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THE EFFECT OF NITROGEN FERTILIZATION ON YIELD AND CHEMICAL COMPOSITION OF GARDEN ROCKET (*Eruca sativa* Mill.) IN AUTUMN CULTIVATION

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Abstract. A vegetation experiment was conducted in 2001–2002 in an unheated greenhouse on the effect of differentiated nitrogen fertilization on yield and quality of garden rocket. Nitrogen was used in three forms, i.e. lime saltpeter, urea and ammonium sulphate, and in three doses: 0.2; 0.4; 0.6 $N \cdot dm^{-3}$ (2001) and 0.25; 0.50; 0.75 g $N \cdot dm^{-3}$ (2002). The plants' growth, yield and content of nutrients were evaluated and an chemical analysis of the substrate after the harvest was conducted. The studies pointed out a possibility of cultivating garden rocket in autumn in an unheated greenhouse. A higher yield of fresh weight was obtained in the treatments with lime saltpetre and urea as compared with ammonium sulphate. Increased doses of nitrogen, independently of the kind of the applied fertilizer, caused a decrease of the yield of rocket fresh weight. The studied plants of garden rocket were characterized by a high content of dry matter, vitamin C, protein, potassium and calcium. The content of nitrates in the dry matter of leaves was within the range 0.02–0.98%, depending on nitrogen dose and the year of studies. The application of 0.2–0.25 g $N \cdot dm^{-3}$ of the substrate in the autumn cultivation of rocket proved to be the most advantageous in view of the highest yield of fresh weight, the highest content of vitamin C and the lowest proportion of nitrates in the leaf dry weight.

Key words: garden rocket, nitrogen fertilization, yield, chemical composition of leaves

INTRODUCTION

Fertilizing plants with nitrogen is closely related to the height and the quality of the obtained yield. An excessive amount of applied nitrogen can have a negative effect on yield as well as chemical composition of plants, including the content of nitrates. The Regulation of the Ministry of Health from 13 January, 2003 [Government Regulations and Laws Gazette 2003] defines the maximum content of nitrates in fresh and frozen

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vegetables, establishing the acceptable content of 3500 mg $NO_3 \cdot kg^{-1}$ f.w. for greenhouse lettuce collected between 1 April and 30 September and 4500 mg $NO_3 \cdot kg^{-1}$ f.w. between 1 October and 31 March. A similar permissible content of these compounds is determined by the regulations of other countries and the European Union [Carranca et al. 2001].

Weather factors and fertilization have the greatest reaching 25–30% effect on the accumulation of nitrates, [Sady 2000]. Low light intensity usually leads to excessive accumulation of nitrates in the edible parts of plants; hence, the plants cultivated in autumn accumulate more of at compound than those in the spring season [Borowski 1995; Sady et al. 1995; Stępowska and Michalik 1996; Jworska and Kmiecik 1999; Frąszczak and Knaflewski 2004]. Dapoigny et al. [2000] founded nearly twice as much nitrates in the leaves of lettuce cultivated in autumn, with a high dose of nitrogen and limited accessibility of light (about 3800 mg $NO_3 \cdot kg^{-1}$ f.w) as compared to spring cultivation. The application of the combination comprising low nitrogen dose and full accessibility of light inhibited the growth of lettuce plants and the content of nitrates. Besides, twice as low intensity of natural light distinctly affected the decrease of biomass production, especially in young plants, and the yield of tomato fruit [Borowski 1995].

The form and dose of applied nitrogen belong to the important factors influencing the yield and its quality. The application of nitrate forms of fertilizers most frequently causes an increase of the fresh weight yield as compared to the others as well as an increase of nitrate concentration in the aboveground parts [Borowski 1994; Kozik and Gleń 1995; Santamaria and Elia 1997; Santamaria et al. 1998; Nurzyńska-Wierdak 2001]. Rożek et al. [1994], Santamaria et al. [1998] and Abu-Rayyan et al. [2004] successfully decreased the concentration of nitrates, using fertilizers containing reduced forms of nitrogen in the cultivation of different vegetable species.

