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Włodzimierz SADY[1], Iwona KOWALSKA[1]
and Anna SZURA[1]

EFFECT OF NITROGEN FERTILIZATION ON THE YIELD AND CONTENT OF NITRATES IN RED BEET STORAGE ROOTS

WPŁYW NAWOŻENIA AZOTEM NA PLON I ZAWARTOŚĆ AZOTANÓW W KORZENIACH SPICHRZOWYCH BURAKA ĆWIKŁOWEGO

Abstract: Field experiment with red beet 'Boro F_1' cv. was carried out in 2005–2007. The aim of the research was to determine the effect of the kind of nitrogen fertilizer (ammonium sulfate or nitrate urea solution – RSM) and the way of fertilizer application either broadcasting (liquid spreading) or localized, with emphasis on diversified (divided) doses of nitrogen and foliar nutrition on the plant yield and the content of nitrates, ammonium form and protein nitrogen in red beet storage roots.

The kind of nitrogen fertilizer and the way of its application did not significantly affect the total yield of the roots. In all years of the experiment there was no repeated effect of experiment factors of the quantity of marketable yield. The effect of the examined factors on the content of nitrates in beet root depended on the year of cultivation. In 2005 pre-sowing fertilization, both broadcasting and localized in the dose of 67.5 kg $N \cdot ha^{-1}$ combined with foliar nutrition resulted in obtaining roots with a slightly lower content of nitrates in comparison with other fertilization ways. Further years of the experiment did not reveal such a tendency. The kind of applied fertilizer did not affect nitrates content in any year of the experiment. The concentration of ammonium nitrogen and protein nitrogen in the roots was not dependent on the kind of nitrogen fertilizer or the way of its application.

Keywords: fertilization method, foliar nutrition, CULTAN method, biological value

Nitrogen fertilization has a significant effect on the quality and quantity of vegetable yield. An increase in the doses of nitrogen fertilizer resulted in the rise in the yield of red beet root, Chinese cabbage and spinach with a simultaneous increase in nitrates concentration in plant tissue and a decrease in dry weight [1–3]. Also foliar nutrition with nitrogen affects the growth in plant yield [4–6].

Nitrogen accumulation in plant cells depends not only on the quantity of nitrogen in soil but also on its form. Many authors [3, 7] noticed the growth in nitrates content in

[1] Department of Soil Cultivation and Fertilization of Horticultural Plants, Faculty of Horticulture, University of Agriculture in Krakow, al. 29 Listopada 54, 31–425 Kraków, Poland, phone: +48 12 662 52 35, fax: +48 12 662 52 40, email: wjsady@ogr.ar.krakow.pl

plants fertilized with nitrate form of nitrogen when compared to plants fertilized with reduced form.

Decreased content of nitrates in vegetables was observed with the application of localized fertilization (CULTAN method) [8, 9]. Del Amor et al [10] demonstrated that replacing a part of soil nitrogen dose with foliar nutrition in the reduced form (urea or ammonium sulfate) results in decrease of nitrogen contents in lettuce.

The aim of this experiment was to determine the effect of nitrogen fertilization type and way of its application (broadcasting/liquid spreading and localized) and the division of nitrogen dose into pre-sowing part in combination with soil top dressing fertilization or foliar nutrition on the quantity of total and marketable yield, and the contents of nitrogen compounds in red beet roots, 'Boro F_1' cv.

Material and methods

The experiment with red beet root, 'Boro F_1' cv., cultivation was conducted in field conditions in the years 2005–2007 in Mydlniki village near Krakow. The plants were cultivated in the second year after manure application in light silt loam, containing 2.7 % organic matter. The content of P, K, Mg and Ca was assessed on the basis of soil chemical analysis and supplemented pre-sowing to the level suitable for beet root requirements. The content of mineral nitrogen (NO_3-N + NH_4-N) in soil before the application of fertilizers was 3–6 mg · dm^{-3}, and pH_{H_2O} 7.10–7.20.

