ACTA Acta Sci. Pol., Hortorum Cultus 7(3) 2008, 15-24

THE INFLUENCE OF VARIED NITROGEN FERTILIZATION ON YIELD AND CHEMICAL COMPOSITION OF SWISS CHARD (*Beta vulgaris* L. var. *cicla* L.)

Katarzyna Dzida, Karolina Pitura
University of Life Sciences in Lublin

Abstract. The examinations were aimed at determining the dependence between form and rate of applied nitrogen fertilizer vs. yield and chemical composition of leaves of Swiss chard cultivated in greenhouse in spring. Nitrogen was applied in a form of urea, potassium nitrate, and ammonium nitrate at three amounts: 0.2; 0.4; 0.6 g $N \cdot dm^{-3}$ of substrate. Following items were assessed: yield, nutrients contents, as well as chemical analyses of substrate after plant harvest were made. Increase of nitrogen rate in objects with potassium nitrate and ammonium nitrate resulted in the decrease of fresh matter yield, while in objects with urea, the yield remained at constant level. The highest yield of above ground parts (356 $g \cdot plant^{-1}$) was achieved by fertilizing the plants with the lowest nitrogen rate (as ammonium nitrate). Contents of nitrates in leaf dry matter was within the range of 0.59–1.27% depending on nitrogen rate and form. The highest nitrate levels were found when potassium nitrate was applied as fertilizer, whereas the lowest – when applying ammonium nitrate; however, regardless the fertilizer type, higher rates caused the increase of nitrate contents. Studies revealed that at increasing nitrogen concentration in a substrate, level of vitamin C also increased. Contents of N, P, K, Ca, and Mg in Swiss chard's leaves depended on nitrogen fertilizer type. Comparison of studied factors influence on potassium concentration in plants indicated that increasing nitrogen rates in objects with urea and ammonium nitrate was accompanied by the decrease of this element content. An inverse dependence was recorded in objects with potassium nitrate, where content of potassium in Swiss chard's leaves increased along with the nitrogen level increase. Application of 0.2 g $N \cdot dm^{-3}$ substrate appeared to be the most profitable in spring cultivation of Swiss chard, because the largest yields of fresh matter and the lowest share of nitrates in dry matter of studied plant were found.

Keywords: Swiss chard, nitrogen fertilizer, yield, chemical composition

Corresponding author – Adres do korespondencji: Katarzyna Dzida, Karolina Pitura, Department of Soil Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin, ul. Leszczyńskiego 58, 20-068 Lublin, Poland, e-mail: kunro@ar.lublin.pl

INTRODUCTION

Swiss chard's chemical composition, and in consequence its nutritional value, may greatly vary depending on the cultivation and fertilization. Nitrogen is very important nutrient for a plant. Under nitrogen-deficient conditions, plants form smaller leaves of yellow color. The nutrient is easily taken by plants, even at excessive amounts [Czuba 1996]. Its concentration increases as nitrogen content in substrate increases [Mun Bo-Heum and Lee-Byoung Yil 2001]. Swiss chard is a vegetable that shows tendency to excessive accumulation of nitrates [Santamaria et al. 1999]. In order to achieve high yields with appropriately large leaves and good tastiness, the plant should be provided with good cultivation conditions, namely proper fertilization.

The study was aimed at evaluating the influence of fertilization using increasing rates of ammonium nitrate, potassium nitrate, and urea on yield and chemical composition of Swiss chard's above ground parts.

MATERIAL AND METHODS

Experiments involving Swiss chard (Lukullus cv.) were carried out in 2004-2005 (30.03.–19.05.). Plants were cultivated on peat substrate of pH_{H2O} 5.8, in cylinders of 5 dm^3 capacity (one plant was grown in one cylinder). The experiment was established in 6 replication. Following amounts of nutrients were applied in the whole vegetation period ($g \cdot dm^{-3}$ of substrate): N – 0.2, 0.4, 0.6; P – 0.4; K – 0.6; Mg – 0.3. Urea, potassium nitrate, ammonium nitrate, granulated triple superphosphate, potassium chloride, and magnesium sulfate were used as fertilizers. Before seedling setting, whole phosphorus rate and microelements were applied (in $mg \cdot dm^{-3}$ of substrate): Cu – 10, Mo – 3, Mn – 3, B – 2, Zn – 0.65, Fe – 6.4. Above mentioned amounts of N, K, and Mg were divided into three doses: 19.04, 28.04 and 09.05.

