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THE CONTENT OF MINERAL AND PROTEIN NITROGEN IN RED BEET DEPENDING ON NITROGEN FERTILIZER TYPE AND FERTILIZATION METHOD

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Abstract. The experiment with 'Boro F_1' red beet was aimed at determining the effect of the kind of nitrogen fertilizer (RSM, ENTEC 26) and the manner of application (broadcasting/liquid spreading, with / without foliar nutrition) on the content of protein nitrogen in roots, and ammonium and nitrate nitrogen content in leaves and roots of red beet. The kind of applied fertilizer did not have any influence on the size of examined parameters. In 2005 foliar nutrition with nitrogen caused a decline in nitrate concentrations in leaves and roots of the plants in comparison with unnourished objects; however, such correlation was not corroborated in the following years of the cultivation. Quantities of all examined parameters were diversified depending on the cultivation year.

Key words: nitrates, urea-ammonium nitrate solution, ENTEC 26, CULTAN, foliar nutrition

INTRODUCTION

Nitrogen is a part of amino acids, pyrimidine, purine bases, and nucleotides and many other compounds, thanks to which it participates in almost every biochemical reaction occurring in living organisms [Gabryś 2002]. Plants assimilate this element mainly in the form of nitrate or ammonium ion. An assimilated ammonium ion can be directly incorporated into organic nitrogen compounds, while a nitrate ion has to undergo reduction process. This ion can be a reserve form of nitrogen in plant [Marschner 1995, Gabryś 2002]. Millard [1988] writes that N-total and nitrate nitrogen ratio in plant tissue can be, depending on the species, up to 0.08–0.61. The results of numerous experiments [ZhaoHui and ShengXiu 2004] demonstrate that particular species of plants accumulate nitrates in different organs. In pe-tsai and pak-choi cabbage, and in rape, higher content of nitrates were assessed in roots, shoots and leaf peduncles than in leaves.

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Striving for the reduction of nitrates content in vegetables results from their harmfulness for consumers. In human digestive system nitrates are reduced to nitrites which in turn are capable of fixing with hemoglobin, causing an illness known as methemoglobinemia. Nitrites presence in human organism can also lead to the creation of carcinogenic N-nitrosamines [Doel et al. 2004, Krul et al. 2004].

As presented by Hëhndel et al. [1994], the use of reduced forms of fertilizer nitrogen i.e. N-NH_4, N-NH_2 supplemented with nitrification inhibitors causes a significant decrease in N-NO_3 accessibility for plants, which in turn reduces the possibility of nitrates accumulation in plant tissue. Hëhndel et al. [1994] observed a decline in nitrates content in red cabbage and celery after the application of DCD nitrification inhibitor. Similar results were obtained by Müller and Wedler [1987] in the experiment with red beet. Kołota and Adamczewska-Sowińska [2007], as well as Krężel and Kołota [2007] noted a decrease in nitrates concentrations in leek and red beed roots after the use of ENTEC 26 fertilizer containing DMPP nitrification inhibitor.

Lowered nitrification of reduced forms of fertilizer nitrogen can be obtained with the help of CULTAN fertilizing method [Sommer 2001], which means introducing nitrogen fertilizers to soil in a localized manner.

Decreased nitrates content in the yield was also noted after the application of foliar nutrition treatment of pepper [del Amor et al. 2007] and lettuce [Biesiada 2005] with fertilizers containing reduced forms of nitrogen. Other experiments do not corroborate this correlation [Kowalska et al. 2006, Smoleń et al. 2006].

The aim of this experiment was to determine the effect of nitrogen fertilizer type i.e. Urea-ammonium nitrate solution (RSM) and ENTEC 26 (containing nitrification inhibitor), and the manner of their application on the content of nitrate and ammonium form of nitrogen in leaves and roots, and protein nitrogen in roots of red beet.

MATERIAL AND METHODS

The experiment with 'Boro F_1' red beet cultivation was conducted in field conditions in the years 2005–2007 in Mydlniki near Krakow. The plants were cultivated in light silt loam with pH_{H2O} – 7.25, containing 2.7% organic matter. The content of P, K, Mg and Ca was assessed on the basis of soil chemical analysis and supplemented to the level suitable for red beet requirements.

