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INFLUENCE OF VARIED DOSES AND FORMS OF MICROELEMENTS AND MEDIUM ON NITRATE(V) AND (III) CONTENT IN LETTUCE

WPŁYW ZRÓŻNICOWANYCH DAWEK I FORM MIKROELEMENTÓW ORAZ PODŁOŻA NA ZAWARTOŚĆ AZOTANÓW(V) I (III) W SAŁACIE

Abstract: Study carried out in 2005–2007 involving lettuce plants, the influence of varied doses and forms of microelements as well as subsoil types on nitrates(V) and (III) contents was determined. Nitrates were analyzed in fresh material by means of spectrophotometric method using Griess's reagent. Lower nitrate(V) concentration was found in plants cultivated in peat subsoil after applying basic (M1) rather than double (M2) microelement dose. No significant influence of the form of applied microelements was recorded; instead, considerable effect of their dose on nitrate contents at lettuce leaves was found. The tendency of decreasing the nitrate concentration in plants along with the increase of organic substance content was also recorded.

Keywords: nitrate(V) and nitrate(III), lettuce, microelements dose and form, peat, sand, soil

Vegetables are an essential element of human diet and are the largest source of nitrates(V) in food. According to FAO/WHO Expert Commission for Food Additives (JECFA), the *acceptable daily intake* (ADI) for nitrates(V) is from 0 to 3.7 mg $NO_3^- \cdot$ kg body weight daily and for nitrates(III) from 0 to 0.06 mg $NO_2^- \cdot$ kg body weight daily [1]. Studies indicate that these limits are often exceeded [2–4]. Currently obligatory maximum nitrates contamination levels for vegetables are set in the decree of Commission Regulation (UE) No. 1881/2006 from 19th December 2006 [5]. The nitrate contents in vegetables depends on genetic features as well as environmental and agrotechnical conditions. Nitrate, potassium, and microelement nutrition is one of the more important factors [6–9].

The present study aimed at evaluating the influence of varied doses and forms of microelements as well as subsoil types on nitrate(V) and (III) contents in lettuce.

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Materials and methods

The studies upon the lettuce (cv. Alanis) were carried out in 2005–2007 during the spring cultivation cycle in a greenhouse in pots of 2 dm^3 capacity. The cultivation period since the seed sowing till the completing lasted about 60 days in all study years. The experiment set in complete randomization pattern included 12 combinations. Each combination was represented by 8 experimental units consisting of a single pot with a single plant each.

Influences of the following factors were studied:

1. microelement forms: chelate or mineral;
2. microelement doses: basic – M 1, double – M 2;
3. subsoil type: peat – 85 % organic substance, soil + bark (v/v 3:1) 10 % organic substance, sand – 0 % organic substance.

Microelements were applied in following forms:

– chelates: iron – 7.5 % Fe (50 % EDTA, 50 % DTPA), copper – 12 % Cu (100 % EDTA), zinc – 14 % Zn (50 % EDTA, 50 % DTPA), manganese – 14 % Mn (50 % EDTA, 50 % DTPA), molybdenum – Molibdenit 3.0 % Mo, boron – Bormax 11 % B;

– mineral forms: iron – $FeSO_4$, copper – $CuSO_4 \cdot 5H_2O$, zinc – $ZnSO_4 \cdot 7H_2O$, manganese – $MnSO_4 \cdot H_2O$, boron – HBO_3, molybdenum – ammonium molybdate.

Following microelement doses were applied (in mg · dm^{-3} subsoil):

– M 1 – Fe – 20; Cu – 12.2; Zn – 7.4; Mn – 5.1; Mo – 3.7; B – 3.2 (basic);

– M 2 – Fe – 40; Cu – 24.4; Zn – 14.8; Mn – 10.2; Mo – 7.4; B – 6.4 (double).

The acidity of all subsoils was adjusted to pH 6.5. The whole microelement and phosphorus, 1/3 N, K, and Mg doses were applied during the pot filling with soil; the remaining N, K, and Mg amounts were used post-crop every 7 days. The content of nutritive components was sustained at the level of (in mg · dm^{-3}): 150 N; 200 P; 300 K; 100 Mg. Considering the whole vegetation period, following quantities of elements were applied (in g · $plant^{-1}$): nitrogen (N) – 1.2 (in a form of KNO_3 (13.5 %, 38 % K) and NH_4NO_3 – 34 % N; phosphorus (P) – 0.4 in a form of $(Ca(H_2PO_4)_2 \cdot H_2O$ – 20.2 % P); potassium (K) – 2.4 in a form of potassium nitrate (KNO_3); magnesium (Mg) – 0.75 in a form of magnesium sulfate ($MgSO_4 \cdot H_2O$ – 17.4 % Mg, while microelements as above. The moisture of subsoil was adjusted to the level of 70 %.