It follows from the studies of a number of authors [Kozik and Gleń 1995; Santamaria et al. 1997; Nurzyńska-Wierdak 2001; Ceylan et al. 2002; Santamaria et al. 2002] that increased nitrogen doses cause an increase of nitrate accumulation in plant tissues. Besides, increasing the doses of nitrogen to 300 $kg \cdot ha^{-1}$ caused an increased yield of garden rocket, whereas a further increase of the dose contributed to a distinct decrease of fresh weight yield [Ceylan et al. 2002].

The purpose of the present studies was to establish the relation between the form and dose of nitrogen and the yield and chemical composition of the leaves of garden rocket cultivated in autumn.

MATERIAL AND METHODS

An experiment was conducted in 2001–2002 in unheated greenhouse on the effect of differentiated nitrogen fertilization on yield and quality of the garden rocket. The substrate was sphagnum peat limed with fertilizer chalk in the quantity of 4.0 $g \cdot dm^{-3}$ of peat to the value of pH 6.2, mixed with loamy-sandy soil in the ratio of 9:1 by volume. Nitrogen was used in three forms, i.e. lime saltpeter, urea and ammonium sulphate, each in the doses of: 0.2; 0.4; 0.6 $N \cdot dm^{-3}$ (2001) and 0.25; 0.50; 0.75 g $N \cdot dm^{-3}$ (2002). The other elements were applied in mg per 1 dm^3 of the substrate: P-400 (as superphosphate

20% P), K – 800 (potassium sulphate), Mg – 200 (magnesium sulphate), Fe – 8.0 (iron chelate 13% Fe), Cu – 13.3 ($CuSO_4 \cdot 5H_2O$), Mn – 5.1. ($MnSO_4 \cdot H_2O$), B – 1.6 (H_3BO_3), Mo – 3.7 (ammonium molybdenian), Zn – 0.74 ($ZnSO_4 \cdot 7H_2O$). The plants were cultivated in pots with the capacity of 2 dm^3 (3 plants). Each series included 8 replications. The seeds were sown at the beginning of September. Garden rocket was picked up after about 60 days of vegetation, and the whole leaf rosettes were cut once. The plants' growth, yield and the content of nutrients were established and an analysis of the substrate after the harvest was conducted. Directly after the harvest the studies determined the content of dry matter in the aboveground parts, total sugars, monosaccharides (using the Luff-Schoorl method) and vitamin C (Tillmans' method). The other part of the plant material after drying at the temperature of 70°C and grinding were prepared for the following chemical analyses: after burning in H_2SO_4 total N was determined using Kjeldahl method in an automatic Kjel-Foss apparatus, in 2% extract of CH_3COOH: $N\text{-}NH_4$ and $N\text{-}NO_3$ were determined by means of Bremner distillation method modified by Starck, chlorine colorimetrically with $AgNO_3$ and sulphates with Ba Cl_2, dry burning at the temperature of 550°C the following were determined: phosphorus colorimetrically with ammonium vanadium molybdenian, potassium, calcium and magnesium by means of absorption spectrometry of atom (ASA). Immediately after the harvest samples of substrate were taken for chemical analyses of: 0.03M CH_3COOH: of $N\text{-}NH_4$ and $N\text{-}NO_3$ in the extract, phosphorus, potassium, calcium and magnesium in the extract of 0.03 M CH3COOH using the method like in the plant material, pH – potentiometrically in H_2O, the concentration of nutrients in the substrate (EC) – conductometrically.

The results were analysed statistically by means of variance analysis for double classification, evaluating the significance of differences by means of Tukey's confidence intervals and calculating LSD at the level of significance of $\alpha = 0.05$.