Nitrogen fertilization was performed directly before sowing with the use of the following fertilizers:

– urea-ammonium nitrate solution (RSM – 7.5% N-NH_4, 7.5% N-NO_3, 15% N-NH_2; produced by Zaklady Azotowe in Tarnow);

– ENTEC 26 (18.5% N-NH_4, 7.5% N-NO_3 + DMPP nitrification inhibitor; produced by COMPO/BASF).

Nitrogen fertilizers were introduced into soil in the following manner:

S-100% – 90 kg · ha^{-1} N pre-sowing, broadcasting/liquid spreading
S-75% + F – 67.5 kg · ha^{-1} N pre-sowing, broadcasting/liquid spreading + foliar nutrition
L-75% – 67.5 kg · ha^{-1} N pre-sowing, localized manner
L-75% + F – 67.5 kg · ha^{-1} N pre-sowing, localized manner + foliar nutrition

Pre-sowing fertilization was performed on the day of sowing i.e. in the first decade of June. In objects with localized fertilization, nitrogen fertilizer was introduced in the form of ammonium deposit in every second between-row on 7–10 cm deep in the soil, also during sowing. In objects with foliar nutrition during vegetation period the plants were treated three times with foliar nutrition. First treatment was conducted in the initial phase (6–8 leaves) of intensive plant growth (17^{th} July), with two next treatments in two-week intervals (31^{st} July and 14^{th} August). 2% solution of urea was applied in the first and third foliar nutrition treatment, while 1% solution of Supervit R ($N\text{-}NH_2$ 2.5%, $N\text{-}NO_3$ 1%, K_2O 3.4%, MgO 0.6% + microelements) was used in the second treatment.

Plant harvesting took place in the first decade of September. The plants were divided into root and leaves and next shredded with the use of mixer/shredder. In obtained pulp after extraction with 0.02 M $Al_2(SO_4)_3$ the content of $N\text{-}NH_4$ and $N\text{-}NO_3$ was assessed with the help of ion-selective electrode (Orion). Protein nitrogen in roots was determined by Kjeldahl method [Persson and Wennerholm 1999]. N-total was calculated from the amount of protein and nitrate nitrogen.

The results were subjected to the two-way analysis of variance (Statistica 7) with type of fertilizer and method of fertilization being the experimental factors. The differences between means were analyzed by LSD Fischer test and the significance of differences was declared at P = 0.05.

RESULTS

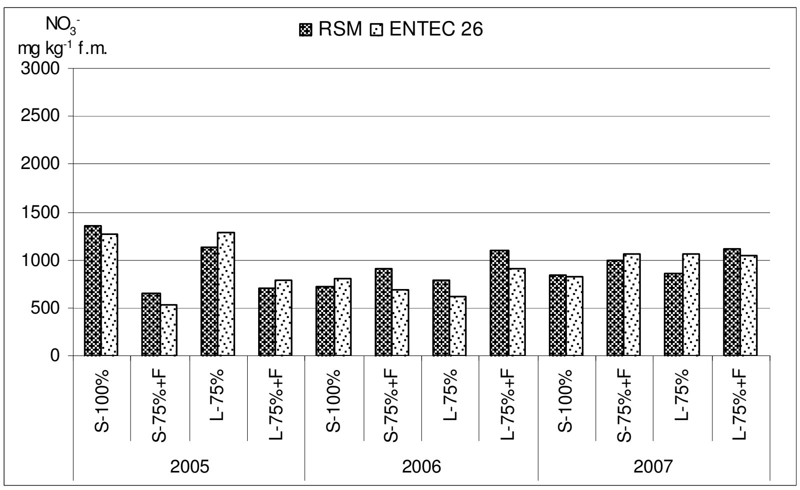
Mean content of ammonium form of nitrogen in red beet leaves was 237, 311 and 205 mg × kg^{-1} f.w. in 2005, 2006 and 2007, respectively. There was no significant influence of the applied type of nitrogen fertilizer and fertilization manner on the value of this parameter (tab. 2). No correlations between experiment factors and the level of ammonium form of nitrogen were noted in storage roots tissue (tab. 3). The highest contents of NH_4^+ in roots were assessed in 2006 (242 mg · kg^{-1} f.w.), while in 2005 – 197, and in 2007 – 178 mg · kg^{-1} f.w.