Substrate and leaf samples were collected after the plant's harvest. Chemical analyses of substrate were made in 0.03 M acetic acid extracts by means of versatile method according to Nowosielski [1988]. Mineral nitrogen ($N\text{-}NH_4$ + $N\text{-}NO_3$) was determined by means of Bremner's method with Starck's modifications, phosphorus – with ammonium metavanadate, potassium, calcium, and magnesium – using ASA technique (Analyst 300 Perkin Elmer), pH and EC were measured in water suspension of determined substrate at 2:1 volumetric ratio.

Fresh leaf material served for vitamin C determination by means of Tillman's method [Rutkowska 1981]. Dry matter of leaves was used for total nitrogen determination (Kjeldahl's method, Tecator). After dry combustion at 550ºC and dissolution in diluted (1:2 v/v) hydrochloric acid, material was subjected to analyses for P, K, Ca, and Mg using the same methods as for substrate. Nitrates were determined in 2% acetic acid extract by Bremner's distillation method.

Achieved results were statistically processed on a base of variance analysis and checking the difference significance applying Tukey's test at the level of $\alpha = 0.05$.

RESULTS

Nitrogen dose and its form exerted significant influence on the achieved yield of fresh weight, vitamin C and nitrate concentrations in Swiss chard.

Nitrogen fertilization considerably affected the Swiss chard's yields. Higher yield of leaveswas achieved when applying ammonium nitrate as compared to urea or potassium nitrate (tab. 1). Increasing nitrogen rate significantly influenced on Swiss chard's yield. Plants fertilized with the lowest nitrogen level were characterized by the highest yields: such dependence was observed in all studied objects, e.g. with urea, potassium nitrate, and ammonium nitrate.

Swiss chard is a vegetable with great susceptibility to accumulate nitrates. Therefore, when substrate contained more than 180 mg $N\text{-}NO_3 \cdot dm^{-3}$, Swiss chard's leaves accumulated large nitrate amounts (up to 1.27% DM $N\text{-}NO_3$). The highest level of nitrates was recorded in Swiss chard's leaves after applying the largest nitrogen rate in a form of potassium nitrate. Lower level was found in objects with urea and ammonium nitrate. Edible parts of Swiss chard accumulated by 37% less nitrates when ammonium nitrate was applied as compared to plants fertilized with urea or potassium nitrate. Elevated accumulation of total nitrogen and nitrates in plant due to increased amounts of applied nitrogen was observed. Total nitrogen content in Swiss chard's leaves from objects fertilized with ammonium nitrate was the highest, while inverse dependence was recorded in the case of nitrates, amount of which was the lowest.

Vitamin C concentration in plant significantly depended on applied nitrogen rate and form. The highest vitamin C content (56 $mg \cdot 100\ g^{-1}$ FM) was found in Swiss chard's leaves fertilized with potassium nitrate, slightly lower due to ammonium nitrate (53 $mg \cdot 100\ g^{-1}$ FM), and the lowest when urea was applied (43 $mg \cdot 100\ g^{-1}$ FM). The increasing tendency of vitamin C content in plants fertilized with KNO_3 and NH_4NO_3 due to their increasing rates was observed. Above ground parts of chard from objects fertilized with 0.6 $g\ N \cdot dm^{-3}$ contained by 34% more vitamin C as compared with plants fertilized with the amount of 0.2 $g\ N \cdot dm^{-3}$ substrate.

Experiments revealed that varied nitrogen fertilization did not have significant effects on phosphorus, potassium, calcium, and magnesium contents in Swiss chard's leaves (tab. 2). Swiss chard fertilized with ammonium nitrate accumulated the highest amounts of phosphorus, whereas when fertilized with potassium nitrate, it contained the highest levels of potassium. Plants fertilized with urea accumulated more calcium, but less magnesium.

The chemical analysis of substrate performed after Swiss chard's harvest revealed significant influence of varied nitrogen fertilization on nitrate and potassium concentrations (tab. 3). Acidity of studied substrate was distinguished by pH ranging 6.2–6.9 regardless the fertilization applied.

Concentrations of salts in the substrate depended on nitrogen rate and form. Applying an increased nitrogen dose caused considerable increase of mineral components contents in substrate, and despite of this, EC was within optimum range for Swiss chard's growth. Value of EC was from 1.0 to 1.86 $mS \cdot cm^{-1}$ and it was lower in objects with potassium nitrate as compared to urea and ammonium nitrate.