The effect of the following factors was determined:

– kind of nitrogen fertilizer:

1) ammonium sulfate (20.5 % NH_4-N),
2) nitrate-urea solution (RSM; 7.5 % NH_4-N, 7.5 % NO_3-N, 15 % NH_2-N),

– way of N fertilizers application – broadcasting (liquid spreading) or localized with different (divided) nitrogen doses and foliar nutrition of the plants:

1) 100 % dose of soil N, pre-sowing broadcasting (liquid spreading),
2) 75 % dose of soil N, pre-sowing, broadcasting (liquid spreading) + 25 % dose of N as top dressing,
3) 75 % dose of soil N, pre-sowing, broadcasting (liquid spreading) + foliar nutrition,
4) 75 % dose of soil N, pre-sowing, localized,
5) 75 % dose of soil N, pre-sowing, localized + 25 % dose of N as top-dressing,
6) 75 % dose of soil N, pre-sowing, localized + foliar nutrition.

90 kg · ha^{-1} was treated as 100 % nitrogen dose. The experimental design was shown in Table 1.

There were 48 plots of 9.6 m^2 each (4 × 2.4 m) in the experiment. Four plots were assigned to every variant of the experiment.

Pre-sowing N fertilization was conducted on the sowing day. Ammonium sulfate was broadcast on the surface of the field, while the RSM fertilizers was dissolved in water (determined dose of RSM was dissolved in dm^3 of water) and spread evenly. After fertilizers application, the soil was stirred with rake. In the sites with localized fertilization, fertilizer was applied just after sowing in every second row at 7–10 cm.

Table 1

Experimental design

Kind of nitrogen fertilizer	Fertilization method		N dose [$kg \cdot ha^{-1}$]		
			Pre-sowing	Top-dressing	Foliar nutrition
Ammonium sulfate	1	broadcasting	90.0	—	—
	2		67.5	22.5	—
	3		67.5	—	14.1
	4	localized	67.5	—	—
	5		67.5	22.5	—
	6		67.5	—	14.1
Nitrate-urea solution (RSM)	1	broadcasting (liquid spreading)	90.0	—	—
	2		67.5	22.5	—
	3		67.5	—	14.1
	4	localized	67.5	—	—
	5		67.5	22.5	—
	6		67.5	—	14.1

Soil top-dressing fertilization was performed in designated sites at the initial stage of intensive plant growth (6 weeks after sowing – 6–8 leaves stage) in broadcasting manner with the use of ammonium sulfate or by liquid spreading with RSM solution (variants 2, 5). Plants in sites with foliar nutrition were sprayed three times (variants 3, 6). The date of first foliar nutrition treatment corresponded to the date of top-dressing fertilization, soil fertilization (17 July), and further spraying was conducted in two-week intervals (31 July and 14 August). In the first and third treatment the fertilization was conducted with 2 % urea solution, while in the second treatment 1 % solution of Supervit R (2.5 % NH_2-N, 1 % NO_3-N, 3.4 % K_2O, 0.6 % MgO + microelements) was applied, with the dose of 700–800 dm^3 solution per hectare. Total nitrogen dose applied in foliar nutrition was 14.1 $kg \cdot ha^{-1}$.

The sowing of seeds in the rows every 30 cm was performed in the first decade of June with the help of hand seed drill. Rouging was conducted after 10 days keeping 7 cm distance between plants.

During harvesting the quantity of marketable yield was estimated (roots 4–10 cm in diameter) and yield out of the selection. Chemical analyses of the roots were carried out directly after harvesting. 10 pieces of roots were collected from marketable yield from every site, washed in distilled water and shredded in homogenizer. The content of NO_3^- and NH_4^+ was determined in the obtained material with the use of ion selective electrode after prior extraction with 0.02 mol $\cdot$ dm^{-3} $Al_2(SO_4)_3$. Protein nitrogen was assessed with Kjeldahl method.

Average mean temperature in the years of the experiments was 16–19 ^oC June–August, with average rainfall at the level of 75–150 mm. The only exception was July 2006, with average temperature of 21 ^oC and rainfall of 20 mm. The lowest mean temperature during the whole vegetation period was measured in 2005 (17 ^oC).