Table 1. Mean air temperature (°C) and rain fall (mm) and number of sunny hours (h) in area of Mydlniki

Tabela 1. Średnia temperatury powietrza (°C) i sumy opadów (mm) oraz liczba godzin słonecznych (h) w rejonie Mydlnik

Year Rok	Temperature – Temperatura			Rain – Opady			Sunny hours – Usłonecznienie		
	June czerwiec	July lipiec	August sierpień	June czerwiec	July lipiec	August sierpień	June czerwiec	July lipiec	August sierpień
2005	17.0	19.9	17.3	40.6	113.4	102.6	225	208	168
2006	21.1	20.9	18.8	89.4	14.2	104.1	215	362	155
2007	19.1	20.0	19.0	76.6	56.8	24.6	238	263	207

The content of nitrates in red beet leaves was: 963, 815 and 974 mg · kg^{-1} f.w. in 2005, 2006 and 2007, respectively. The size of nitrates accumulation did not depend on the type of applied nitrogen fertilizer in any year of the experiment (tab. 2). In 2005 a meaningful correlation between the manner of nitrogen fertilizers application and nitrates content in red beet leaves tissue was found. The plants with foliar nutrition (objects S-75% + F and L-75% + F) were characterized by a significantly lower level of examined compound (590 and 738 mg · kg^{-1} f.w. respectively) in comparison with the plants fertilized exclusively pre-sowing into soil (1311 and 1212 mg·kg^{-1} f.w. respectively in objects S-100% and L-75%). In the following years of the cultivation nitrates content in red beet leaves was not dependent on the fertilization manner; yet a tendency to elevated level of NO_3^- was observed in the leaves of plants with foliar nutrition (chart 1).



*S-100% – 90 kg × ha^{-1} N pre-sowing. broadcasting/liquid spreading; S-75% + F – 67.5 kg · ha^{-1} N pre-sowing. broadcasting/liquid spreading + foliar nutrition; L-75% – 67.5 kg · ha^{-1} N pre-sowing. localized manner; L-75% + F – 67.5 kg · ha^{-1} N pre-sowing. localized manner + foliar nutrition

*S-100% – 90 kg · ha^{-1} N przedsiewnie, w sposób rzutowy/rozlewowy; S-75% + F – 67,5 kg · ha^{-1} N przedsiewnie, w sposób rzutowy/rozlewowy + dokarmianie dolistne; L-75% – 67,5 kg · ha^{-1} N przedsiewnie, w sposób zlokalizowany; L-75% + F – 67,5 kg · ha^{-1} N przedsiewnie, w sposób zlokalizowany + dokarmianie dolistne

Fig. 1. Effect of interaction between nitrogen fertilizer type and fertilization method on the contents of nitrate nitrogen form in red beet leaves

Rys. 1. Wpływ współdziałania rodzaju nawozu azotowego i sposobu nawożenia na zawartość azotanów w liściach buraka ćwikłowego

Nitrates content in red beet roots was varied depending on the year of cultivation. The highest contents in red beet roots were assessed in 2005 – 1958 mg · kg^{-1} f.w. (tab. 3), while in the next years of the experiment similar concentrations if this element (1306 and 1272 mg · kg^{-1} f.w. in 2006 and 2007 respectively) were noted.

Table 2. Effects of nitrogen fertilizer type and fertilization method on the contents of ammonium and nitrate nitrogen form in red beet leaves
Tabela 2. Wpływ rodzaju nawozu azotowego i sposobu nawożenia na zawartość amonowej i azotanowej formy azotu w liściach buraka ćwikłowego

Treatments – Obiekty		NH_4^+ (mg · kg^{-1})				NO_3^- (mg · kg^{-1})			
		2005	2006	2007	mean średnia	2005	2006	2007	mean średnia
Means for: Średnia dla:									
fertilizer	RSM	251	291	195	245	958	875	949	927
nawozu	ENTEC 26	224	330	214	256	967	755	999	907
fertilization	S-100%	254	322	180	252	1311	761	833	968
method*	S-75%+F	191	324	222	246	590	797	1030	805
sposobu	L-75%	250	275	205	244	1212	700	960	958
nawożenia**	L-75%+F	253	319	212	261	738	1003	1073	938
LSD$_{0,05}$ for: NIR$_{0,05}$ dla:	fertilizer – nawozu	n.s.	n.s.	n.s.		n.s.	n.s.	n.s.	
	fertilization method sposobu nawożenia	n.s.	n.s.	n.s.		297.9	n.s.	n.s.	
	interaction współdziałania	n.s.	n.s.	n.s.		n.s.	n.s.	n.s.	