Table 1. Yield and chemical composition of Swiss chard (mean of year 2004 and 2005)
Tabela 1. Plon i skład chemiczny buraka liściowego (średnia z lat 2004 i 2005)

Dose N Dawka N $g \cdot dm^{-3}$ (B)	Kind of fertilizer Rodzaj nawozu (A)	Fresh weight yield, $g \cdot pot^{-1}$ Plon św.m., $g \cdot wazon^{-1}$	Plant height Wysokość roślin cm	Dry matter Sucha masa %	Vitamin C Witamina C $mg \cdot 100\ g^{-1}$ f.m. – św.m.
0.2	$CO(NH_2)_2$	290	51	17.6	45.2
0.4		289	51	17.8	44.4
0.6		289	51	18.2	46.4
	mean – średnia	289	51	17.9	45.2
0.2	KNO_3	350	51	15.9	45.0
0.4		272	51	17.3	53.4
0.6		269	49	18.6	69.4
	mean – średnia	297	51	17.3	55.8
0.2	NH_4NO_3	356	50	17.1	41.6
0.4		278	50	18.7	54.0
0.6		264	52	24.2	63.8
	mean – średnia	299	51	19.6	53.2
mean – średnia					
0.2		332	51	16.8	43,8
0.4		279	51	17.9	52,6
0.6		274	51	20.3	59,8
$LSD_{0.05}$for, $NIR_{0.05}$dla					
	A	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.	7.008
	B	33.027	n.s. – n.i.	n.s. – n.i.	7.008

Table 2. Chemical composition of Swiss chard (mean of year 2004 and 2005)
Tabela 2. Skład chemiczny buraka liściowego (średnia z lat 2004 i 2005)

Dose N Dawka N g·dm^{-3} (B)	Kind of fertilizer Rodzaj nawozu (A)	% dry matter – % suchej masy						
		protein białko	N-total N-og.	N-min.	P	K	Ca	Mg
0.2	$CO(NH_2)_2$	21.19	3.39	0.66	0.84	6.99	1.39	0,84
0.4		32.38	5.18	0.80	1.05	6.94	1.23	0,64
0.6		36.93	5.91	0.85	0.97	6.39	1.24	0,78
	mean – średnia	30.19	4.83	0.77	0.95	6.78	1.29	0,75
0.2	KNO_3	27.94	4.47	0.90	1.07	7.35	1.30	0,93
0.4		29.38	4.70	1.00	0.68	8.77	1.01	0,77
0.6		30.19	4.83	1.27	0.53	9.23	1.16	0,86
	mean – średnia	29.13	4.66	1.06	0.76	8.45	1.15	0,85
0.2	NH_4NO_3	29.69	4.75	0.49	1.19	7.21	1.21	0,85
0.4		31.56	5.05	0.70	1.04	6.69	1.19	0,86
0.6		33.81	5.41	0.74	1.17	6.45	1.28	0,94
	mean – średnia	31.69	5.07	0.64	1.13	6.78	1.22	0,88
mean – średnia								
0.2		26.31	4.21	0.68	1.03	7.19	1.30	0,87
0.4		31.06	4.97	0.83	0.92	7.47	1.14	0,75
0.6		33.63	5.38	0.95	0.89	7.35	1.22	0,86
$LSD_{0.05}$for, $NIR_{0.05}$dla								
	A	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.	0.169	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.
	B	7.106	7.106	1.137	0.169	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.

Table 3. Nutrient content, EC and pH_{H2O} of substrate after the harvest (mean of year 2004 and 2005)
Tabela 3. Zawartość składników pokarmowych, EC i pH_{H2O} w podłożu po zbiorze roślin (średnia z lat 2004 i 2005)