The obtained results underwent a two-factor variance analysis (Statistica 7). Differences in means were analyzed with LSD Fischer test. Differences significance was declared at p = 0.05.

Results

The results obtained from individual years of the experiment are presented in Tables 2 and 3. Mean total yield of the red beet root was 72.1, 55.4 and 68.6 Mg · ha^{-1} for 2005, 2006 and 2007, respectively (Table 2). The yield was not dependent on the kind of applied fertilizer (ammonium sulfate, RSM) in any year of the experiment. Only in 2006 the way of fertilizer application influenced the quantity of total yield; the highest yield was obtained in the sites with broadcasting fertilization (with the use of ammonium sulfate) or liquid spreading (with the use of RSM) in combination with top dressing fertilization in soil (59.2 Mg · ha^{-1} on average). Slightly lower yield was obtained in the sites with localized fertilization combined with foliar nutrition (58.5 Mg · ha^{-1} on average). The lowest total yield of red beet roots in 2006 was observed after pre-sowing fertilization with nitrogen in localized way linked with top-dressing (50.4 Mg · ha^{-1} on average).

The analysis of the results from three years of experiments shows a slightly higher total beet root yield from the sites fertilized with the dose of nitrogen divided into pre-sowing and top-dressing applied into soil as liquid spreading. Localized fertilization did not reveal such an interrelation.

The influence of experiment factors on the marketable yield quantity was diversified in the individual years of the experiment (Table 2). In 2005 and 2007 higher marketable yield was obtained from the sites fertilized with RSM, while in 2006 from the sites fertilized with ammonium sulfate. In 2005 and 2006 these differences were statistically significant. The use of nitrogen fertilization as pre-sowing only in the full dose, ie 90 kg N · ha^{-1} (100 % dose of N) and the division of the dose into pre-sowing (75 % dose of N) applied in a traditional way combined with top-dressing fertilization influenced the highest marketable yield in 2005 and 2006 irrespectively of the way of pre-sowing way of fertilizer application to the soil. In 2006 the level of the yield was equally high in the site where nitrogen was applied pre-sowing in the form of deposit in combination with top-dressing foliar nutrition. This year revealed a significant cooperation between the kind of nitrogen fertilizer and the way it was applied. To provide the plants with nitrogen in case of ammonium nitrate it seemed a better way to use broadcasting method on the whole surface, and in case of RSM to introduce it in the form of nitrogen deposit.

In the last year of the experiments (2007) the way of fertilizer application did not have any significant effect on the yield quantity, though there was a tendency of higher yield of plants after the fertilization with full pre-sowing N dose, ie 90 kg · ha^{-1}.

The kind of used fertilizer and the way of its application did not bring any statistically significant effect on the concentration of NH_4^+ in red beet storage roots (Table 3).

The content of nitrates in red beet storage roots was considerably diversified in the individual years of the experiment (Table 3). The highest level of NO_3^- (2047 mg · kg^{-1} fm) was assessed in 2005, while nitrates content in the following years were similar and reached 1260 and 1374 mg · kg^{-1} f.m., in 2006 and 2007, respectively.

Table 2

Effects of nitrogen fertilizer type and fertilization method on the total and marketable yield of red beet roots in 2005–2007