*S-100% – 90 kg · ha^{-1} N pre-sowing. broadcasting/liquid spreading; S-75% + F-67.5 kg · ha^{-1} N pre-sowing. broadcasting/liquid spreading + foliar nutrition; L-75% – 67.5 kg · ha^{-1} N pre-sowing. localized manner; L-75% + F – 67.5 kg · ha^{-1} N pre-sowing. localized manner + foliar nutrition; n.s.- non-significant differences
**S-100% – 90 kg · ha^{-1} N przedsiewnie, w sposób rzutowy/rozlewowy; S-75% + F – 67,5 kg · ha^{-1} N przedsiewnie, w sposób rzutowy/rozlewowy + dokarmianie dolistne; L-75% – 67,5 kg · ha^{-1} N przedsiewnie, w sposób zlokalizowany; L-75% + F – 67,5 kg · ha^{-1} N przedsiewnie, w sposób zlokalizowany + dokarmianie dolistne; n.s. – różnice nieistotne

Table 3. Effects of nitrogen fertilizer type and fertilization method on the contents of ammonium and nitrate nitrogen form in red beet roots

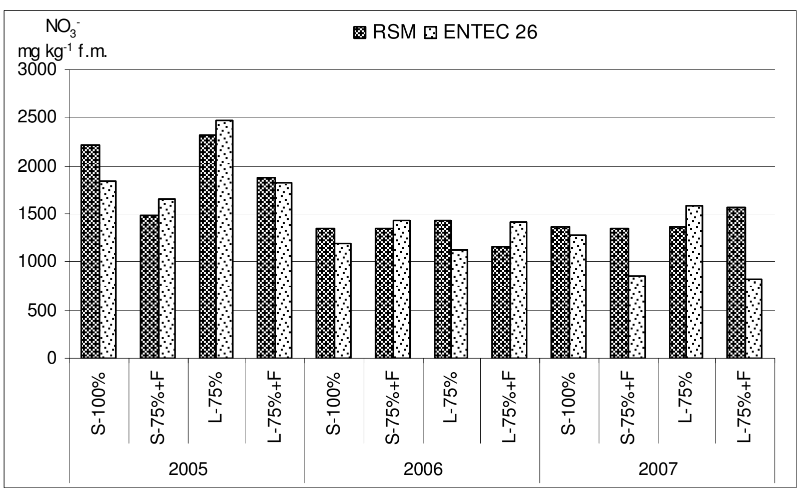
Tabela 3. Wpływ rodzaju nawozu azotowego i sposobu nawożenia na zawartość amonowej i azotanowej formy azotu w korzeniach spichrzowych buraka ćwikłowego

Treatments – Obiekty		NH_4^+ (mg · kg^{-1})				NO_3^- (mg · kg^{-1})			
		2005	2006	2007	mean średnia	2005	2006	2007	mean średnia
Means for: Średnia dla:									
fertilizer	RSM	217	230	178	208	1971	1318	1410	1566
nawozu	ENTEC 26	176	254	178	203	1946	1294	1134	1458
fertilization	S-100%	198	237	158	198	2024	1267	1325	1539
method*	S-75% + F	188	248	183	206	1566	1395	1098	1353
sposobu	L-75%	216	236	188	213	2397	1277	1473	1716
nawożenia**	L-75% + F	184	247	183	205	1848	1286	1191	1442
$LSD_{0.05}$ for: $NIR_{0,05}$ dla:	fertilizer – nawozu	n.s.	n.s.	n.s.		n.s.	n.s.	n.s.	
	fertilization method sposobu nawożenia	n.s.	n.s.	n.s.		212.5	n.s.	n.s.	
	interaction współdziałania	n.s.	n.s.	n.s.		300.5	n.s.	n.s.	

Note: see Table 2 – Objaśnienia jak w tabeli 2

All years of the experiment were characterized by a slight decline in nitrates content in red beet roots fertilized with ENTEC 26 in comparison to the plants fertilized with RSM. Those differences were most visible in 2007: the roots of plants fertilized with ENTEC 26 accumulated 1134 mg · kg^{-1} f.w., while those fertilized with RSM – 1410 mg · kg^{-1} f.w. However, these variations were not statistically significant.