Dose N Dawka N $g \cdot dm^{-3}$ (B)	Kind of fertilizer Rodzaj nawozu (A)	$mg \cdot dm^{-3}$						EC $mS \cdot cm^{-1}$	pH_{H2O}
		$N\text{-}NH_4$	$N\text{-}NO_3$	$P\text{-}PO_4$	K	Ca	Mg		
0.2		25	61.5	137.5	213.5	2562	243.5	1.20	6,79
0.4	$CO(NH_2)_2$	58	197.5	154.5	305.5	2464	192.0	1.51	6,67
0.6		97	288.5	147.5	271.5	2429	232.0	1.85	6,63
	mean-średnia	60	182.5	146.5	263.5	2485	222.5	1.52	6,70
0.2		21	55.0	130.5	177.5	2202	204.5	1.01	6,86
0.4	KNO_3	20	133.5	131.5	269.0	2203	290.0	1.19	6,85
0.6		23	185.5	123.5	321.0	2126	217.0	1.69	6,84
	mean-średnia	21	124.7	128.5	255.8	2177	237.2	1.30	6,85
0.2		26	55.5	139.5	207.5	2721	224.5	1.32	6,58
0.4	NH_4NO_3	13	149.5	143.0	220.5	2603	261.0	1.63	6,40
0.6		99	259.5	110.0	186.0	2650	169.0	1.86	6,24
	mean-średnia	41	154.8	130.8	204.7	2658	218.2	1.60	6,41
mean – średnia									
0.2		24.0	57.3	135.8	199.5	2495	224.2	1.18	6,74
0.4		30.3	160.2	143.0	265.0	2423	247.7	1.44	6,64
0.6		73.2	244.5	127.0	259.5	2401	206.0	1.80	6,57
$LSD_{0.05}$for, $NIR_{0.05}$dla									
	A	n.s.-ni.	54.548	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.	
	B	n.s.-ni.	54.548	n.s.-ni.	64.965	n.s. – n.i.	n.s. – n.i.	0.388	

DISCUSSION

Conducted experiments revealed significant decrease of Swiss chard's fresh matter yield due to increasing nitrogen rates. The highest yields were achieved at application of 0.2 g N·dm^{-3} of substrate, regardless the form of nitrogen fertilizer. Chen et al. [2004] achieved optimum yield of turnip, Chinese cabbage, and spinach when applying 0.3 g N·kg^{-1} of soil, whereas the increase of nitrogen dose to 0.45 g N·kg^{-1} of soil caused the decrease of plant's yields. Those authors also obtained the elevated nitrate levels as a result of increasing nitrogen rates. That result is confirmed in here presented research as well as findings of other authors [Michalik et al. 1980, Kozik and Gleń 1995, Santamaria et al. 1999a, 1999b].

Nurzyńska-Wierdak [2001, 2006], in studies upon garden rocket, observed the increase of nitrates concentration in leaf dry matter (0.01–1.07%) due to elevated nitrogen doses application. In Swiss chard, increasing nitrate contents (0.59–1.27% DM) resulted from introducing the elevated nitrogen rates from 0.2 to 0.6 g N·dm^{-3}.

Besides rate and form of applied fertilizer (namely nitrogen one), also vegetation period affected the nitrate accumulation in a plant. Rożek [2000] as well as Lisiewska and Kmiecik [1991] found that plants with short vegetation period, e.g. spinach or lettuce, accumulated less nitrates when cultivated in spring-summer than those grown in autumn seasons. Studies carried out by Stępowska and Michalik [1996] as well as Burns et al. [2002] revealed that lettuce cultivated in autumn contained two times more nitrates as compared to spring cultivation. Plants of Swiss chard grown in spring at the lowest nitrogen dose in a form of ammonium nitrate accumulated 0.59% $N\text{-}NO_3$ DM of leaves, potassium nitrate – 0.9% DM, urea – 0.94% DM.

Here achieved results indicated that Swiss chard is characterized by high nutritional value, contains large amount of dry matter, vitamin C, protein, and has rich mineral composition: high levels of phosphorus, potassium, calcium, and magnesium. Similar results were published by Pokluda and Kuben [2002], Kołota and Czerniak [2006] as well as Dzida [2004].

Concentration of nutrients in above ground parts of Swiss chard depended on nitrogen rate and fertilizer form. More vitamin C, protein, phosphorus, and magnesium were detected in Swiss chard's leaves fertilized with ammonium nitrate than urea. Plants fertilized with urea contained the highest contents of calcium, while those fertilized with potassium nitrate – potassium (tab. 2).

Presented study revealed that vitamin C, protein, and total nitrogen contents in above ground parts of Swiss chard increased as an effect of increasing nitrogen fertilizer rate application. Varied nitrogen fertilization did not have an apparent influence on contents of other nutrients in plant's dry matter. Kozik and Ruprik [2000] recorded the decrease of vitamin C concentration resulting from the increasing nitrogen fertilization in lettuce cultivated on mixed substrate: peat + bark and soil + bark. Kozik [1998], when studying several lettuce varieties, observed the decrease of vitamin C content due to increasing nitrogen rates. Wierzbicka and Kuskowska [2002] found that vitamin C level in plant also depended on a variety, storage time, and sowing date.