RESULTS

The yield of garden rocket cultivated in autumn 2001 was significantly related to nitrogen fertilization. The highest yield of fresh weight was obtained using urea (tab. 1). In 2002 the yielding of garden rocket was also significantly related to the applied nitrogen fertilization. Plants fertilized with lime saltpetre and urea were characterized by a significantly higher yield than the plants fertilized with ammonium sulphate. Increased doses of nitrogen caused a significant decrease of fresh weight yield. The highest plants were characteristic of urea fertilization, while the greatest number of leaves were formed by plants fertilized with urea (2001) and ammonium sulphate (2002).

Garden rocket contained high amounts of dry matter, protein and vitamin C, but relatively little total sugars and monosaccharides. The highest amount of dry matter was found in the object with urea and ammonium sulphate as well as the highest dose of nitrogen. In 2001 the highest amounts of vitamin C and monosaccharides were accumulated in the plants fertilized with lime saltpetre as compared to the other fertilizers. Plants from the objects with the smallest dose of nitrogen were characterized by the highest concentration of dry matter and vitamin C as compared to the others.

Table 1. Yield and chemical composition of garden rocket
Tabela 1. Plon i skład chemiczny rokietty siewnej

Kind of fertilizer Rodzaj nawożenia	Dose N Dawka N ($g \cdot dm^{-3}$)		Fresh weight yield ($g \cdot pot^{-1}$) Plon św.m. ($g \cdot wazon^{-1}$)		Plant height Wysokość rośliny (cm)		No. of leaves (per plant) Liczba liści (na roślinach)		Dry weight Sucha masa (%)		In fresh weight W świeżej masie: vitamin C witamina C $mg \cdot 100 g^{-1}$		total sugars cukry ogółem %		monosaccharides cukry proste %	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
$Ca(NO_3)_2$	0.2	0.25	20.8	32.2	25.0	21.5	10.4	8.8	12.1	8.4	132.1	182.4	1.37	2.44	1.12	1.12
	0.4	0.50	20.5	30.1	29.6	21.6	11.3	8.4	11.0	8.7	123.1	184.9	1.55	1.89	1.09	1.01
	0.6	0.75	16.3	25.1	25.7	17.6	9.1	9.0	11.5	9.6	128.3	181.1	1.43	1.77	1.22	1.03
	mean – średnio		19.2 a	29.1 a	26.8 a	20.2 a	10.3 a	8.7 a	11.5 a	8.9 a	127.8 a	182.8 a	1.45 b	2.03 a	1.17 a	1.05 a
$CO(NH_2)_2$	0.2	0.25	18.6	36.5	30.6	24.3	11.1	8.2	12.0	8.2	105.3	192.4	1.55	1.86	0.73	1.00
	0.4	0.50	24.7	28.5	26.9	22.5	11.0	9.0	12.1	8.0	124.3	183.0	1.48	1.46	1.03	1.02
	0.6	0.75	18.4	22.0	25.5	19.6	10.0	9.2	11.5	8.3	102.0	183.1	2.10	1.70	1.27	0.99
	mean – średnio		20.6a	29.0 a	27.7a	22.1 a	10.7a	8.8 a	11.9 a	8.2 a	110.5b	186.2a	1.71a	1.67 b	1.01 b	1.00 a
$(NH_4)_2SO_4$	0.2	0.25	16.7	25.4	24.6	20.9	8.9	8.7	12.7	9.3	133.3	173.4	1.63	1.34	1.08	1.16
	0.4	0.50	16.6	24.1	25.8	18.7	8.9	9.1	11.1	8,1	106.8	174.3	1.48	1.20	0.81	0.96
	0.6	0.75	12.3	20.3	19.7	20.3	7.4	9.0	11.9	8.6	94.3	165.5	2.10	1.30	1.11	0.91
	mean – średnio		15.2 b	23.3 b	23.4 b	20.0 a	8.4 b	8.9 a	11.9 a	8.7 a	111.5 b	171.1 b	1.73 a	1.28 c	1.00 b	1.01 a
Average for N dose Średnio dla dawki N	0.2	0.25	18.7 a	31.4 a	26.7 a	22.2 a	10.1a	8.6 a	12.3 a	8.6 a	123.6a	182.7a	1.52b	1.88 a	0.98 b	1.09 a
	0.4	0.50	20.6 a	27.6 b	27.4 a	20.9 a	10.4a	8.8 a	11.4 b	8.3 a	118.1a	180.7a	1.50b	1.52 b	0.98 b	1.00 a
	0.6	0.75	15.7 b	22.5 c	23.6b	19.2 a	8.8 b	9.1 a	11.6 b	8.8 a	112.4b	176.6a	1.88a	1.59 b	1.20 a	0.98 a