Fertilizer	Fertilization method	Total [$Mg \cdot ha^{-1}$]				Marketable [$Mg \cdot ha^{-1}$]			
		2005	2006	2007	Means	2005	2006	2007	Means
$(NH_4)_2SO_4$	1*	72.3	58.2	66.4	*65.6*	60.9	57.1	58.3	*58.7*
	2	76.2	63.0	71.9	*70.4*	57.5	62.0	50.2	*56.6*
	3	70.4	61.5	66.6	*66.2*	49.7	58.3	57.2	*55.1*
	4	68.1	52.2	78.5	*66.3*	56.0	48.4	60.9	*55.1*
	5	68.5	48.0	69.1	*61.9*	53.8	46.1	57.7	*52.5*
	6	77.3	56.4	65.3	*66.3*	53.2	54.4	52.8	*53.5*
RSM	1	78.2	52.4	72.2	*67.6*	65.5	50.1	62.6	*59.4*
	2	69.6	55.5	71.6	*65.6*	60.6	50.6	61.0	*57.4*
	3	75.5	51.7	66.2	*64.5*	62.9	45.7	60.5	*56.4*
	4	71.3	52.2	64.9	*62.8*	57.1	51.0	56.9	*55.0*
	5	66.9	52.9	66.0	*61.9*	52.3	47.4	58.2	*52.7*
	6	74.3	60.7	64.9	*66.6*	54.1	57.8	62.1	*58.0*
Means for year:		*72.1*	*55.4*	*68.6*		*57.0*	*52.2*	*58.2*	
Means for factors:									
fertilizer	$(NH_4)_2SO_4$	72.1	56.6	69.6	*66.1*	55.2	54.4	56.2	*55.2*
	RSM	72.0	54.2	67.6	*64.6*	58.8	50.4	60.2	*56.5*
fertilization method	1	75.2	55.3	69.3	*66.6*	63.2	53.6	60.4	*59.1*
	2	72.9	59.2	71.8	*68.0*	59.1	56.3	55.6	*57.0*
	3	73.0	56.6	66.4	*65.3*	56.3	52.0	58.8	*55.7*
	4	69.7	52.2	71.7	*64.5*	56.5	49.7	58.9	*55.0*
	5	67.7	50.4	67.5	*61.9*	53.0	46.8	58.0	*52.6*
	6	73.9	58.5	65.1	*65.8*	53.6	56.1	57.5	*55.7*
$LSD_{0.05}$ for:	fertilizer	ns	ns	ns		3.15	3.70	ns	
	fertilization method	ns	6.19	ns		5.45	6.42	ns	
	interaction	ns	ns	ns		ns	9.07	ns	

* 1 – 90 kg N · ha^{-1} pre-sowing, broadcasting (liquid spreading); 2 – 67.5 kg N · ha^{-1} pre-sowing, broadcasting (liquid spreading) + 22.5 kg N · ha^{-1} as top dressing; 3 – 67.5 kg N · ha^{-1} pre-sowing, broadcasting (liquid spreading) + foliar nutrition; 4 – 67.5 kg N · ha^{-1} pre-sowing, localized; 5 – 67.5 kg N · ha^{-1} pre-sowing, localized + 22.5 kg N · ha^{-1} as top-dressing; 6 – 67.5 kg N · ha^{-1} pre-sowing, localized + foliar nutrition; ns – non-significant differences.

Table 3

Effects of fertilizer type and fertilization method on the contents of ammonium and nitrates and protein-N in red beet roots in 2005–2007