Nitrogen fertilization manner did not have any significant effect on nitrates content in red beet roots in 2005 (tab. 3). As in case of leaves, the lowest level of NO_3^- was noted in the plants fertilized in broadcasting/liquid spreading manner combined with foliar nutrition (S-75% + F – 1566 mg · kg^{-1} f.w.) and fertilized in a localized manner in combination with foliar nutrition (L-75% + F – 1848 mg · kg^{-1} f.w.). The plants fertilized in a broadcasting/liquid spreading manner only (S-100%) were characterized by nitrates content on the level of 2024 mg · kg^{-1} f.w., while the highest concentrations of this compound were assessed in the roots of plants fertilized with localized manner only (L-75% – 2397 mg · kg^{-1} f.w.). A similar tendency was observed in 2007 (chart 2), and in 2006 the highest amount of nitrates was observed in the plants fertilized in broadcasting/liquid spreading manner combined with foliar nutrition (L-75% + F – 1395 mg · kg^{-1} f.w.). In 2005 there was a significant influence of experiment factors interaction on the content of nitrates in roots (chart 2). The highest amounts of nitrates were found in the object where ENTEC 26 was applied in a localized manner (L-75% – 2480 mg · kg^{-1} f.w.), while the lowest content of NO_3^- (1477 mg · kg^{-1} f.w.) was noted in the plants fertilized with RSM in liquid spreading manner combined with foliar nutrition (S-75% + F).



Note: see Figure 1 – Objaśnienia jak na rysunku 1

Fig. 2. Effect of interaction between nitrogen fertilizer type and fertilization method on the contents of nitrate nitrogen form in red beet roots

Rys. 2. Wpływ współdziałania rodzaju nawozu azotowego i sposobu nawożenia na zawartość azotanów w korzeniach spichrzowych buraka ćwikłowego

Table 4. Effects of nitrogen fertilizer type and fertilization method on the contents of protein-N (% d.m.) and on the ratio of nitrate-N to total-N in red beet roots

Tabela 4. Wpływ rodzaju nawozu azotowego i sposobu jego stosowania na zawartość azotu białkowego (% s.m.) oraz na stosunek azotu azotanowego do azotu ogółem w korzeniach buraka ćwikłowego

Treatments – Obiekty		Protein-N				$N\text{-}NO_3 : N_{total}$			
		2005	2006	2007	mean średnia	2005	2006	2007	mean średnia
Means for: Średnia dla:									
fertilizer nawozu	RSM	1.93	2.40	3.02	2.45	0.181	0.091	0.095	0.122
	ENTEC 26	2.00	2.30	2.92	2.41	0.168	0.098	0.078	0.115
fertilization method* sposobu nawożenia**	S-100%	1.88	2.21	2.90	2.33	0.186	0.097	0.091	0.125
	S-75% + F	1.87	2.47	2.92	2.42	0.152	0.095	0.079	0.109
	L-75%	1.97	2.36	3.01	2.45	0.202	0.092	0.098	0.131
	L-75% + F	2.13	2.35	3.04	2.51	0.157	0.095	0.079	0.110
$LSD_{0.05}$ for: $NIR_{0,05}$ dla:	fertilizer – nawozu	n.s.	n.s.	n.s.		n.s.	n.s.	n.s.	
	fertilization method sposobu nawożenia	n.s.	n.s.	n.s.		0.0299	n.s.	n.s.	
	interaction współdziałania	n.s.	n.s.	n.s.		n.s.	n.s.	n.s.	

Note: see Table 2 – Objaśnienia jak w tabeli 2

Mean content of protein nitrogen in red beet roots was 1.96, 2.35 and 2.97% d.w. in 2005, 2006 and 2007 individually and did not depend on the factors of the experiment (tab. 4). The ratio of nitrate nitrogen to N-total in the roots was maintained on the level of 0.079–0.202 (tab. 4). The highest mean values of $N\text{-}NO_3^-$ in N-total were obtained in 2005 (ratio $N\text{-}NO_3/N$ – 0.175), with the lowest in 2007 (ratio $N\text{-}NO_3/N$ – 0.087). The year 2005 revealed the effect of fertilization manner on the share of $N\text{-}NO_3^-$ in N-total. In plants nourished / fertilized foliarly (S-75% + F and L-75% + F) the ratio of nitrates nitrogen to N-total was 0.152 and 0.157 respectively, and was significantly lower than in the plants fertilized in a localized manner exclusively (L-75%), on the level 0.202. Similar tendencies were observed in 2007.