CONCLUSIONS

1. Higher yields of Swiss chard's fresh matter were achieved in objects with ammonium nitrate and potassium nitrate as compared to urea. Increasing nitrogen rates, regardless the type of applied fertilizer caused the yield decrease.
2. Swiss chard was characterized by high concentrations of dry matter, vitamin C, and protein. Chemical composition of leaves depended on nitrogen dose and form of the fertilizer.
3. Nitrate concentration in dry matter of Swiss chard's leaves was within the range from 0.59% to 1.27%. Plants fertilized with urea and potassium nitrate contained higher nitrate content, and significantly lower – fertilized with ammonium nitrate.
4. Rate of 0.2 g $N \cdot dm^{-3}$ of substrate appeared to be the most favorable for Swiss chard due to the highest fresh matter yields, phosphorus, calcium, and magnesium concentrations as well as the lowest nitrate level in plant's dry matter.

REFERENCES

Burns I.G., Lee A., Escobar-Gutierrez, 2002. Nitrate accumulation in protected lettuce. Acta Hort. 633, 120–124.

Chen B.M., Wang Z.H., Li S.X., Wang G.X., Song H.X., Wang X.N., 2004. Effects of nitrate supply on plant growth, nitrate accumulation, metabolic concentration and nitrate reductase activity in three leafy vegetables. Plant Sci. 167, 635–643

Czuba R., 1996. Technika nawożenia mineralnego a zawartość azotanów w roślinach. Zesz. Probl. Post. Nauk Rol. 440, 65–73.

Dzida K., 2004. Wpływ nawożenia azotowo-potasowego na plonowanie buraka liściowego (*Beta vulgaris* var. *cicla*) i zawartość składników w podłożu. Roczn. AR w Poznaniu, 356, 55–60.

Kołota E., Czerniak K., 2006. Ocena plonowania i wartości odżywczej kilku odmian buraka liściowego (*Beta vulgaris* L. var *cicla* L.) w uprawie wiosennej. Folia Hort., Supl. (1), 233–236.

Kozik E., Gleń B., 1995. Wpływ poziomu i formy azotu na zawartość azotanów w sałacie (*Lactuca sativa* L.) mat. Konf. „Nauka w Praktyce Ogrodniczej", AR Lublin, 699–702.

Kozik E., 1998. Wpływ poziomu nawożenia azotem na plon oraz zawartość cukrów i kwasu askorbinowego w siedmiu odmianach sałaty. VII Konf. Nauk. Efektywność stosowania nawozów w uprawach ogrodniczych, AR Lublin, 93–96.

Kozik E., Ruprik B., 2000. Skład chemiczny sałaty uprawianej w różnych podłożach przy wzrastającym nawożeniu azotem. Rocz. AR Poznań 323, Ogrodnictwo 31, 1, 351–355.

Lisiewska Z., Kmiecik W., 1991. Azotany i azotyny w warzywach. Post. Nauk Roln. 3, 11–23.

Michalik H., Bąkowski J., 1997. Wpływ warunków składowania na jakość sałaty masłowej ze szczególnym uwzględnieniem azotanów i azotynów. Biul. Warz. XLVI, 79–91.

Michalik H., Bąkowski J., Czapski J., Szwonek E., Szmidt B., 1980. Wpływ nawożenia azotem na zawartość azotanów i azotynów w marchwi, sałacie i szpinaku. Rocz. PZH 5, 471–478

Mun BoHeum M., Lee Byoung Yil L., 2001. Changes of nitrate and ascorbic acid contents in hydroponically grown water dropwort (*Oenanthe stolonifera* DC.) and lettuce (*Lactuca sativa* L.) as affected by nutrient solution conditioning before harvest. J. Korean Soc. Hort. Sci. 42 (1), 60–64.