Fertilizer	Fertilization method	NH_4^+ [mg · kg^{-1} f.m.]				NO_3^- [mg · kg^{-1} f.m.]				Protein-N [% dm]			
		2005	2006	2007	Means	2005	2006	2007	Means	2005	2006	2007	Means
$(NH_4)_2SO_4$	1*	242	224	173	*213*	2160	1332	1340	*1611*	1.91	2.30	2.96	*2.39*
	2	202	243	191	*212*	2052	1587	1717	*1785*	1.88	2.35	3.00	*2.41*
	3	222	238	159	*206*	1621	1249	1328	*1399*	1.73	2.47	2.78	*2.33*
	4	212	255	161	*209*	2340	1028	1031	*1466*	1.81	2.30	3.01	*2.37*
	5	253	220	160	*211*	2300	1035	1292	*1542*	1.81	2.26	3.13	*2.40*
	6	274	243	180	*232*	2028	1441	1283	*1584*	1.77	2.10	3.08	*2.32*
RSM	1	221	220	165	*202*	2215	1343	1369	*1642*	1.80	2.25	3.03	*2.36*
	2	243	255	167	*221*	1987	1011	1269	*1422*	1.71	2.00	2.89	*2.20*
	3	173	240	181	*198*	1477	1351	1342	*1390*	1.94	2.48	2.87	*2.43*
	4	245	220	186	*217*	2313	1427	1368	*1703*	1.94	2.46	3.13	*2.51*
	5	207	228	192	*209*	2186	1166	1580	*1644*	2.14	2.25	3.00	*2.46*
	6	253	242	179	*225*	1881	1152	1561	*1531*	2.02	2.40	3.06	*2.50*
Means for year:		*229*	*236*	*175*		*2047*	*1260*	*1374*		*1.88*	*2.31*	*3.00*	
Means for factors:													
fertilizer	$(NH_4)_2SO_4$	234	237	171	*214*	2083	1279	1332	*1564*	1.82	2.30	3.00	*2.37*
	RSM	224	234	178	*212*	2010	1241	1415	*1555*	1.93	2.31	2.99	*2.41*
fertilization method	1	231	222	169	*208*	2188	1337	1354	*1626*	1.86	2.27	2.99	*2.37*
	2	223	249	179	*217*	2019	1299	1493	*1604*	1.79	2.17	2.94	*2.30*
	3	197	239	170	*202*	1549	1300	1335	*1394*	1.83	2.48	2.83	*2.38*
	4	229	237	174	*213*	2327	1227	1199	*1584*	1.87	2.38	3.07	*2.44*
	5	230	224	176	*210*	2243	1100	1436	*1593*	1.98	2.25	3.06	*2.43*
	6	263	242	179	*228*	1954	1296	1422	*1557*	1.90	2.25	3.07	*2.41*
$LSD_{0.05}$ for:	fertilizer	ns	ns	ns		ns	ns	ns		ns	ns	ns	
	fertilization method	ns	ns	ns		186.3	ns	ns		ns	ns	ns	
	interaction	ns	ns	ns		ns	ns	ns		ns	ns	ns	

* See Table 2.

Means calculated from the three years of the experiment for the kind of fertilizer point to a slightly higher concentrations of nitrates in the beet root fertilized with ammonium sulfate (1564 mg · kg^{-1} f.m.). Rather than those fertilized with RSM (1555 mg · kg^{-1} f.m.). Such tendencies were observed in 2005 and 2006. Fertilization way influenced the content of nitrates in the roots in 2005 only (Table 3). The lowest NO_3^- content was assessed in the roots of plants fertilized with 75 % N pre-sowing (in traditional and localized way) in combination with foliar nutrition (1549 and 1954 mg · kg^{-1} fm respectively), with its highest concentration in plants fertilized pre-sowing in a localized way (2327 mg · kg^{-1} f.m.). Such a dependency did not reoccur in the following years of the experiment.

The analysis of mean data from the three-year period of the research demonstrates that pre-sowing (broadcasting or liquid spreading) fertilization with a lowered dose of nitrogen (75 % N) was the most favourable fertilization way with regards to limited accumulation of nitrates in storage roots in comparison with the 100 % dose and to combination with foliar nutrition. Slightly higher contents of nitrates were assessed in the plants with foliar nutrition but in combination with pre-sowing lowered dose of N in the form of deposit.

The highest content of protein nitrogen (3.00 %) was observed in the roots of plants cultivated in 2007 (Table 3). In 2005 red beet plants contained 1.88 % on average and in 2006 – 2.31 % of protein nitrogen. What seems interesting is the lower content of protein nitrogen with simultaneous highest content of nitrates in the roots collected in 2005, in comparison with the other years of the experiment.

Discussion

The results of conducted research show the lack of any significant effect of the way of fertilization on the quantity of total yield of red beet storage roots. Sites fertilized in localized way (CULTAN method) were characterized by the yield similar to the plants fertilized in a traditional way (broadcasting/liquid spreading). Sommer [11] points to high effectiveness of CULTAN method, which allows reducing the dose of mineral nitrogen fertilizers by 20 % without the decrease in the yield. This author reveals that better effectiveness of this method results from the reduction of waste in fertilizer nitrogen in the soil. Our research demonstrated a tendency to decrease marketable yield as a result of fertilization with ammonium deposit method; in 2005 and 2006 the highest marketable yield was obtained in the sites fertilized in a localized way (single application and divided dose). These results can show that CULTAN method is not efficient enough in the cultivation of red beet root.