DISCUSSION

Conducted experiments did not corroborate the effect of nitrogen fertilizer type or fertilization manner on the content of ammonium form of nitrogen in red beet leaves and roots. Thus, the use of fertilizers containing significant amounts of nitrogen in reduced forms and the methods inhibiting nitrification processes (DMPP nitrification inhibitor in ENTEC 26 fertilizer, CULTAN method), as well as the combination of those two methods, did not influence the accumulation of ammonium nitrogen form in plant tissue. It may be a result of toxicity of $N\text{-}NH_4$ high concentrations in root environment [Britto and Kronzucker 2002], which influences plants regulation of the pace of this nitrogen form intake depending on the amount of substrates capable of fixing this compound [Sommer 2001]. This correlation makes it possible for plants to control nitrogen intake supplied in the form of ammonium ion.

The content of nitrates in leaves and roots of red beet was not dependent on the applied nitrogen fertilizer type. Thus, it did not corroborate the results by Kołota and Adamczewska-Sowińska [2007], and Krężel and Kołota [2007], who demonstrated that the use of ENTEC 26 leads to a lowered nitrates content in leek and red beet.

In 2005 a correlation was revealed between fertilization manner and nitrates content in red beet leaves. Lowering of N dose (75% N) applied to soil in broadcasting/liquid spreading or localized manner combined with foliar nutrition resulted in obtaining plants with lowered level of nitrates in leaves in comparison to the plants fertilized in pre-sowing way only. Similarly, Biesiada [2005] observed a positive effect of foliar nutrition with nitrogen on a decrease in nitrates content in lettuce leaves, while Wojciechowska et al. [2005] – in broccoli. This correlation was not confirmed in the following years of our experiment as 2006 and 2007 were characterized by a small increase of this parameter in leaves nourished foliarly (tab. 2). Bednarz et al. [1998] observed an increase in the content of nitrate ion in cotton plant leaves fed with urea, but Kowalska et al. [2006] did not present any effect of foliar nutrition on the content of nitrates in lettuce leaves. Results of numerous experiments demonstrate that the effect of foliar nutrition on the content of nitrates in assimilating parts of the plant is variable and most probably dependent on other factors e.g. weather conditions.

The content of mineral form of nitrogen in red beet leaves was varied in the years of our experiment. In 2006 with drought occurring in vegetation period (July) (tab. 1), the lowest concentrations of nitrates were assessed, and the highest content of ammonium ion in red beet tissue was noted. It could have resulted from the reduction of nitrification intensification in the conditions of low humidity, which led to plant intake of ammonium nitrogen. Also in storage roots of plants cultivated in 2006, relatively low contents of nitrates were observed. The lowest accumulation of NO_3^- in red beet storage roots was assessed in 2007 distinguished by a limited amount of rainfall in the period preceding plant harvesting (25 mm H_2O in August), which to some extent could have reduced nitrification process. Simultaneously, a high number of sunshine hours caused an increase in the effectiveness of nitrates reduction in plant cells. The process of nitrates reduction is dependent on energy coming from photosynthesis process [Gabryś 2002]. Low level of NH_4^+ in root tissue in the same year (2007) can prove the effectiveness of individual stages of nitrate nitrogen assimilation, also confirmed by the highest level of determined protein nitrogen.

Our experiment revealed a similar content of nitrates in leaves of the plants with presowing fertilization only in broadcasting/liquid spreading (S-100%) and localized manner (L-75%), which in turn points to the lack of any effect of localized fertilization when compared to traditional fertilization (broadcasting/liquid spreading) (tab. 1). This does not corroborate the results presented by Schumacher [2001] and Sommer [2005] indicating repeated decrease in nitrates content in spinach leaves as a result of CULTAN method application.

