33				3.29			
cultivar	0.16				1.57			
kind of fertilizer × cultivar	0.47				4.70			

Regardless of the kind of fertilizer applied, tubers of 'Fresco' cv. contained more total nitrogen compounds and nitrates(V) than 'Aster' and 'Gloria' cvs. (Table 2). Total nitrogen content and nitrate(V) content in the tubers of 'Fresco' cv. were on average, respectively, by 1.10 $g \cdot kg^{-1}$ d.m. and 1.58 mg $NO_3 \cdot kg^{-1}$ f.m. higher. The cultivars examined displayed a varied response to fertilizers applied. An application of Nitrophoska blue special and Viking 13 was followed by the highest increase in total nitrogen content in the tubers of, respectively, 'Aster' and 'Gloria' cvs. A higher increase in nitrate(V) content following an application of HydroComplex was recorded for tubers of 'Fresco' and 'Gloria' compared with 'Aster' cv.

Conclusions

1. Rainfall shortages over the potato growing season increased total nitrogen compound contents in tubers, which was accompanied by a considerable decreas in nitrate(V) concentration.

2. When the multinutrient complex fertilizers (nitrophoska group) Nitrophoska blue special and Viking 13 were applied, total nitrogen content in tubers was higher, and an application of HydroComplex resulted in similar total nitrogen contents compared with singlenutrient fertilizers.

3. An application of Polimag S (amophoska group) increased total nitrogen content compared with singlenutrient fertilizers only in the year with higher rainfall over the potato growing season.

4. Nitrate(V) contents in tubers increased only when the multinutrient complex fertilizer HydroComplex containing most of magnesium and sulphur of all with the nitrophoska group was applied.

5. Regardless of the kind of fertilizer applied, tubers of 'Fresco' cv. contained more total nitrogen and nitrates(V) than 'Aster' and 'Gloria' cvs.

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WPŁYW WIELOSKŁADNIKOWYCH NAWOZÓW KOMPLEKSOWYCH NA ZAWARTOŚĆ AZOTU OGÓLNEGO I AZOTANÓW(V) W BULWACH BARDZO WCZESNYCH ODMIAN ZIEMNIAKA

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Abstrakt: Porównywano wpływ wieloskładnikowych nawozów kompleksowych i nawozów jednoskładnikowych na zawartość azotu ogólnego i azotanów(V) w bulwach bardzo wczesnych odmian ziemniaka.

Po zastosowaniu wieloskładnikowych nawozów kompleksowych z grupy nitrofosek: Nitrophoska special niebieska i Viking 13, ogólna zawartość azotu w bulwach była większa, a po zastosowaniu HydroComplexu

podobna jak przy stosowaniu nawozów jednoskładnikowych. Stosowanie nawozu Polimag S, z grupy amofosek, tylko w roku z większą ilością opadów w okresie wegetacji ziemniaka powodowało zwiększenie ogólnej zawartości azotu w porównaniu z nawozami jednoskładnikowymi. Badania wykazały istotny wzrost zawartości azotanów(V) w bulwach tylko po zastosowaniu wieloskładnikowego nawozu kompleksowego HydroComplex, zawierającego najwięcej magnezu i siarki ze wszystkich stosowanych nitrofosek.

Słowa kluczowe: ziemniak, nawożenie, wieloskładnikowe nawozy kompleksowe, N ogólny, $N\text{-}NO_3$