Nowosielski O., 1988. Zasady opracowywania zaleceń nawozowych w ogrodnictwie. PWRiL, Warszawa.
Nurzyńska-Wierdak R., 2001. Fielding of garden rocket (*Eruca sativa*) in dependence on differentiated nitrogen fertilization. VCRB 54, 71–76.
Nurzyńska-Wierdak R., 2006. The effect of nitrogen fertilization on yield and chemical composition of garden rocket (*Eruca sativa* Mill.) in autumn cultivation. Acta Sci. Pol., Hortorum Cultus 5 (1), 53–63.
Pokluda R., Kuben J., 2002. Comparison of selected Swiss chard (*Beta vulgaris* ssp. *cicla* L.) varieties. Hort. Sci 29 (3), 114–118.
Rutkowska U., 1981. Wybrane metody badań składu i wartości odżywczej żywności. PZWL, Warszawa.
Rożek S., 2000. Czynniki wpływające na akumulację azotanów w plonie warzyw. Zesz. Nauk. AR Kraków 364, 19–31.
Santamaria P., Elia A., Serio F., Todaro E., 1999a. A survey of nitrate and oxalate content in fresh vegetables. J. Sci. Food Agric. 79, 13, 1882–1888.
Santamaria P., Elia A., Serio F., Gonella M., Parente A., 1999b. Comparison between nitrate and ammonium nutrition in Fennel, celery and Swiss chard. J. Plant Nutr. 22, 7, 1091–1106.
Stępowska A., Michalik H., 1996. Wpływ warunków uprawy na zawartośc azotanów w sałacie masłowej (*Lactuca sativa* L.) pod osłonami. Now. Warzyw. 29, 19–26.
Wierzbicka B., Kuskowska M., 2002. Wpływ wybranych czynników na zawartość witaminy C w warzywach. Acta Sci. Pol., Hortorum Cultus 1(2), 49–57.

WPŁYW ZRÓŻNICOWANEGO NAWOŻENIA AZOTOWEGO NA PLON I SKŁAD CHEMICZNY BURAKA LIŚCIOWEGO (*Beta vulgaris* L. var. *cicla* L.)

Streszczenie. Burak liściowy (*Beta vulgaris* L. var. *cicla* L.) jest warzywem o krótkim okresie wegetacji, należącym do rodziny komosowatych – *Chenopodiaceae*. Jest to cenne warzywo liściowe, które posiada wysoką wartość odżywczą, zwłaszcza duże zawartości białka (do 25% s.m.), witaminy C, betakarotenu, witamin z grupy B, a także soli mineralnych. Jest rośliną mało znaną w naszym kraju, natomiast powszechnie uprawianą w krajach Europy Zachodniej. Badania przeprowadzone w latach 2004–2005 miały na celu określenie zależności pomiędzy formą oraz dawką stosowanego nawozu azotowego a plonem i składem chemicznym części nadziemnych buraka liściowego uprawianego w szklarni w okresie wiosennym. Azot zastosowano w postaci mocznika, saletry potasowej i saletry amonowej w trzech dawkach: 0,2; 0,4; 0,6 g $N \cdot dm^{-3}$ podłoża. Oceniono wielkość plonu, zawartość składników pokarmowych w liściach oraz dokonano analizy chemicznej podłoża po zbiorze roślin. Zwiększenie dawki azotu w obiektach z saletrą potasową i saletrą amonową powodowało zmniejszenie plonu świeżej masy roślin, natomiast w obiektach z mocznikiem plon utrzymywał się na wyrównanym poziomie. Największy plon (356 $g \cdot rośliny^{-1}$) otrzymano nawożąc rośliny najniższą dawką azotu przy stosowaniu saletry amonowej. Zawartość azotanów w suchej masie liści mieściła się w zakresie 0,59–1,27% w zależności od dawki i formy azotu. Najwięcej azotanów stwierdzono przy stosowaniu saletry potasowej, najmniej przy zastosowaniu saletry amonowej. W liściach buraka odnotowano zwiększoną ilość azotanów pod wpływem rosnącej dawki azotu. Zawartość witaminy C w roślinie zależała istotnie od badanych czynników. Przy rosnącej koncentracji azotu w podłożu zawartość witaminy C w roślinie również wzrastała. Porównując wpływ badanych czynników na koncentrację potasu w roślinie, odnotowano, iż wzrastającej dawce azotu w obiektach z mocznikiem i saletrą amonową towarzyszył spadek zawartości tego pierwiastka. Odwrotną zależność odnotowano w obiektach z saletrą potasową, gdzie wraz ze wzrostem ilości azotu w podłożu wzrastała ilość potasu w liściach buraku. W warunkach przeprowadzonych doświadczeń stwierdzono, że najwyższy plon części nadziemnych buraka liściowego oraz najmniejszą zawartość azotanów w liściach uzyskano po zastosowaniu 0,2 $gN \cdot dm^{-3}$ podłoża, niezależnie od formy azotu w nawozach.

Słowa kluczowe: Burak liściowy, nawóz azotowy, plon, skład chemiczny

Accepted for print – Zaakceptowano do druku: 13.05.2008