The effect of foliar nutrition of the quantity of marketable yield of red beet root is also interesting. In 2005 and 2006 the replacement of nitrogen dose applied to soil with foliar nutrition caused similar results as on the sites with soil fertilization only. It is particularly favourable result with regards to the possibility of reducing environment burden with nitrogen while preserving similar yield. Only in 2005 the sites nourished foliarly were characterized by lower marketable yield than the plants fertilized pre-sowing with full N dose (100 % broadcasting/liquid spreading). It is possible that rainfall and temperature conditions, on which effectiveness of foliar nutrition depends influenced this result [12]. The study by some authors [5, 6, 13] clearly demonstrated that the use of foliar nutrition, supplementing plant nourishment with N, with limited soil fertilization (reduces doses), influenced the increase in the yield quantity.

There were significant differences in yield quantity in individual years of the experiment. The lowest yield was obtained in 2006. This year was characterized by the period of high temperatures (mean temperature in July equaled 21 ^{o}C) and drought (rainfall in July amounted 20 mm), which could have had a negative influence on plant growth and development.

The greatest differences in the nitrates concentrations in beet root were observed between the years of the experiment which can indicate that environment conditions can have a greater effect on the contents of nitrogen rather than its kind and way of application to soil. Many authors [14, 15] revealed that nitrates content in plant tissue depends on diverse natural factors, including sunshine. In a study of Wang and Li [3] higher nitrates content was observed in vegetables fertilized with oxidized form of nitrogen in comparison with fertilization with ammonium nitrogen form. In our experiment, the use of ammonium sulfate containing reduced N form only, slightly influenced the decrease in NO_3^- ions in red beet storage roots in one year of experiment.

Localized fertilization did not affect decrease in nitrates content in red beet yield and in 2005 the plants fertilized with ammonium deposit belonged to the sites with their highest concentrations. Thus, it did not confirm the results obtained by others [9, 16] pointing to the reduction in nitrates content in the plants fertilized with CULTAN method. Del Amor et al [10] revealed that foliar nutrition with urea allows reducing the content of nitrates in vegetable yield. Our research corroborated such a dependency only in 2005, where the use of 67.5 kg · ha^{-1} dose of nitrogen as pre-sowing combined with foliar nutrition in the vegetation period resulted in plants with considerably lower nitrates content when compared with the plants fertilized pre-sowing with full nitrogen dose 90 kg · ha^{-1} N and divided dose, ie 67.5 kg · ha^{-1} N pre-sowing + 22.5 kg · ha^{-1} N as top-dressing, to the soil.

The research did not reveal the effect of the kind of nitrogen fertilizer or the way of its application on the content of protein-N in red beet storage roots. The increase in protein-N quantity after the application of foliar nutrition has already been observed by del Amor et al [10].

Conclusions

1. The kind of nitrogen fertilizer or the way of its application did not affect the quantity of total yield of red beet roots and the effect on marketable yield was diversified between the years of the experiment.
2. In comparison with traditional fertilization method (broadcasting/liquid spreading) the fertilization with CULTAN method did not result in the increase of biological quality of red beet root yield.
3. There were tendencies for decreasing the concentrations of nitrates in the roots of plants fertilized pre-sowing combined with foliar nutrition.