A meaningful effect of nitrogen fertilization manner on nitrates content in roots was revealed only in 2005. In this year, as in case of leaves, the lowest nitrates concentrations were assessed in plants with foliar nutrition. The combination of broadcasting/liquid spreading fertilization and foliar nutrition turned out to be the most favourable fertilization manner (object S-75%+F). A similar correlation, however not proved statistically, was revealed in 2007. Smoleń et al. [2006] demonstrated the lack of effect of foliar nutrition with urea on the content of nitrates in carrot roots. However, Rożek et al. [2000] showed that the influence of foliar nutrition on the content of NO_3^- depends on the kind of applied fertilizer; foliar nutrition with urea resulted in an elevated level of nitrates in carrot regardless of the dose of nitrogen applied to the soil (full, lowered), while the use of Supervit R caused a significant decline in the accumulation of this element. The results of this experiment and other authors' results do not allow to draw any unambiguous conclusions concerning the effect of foliar nutrition treatment with nitrogen on nitrates content in storage roots of root vegetables.

The experiments in 2005 revealed a significant increase in the content of nitrates ions in plants roots fertilized with nitrogen in a localized manner (L-75%) in comparison with the plants fertilized in broadcasting manner (S-100%). A similar tendency was observed in 2007. This correlation, however, does not reflect the results of earlier research on plants fertilization with CULTAN method [Sommer 2001, Schumacher 2001].

Numerous authors [Smoleń et al. 2006, del Amor et al. 2007] noted an increase in N-total content in plants treated with foliar nutrition with nitrogen, with simultaneous decline in nitrates content. It may indicate the growth in organic nitrogen content in plant tissue. Our research did not reveal any interactions / correlations between nitrogen fertilization manner and the content of protein nitrogen in red beet roots. The value of this parameter did not depend on the kind of applied fertilizer (RSM, ENTEC 26). Still, the research revealed the effect of foliar nutrition on the decrease in the share of nitrate nitrogen in N-total which may indicate a more effective assimilation of nitrogen supplied to the plants by foliar nutrition.

Variations in the content of mineral and protein nitrogen were observed in individual years of the experiment. The highest share of nitrate nitrogen in N-total in red beet roots was assessed in 2005 (0.175). This year was characterized by the lowest mean air temperatures, the highest rainfall and the lowest number of sunshine hours in comparison to other years of the experiment (tab. 1). Unfavourable weather conditions could have resulted in a decline in the effectiveness of nitrates reductive assimilation as this process takes place with the share of energy obtained in photosynthesis process [Gabryś 2002]. Furthermore, a high amount of sunshine hours in the period before plant harvesting in 2007 most probably intensified nitrates reduction in plant tissue, which in turn caused the assessment of the lowest nitrate nitrogen share in N-total in this year of the experiment.

CONCLUSIONS

1. The type of nitrogen fertilizer (RSM, ENTEC 26) did not affect the content of ammonium and nitrate nitrogen in leaves and roots, and the content of protein nitrogen in the roots of red beet.

2. Foliar nutrition with urea and Supervit R caused a lowered content of nitrates in red beet leaves and roots, though this effect was proved statistically in 2005 only.

3. The content of nitrates, protein nitrogen as well as the share of nitrate nitrogen in N-total was varied in individual years of the experiment.

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ZAWARTOŚĆ AZOTU MINERALNEGO I BIAŁKOWEGO W BURAKU ĆWIKŁOWYM W ZALEŻNOŚCI OD RODZAJU NAWOZU I SPOSOBU NAWOŻENIA AZOTEM

Streszczenie. Przeprowadzone doświadczenie z burakiem ćwikłowym 'Boro F_1' miało na celu zbadanie wpływu rodzaju nawozu azotowego (RSM, ENTEC 26) oraz sposobu stosowania (rzutowy/rozlewowy, zlokalizowany, z dokarmianiem dolistnym lub bez) na zawartość azotu białkowego w korzeniach oraz azotu amonowego i azotanowego w liściach i korzeniach buraka ćwikłowego. Rodzaj zastosowanego nawozu nie miał wpływu na wielkość badanych parametrów. W 2005 r. dolistne dokarmianie azotem spowodowało spadek zawartości azotanów w liściach i korzeniach roślin w stosunku do obiektów niedokarmianych, ale zależność ta nie została potwierdzona w kolejnych latach uprawy. Wielkości wszystkich badanych parametrów były zróżnicowane w zależności od roku uprawy.

Słowa kluczowe: azotany, RSM, ENTEC 26, CULTAN, dokarmianie dolistne

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