Contents of nitrates(V) and (III) were determined in fresh material directly after the harvest by means of spectrophotometric method using Griess's reagent according to PN-92/A-75112 [10].

Results were statistically processed applying variance analysis. The difference significance was verified on a base of t-Tukey's multiple confidence intervals at the significance level of $\alpha = 0.05$.

Results and discussion

Contents of nitrates(III) and (V) were determined in fresh leaves directly after lettuce harvest. Achieved results were listed in Table 1 as well as Figs. 1–2. No univocal dependence within nitrates(III) was found, because their concentrations oscillated from

Table 1

The content nitrate [mg NO_3^- · kg^{-1} f.m.] dependent microelements forms doses and mediums in lettuce

Kind of medium	Microelement		Years			Average for dose
	Form	Dose	2005	2006	2007	
Peat	chelat	M 1	1349	2138	1664	1717
		M 2	1445	2358	1979	1927
	mineral	M 1	1030	1979	1664	1558
		M 2	1215	2338	1979	1844
Average for peat			1260	2203	1822	1762
Soil + bark	chelat	M 1	1349	2338	2024	1904
		M 2	1619	2158	1484	1754
	mineral	M 1	1619	2338	1979	1979
		M 2	1259	2158	1644	1687
Average for soil + bark			1462	2248	1783	1831
Sand	chelat	M 1	2148	2158	2159	2155
		M 2	1619	1619	1484	1574
	mineral	M 1	1990	1979	2519	2163
		M 2	1349	1879	1799	1676
Average for sand			1777	1909	1990	1892
Average for years			1499	2120	1864	
Total average						1828

$LSD_{0.05}$ for dose – 119
for years – 202
for medium × dose – 380
for medium × years – 527

0 to 12 mg NO_2^- · kg^{-1} f.m. In majority of samples, there were trace amounts, thus those results are not shown in the tables.

Content of nitrates (V) at lettuce leaves (cv. Alanis) was significantly differentiated by the dose of applied microelements as well as dose and type of the subsoil. Regardless of microelement form used, plants cultivated on peat revealed lower level of nitrates (V) after applying basic (M1) than double (M2) microelement dose. In subsoil containing ≤ 10 % of organic substance, adverse dependence was recorded (Table 1, Fig. 2). Such results indicate that organic matter present in peat had a positive effect on nitrogen conversion in plants. This dependence can be confirmed by studies [11, 12] that revealed the greater nitrate(V) concentration in lettuce cultivated in sand, comparing with mineral soil, with the same level of nitrogen in subsoil (150 mg N · dm^{-3}).

Microelements were applied at the basic dose, that is commonly recommended for plants cultivated under covering, and double one. Achieved results confirmed a significant influence of applied microelement dose as well as the lack of considerable effects of their form. Lower nitrate(V) contents was found at plants fertilized with the double than basic microelement dose (Fig. 1). Therefore, present study prove that the

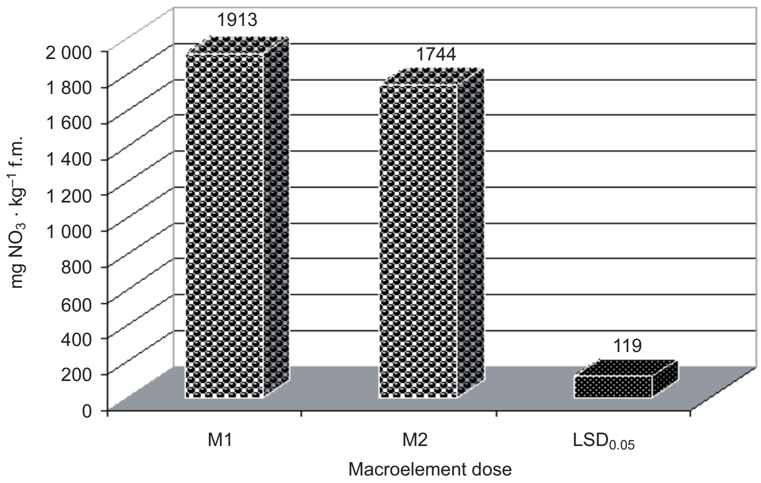

Fig. 1. Content nitrate(V) (in $NO_3^- \cdot kg^{-1}$ f.m.) dependent doses microelements in lettuce (average for years 2005–2007)