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References

[1] Chen B.M., Wang Z.H., Li S.X., Wang G.X., Song H.X. and Wang X.N.: Plant Sci. 2004, **167**, 635–643.
[2] Pavlou G.C., Ehaliotis C.D. and Kavvadias V.A.: Sci. Hort. 2007, **111**, 319–325.
[3] Wang Z.H. and Li S.X.: J. Plant Nutr. 2004, **27**(3), 539–556.
[4] Bahr A.A.: Res. J. Agric. Biol. Sci. 2007, **3**(4), 220–223.
[5] Satoshi S., Toshihiro M. and Yoichi N.: Sci. Bull. Facul. Agric. 2006, **61**(1), 63–67.
[6] Yildirim E., Guvenc I., Turan M. and Karata A.: Plant Soil Environ. 2007, **53**(3), 120–128.
[7] Stagnari F., Di Bitetto V. and Pisante M.: Sci. Hort. 2007, **114**, 225–233.
[8] Blanke M. and Bacher W.: Acta Hort. 2001, **563**, 61–66.
[9] Sommer K.: [in:] Landbauforschung Völkenrode, Anbauverfahren mit N-Injektion (CULTAN) Ergebnisse, Perspektiven, Sonderheft 2001, **245**, 1–22.
[10] del Amor F.M., Molina A S., Espinosa M.F., Varó P. and Gómez M.C.: Acta Hort. 2007, **761**, 403–408.
[11] Sommer K.: [in:] VDI-MEG Kolloquium Agrartechnik, Anbau-, Ernte- und Nacherntetechnologie von Zuckerrüben Institut für Landtechnik, Rheinische Friedrich-Wilhelm-Universität Bonn 1997, **23**, 68–82.
[12] Wójcik P.: Uptake of Mineral Nutrients from Foliar Fertilization (Review). J. Fruit Orn. Plant Res. Spec. Ed. 2004, **12**, 201–218.
[13] Ling F. and Silberbush M.: J. Plant Nutr. 2002, **25**(11), 2333–2342.
[14] Campbell W.H.: Ann. Rev. Plant Physiol. Mol. Biol. 1999, **50**, 277–303.
[15] Escobar-Gutierrez A.J. and Burns I.G.: J. Hort. Sci. Biotech. 2002, **77**(2), 232–237.
[16] Schumacher F.J.: [in:] Landbauforschung Völkenrode, Anbauverfahren mit N-Injektion (CULTAN) Ergebnisse, Perspektiven, Sonderheft 2001, **245**, 63–68.

WPŁYW NAWOŻENIA AZOTEM NA PLON I ZAWARTOŚĆ AZOTANÓW W KORZENIACH SPICHRZOWYCH BURAKA ĆWIKŁOWEGO

Katedra Uprawy Roli i Nawożenia Roślin Ogrodniczych
Uniwersytet Rolniczy im. Hugona Kołłątaja w Krakowie

Abstrakt: Doświadczenie polowe z burakiem ćwikłowym odm. 'Boro F_1' przeprowadzono w latach 2005–2007. Badano wpływ rodzaju nawozu azotowego (siarczan amonu lub roztwór saletrzano-mocznikowy – RSM) oraz sposobu ich stosowania – rzutowe (rozlewowe) lub zlokalizowane z uwzględnieniem zróżnicowanych (dzielonych) dawek azotu i dolistnego dokarmiania roślin na plonowanie oraz zawartość azotanów, formy amonowej i azotu białkowego w korzeniach buraka ćwikłowego.

Rodzaj nawozu azotowego oraz sposób jego stosowania nie miały wpływu na plon ogólny korzeni. Nie wykazano także powtarzalnego w latach badań wpływu czynników doświadczenia na ilość plonu handlowego.

Wpływ badanych czynników na zawartość azotanów w korzeniach buraka zależał od roku uprawy. W 2005 r. po zastosowaniu nawożenia przedsiewnego rzutowego i zlokalizowanego w dawce 67,5 kg N · ha^{-1} w połączeniu z dokarmianiem dolistnym uzyskano korzenie o mniejszej zawartości azotanów w porównaniu z pozostałymi sposobami nawożenia. W kolejnych latach uprawy nie wykazano takiej zależności. Rodzaj zastosowanego nawozu w żadnym roku badań nie miało wpływu na zawartość azotanów. Zawartość azotu amonowego oraz azotu białkowego w korzeniach buraka nie zależała od rodzaju nawozu azotowego oraz sposobu nawożenia.

Słowa kluczowe: sposób nawożenia, nawożenie dolistne, metoda CULTAN, wartość biologiczna