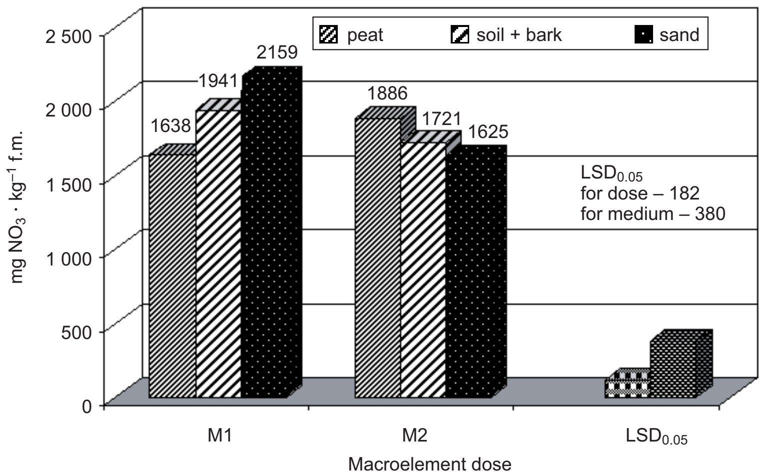

Fig. 2. Content nitrate(V) (in mg $NO_3^- \cdot kg^{-1}$ f.m.) dependent microelements doses and mediums in lettuce (average for years 2005–2007)

dose rather than form of applied microelements had greater influence on nitrate(V) concentration. In research [13] it has been indicated that lettuce tolerates better the deficit and overdose of microelements in peat rather than in mineral subsoil. Furthermore, the optimal level of microelements in subsoil has been estimated.

There was no significant effect of subsoils with varied contents of organic matter on nitrate level at lettuce plants. Although a tendency (Table 1) that the nitrate(V) content at lettuce decreased along with the organic substance content increase in a subsoil was apparent, their largest amounts were recorded in plants cultivated in sand, while the smallest – in peat. Similar dependence was observed in study [6, 14] upon lettuce and the subsoil influence on nitrate(V) contents.

Contents of nitrate were significantly differentiated when comparing results of studies carried out in different years (Table 1). This can be explained with various environmental conditions (light, its amount and intensity). Studies [8, 15] have also revealed significant impact of these factors on nitrate(V) concentration in lettuce.

Conclusions

1. Regardless of the microelement form applied for plants cultivated in peat subsoil, lower nitrates(V) content was recorded when basic (M1) rather than double (M2) microelement dose was used.
2. No significant influence of the microelement form was found, instead their dose appeared to have considerable impact on nitrate content at lettuce.
3. The tendency of decreasing the nitrate concentration at plants along with the increase of organic substance content was recorded.

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WPŁYW ZRÓŻNICOWANYCH DAWEK I FORM MIKROELEMENTÓW ORAZ PODŁOŻA NA ZAWARTOŚĆ AZOTANÓW(V) I (III) W SAŁACIE

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Abstrakt: W badaniach przeprowadzonych w latach 2005–2007 z sałatą określono wpływ zróżnicowanych dawek i form mikroelementów oraz podłoży na zawartość azotanów(V) i (III) w liściach sałaty. Zawartość azotanów oznaczono w świeżej masie roślin metodą spektrofotometryczną z odczynnikiem Griessa. Wykazano w roślinach uprawianych tylko w podłożu torfowym mniejszą zawartość azotanów(V) po zastosowaniu podstawowej dawki (M1) mikroelementów niż podwójnej (M2). Stwierdzono brak istotnego wpływu formy zastosowanych mikroelementów, natomiast wykazano istotny wpływ ich dawki na zawartość azotanów(V) w sałacie. Odnotowano tendencję, iż wraz ze wzrostem zawartości substancji organicznej w podłożu obniżała się zawartość azotanów(V) w roślinach.

Słowa kluczowe: azotany(V) i (III), sałata, dawki i formy mikroelementów, torf, piasek, gleba