*Means followed by the same letters do not differ significantly at 0.05 level of probability
*Średnie oznaczone tymi samymi literami nie różnią się miedzy sobą istotnie przy $\alpha = 0,05$

Table 2. Chemical composition of rocket leaves
Tabela 2. Skład chemiczny liści rokietty

Kind of fertilizer Rodzaj nawożenia	Dose N Dawka N g·dm^{-3}		% dry weight % suchej masy													
			protein – białko		$N-NO_3$		N-total – N-og.		P		K		Ca		Mg	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2001	2001	2002	2001	2002	2001	2002
$Ca(NO_3)_2$	0.2	0.25	14.3	40.6	0.03	1.30	2.90	6.50	0.45	0.52	3.31	2.32	1.54	2.52	0.21	0.23
	0.4	0.50	30.0	40.0	0.27	1.37	4.81	6.40	0.55	0.62	3.40	2.31	1.51	2.47	0.32	0.20
	0.6	0.75	28.8	43.1	0.91	1.53	4.57	6.86	0.51	0.60	4.23	2.67	2.40	2.41	0.20	0.23
	mean – średnio		24.4 b*	41.2 a	0.40 a	1.40 a	4.09 b	6.58 a	0.50 a	0.58 a	3.64 a	2.43 a	1.81 b	2.46 a	0.24 b	0.22 a
$CO(NH_2)_2$	0.2	0.25	27.7	38.8	0.02	1.09	4.44	6.23	0.55	0.55	3.23	2.54	2.18	2.37	0.11	0.22
	0.4	0.50	32.7	41.3	0.21	0.85	5.23	6.58	0.46	0.62	3.31	2.25	3.02	2.47	0.20	0.19
	0.6	0.75	34.1	43.8	0.64	1.09	5.50	7.00	0.47	0.56	3.22	2.27	2.60	2.15	0.23	0.19
	mean – średnio		31.5 a	41.3 a	0.29 b	1.01 b	5.06 a	6.60 a	0.49 a	0.57 a	3.25 b	2.35 a	2.60 a	2.33 a	0.18 b	0.20 a
$(NH_4)_2SO_4$	0.2	0.25	31.1	37.5	0.02	0.54	4.88	5.97	0.55	0.50	3.63	2.76	1.42	2.19	0.33	0.23
	0.4	0.50	32.6	36.9	0.18	0.63	5.22	5.94	0.54	0.62	3.23	2.28	2.30	2.46	0.38	0.20
	0.6	0.75	32.7	38.8	0.46	1.13	5.20	6.16	0.61	0.62	3.90	2.65	2.41	2.34	0.23	0.23
	mean – średnio		32.1 a	37.7 b	0.22 c	0.76 c	5.10 a	6.02 b	0.56 a	0.58 a	3.58 a	2.56 a	2.04 b	2.33 a	0.31 a	0.22 a
Average for N dose Średnio dla dawki N	0.2	0.25	24.4 b	39.0 b	0.02 c	0.98 b	4.07 b	6.23 a	0.52 a	0.52 a	3.39 b	2.54 a	1.71 b	2.36 a	0.22 b	0.23 a
	0.4	0.50	31.8 a	39.4 b	0.22 b	0.95 b	5.09 a	6.31 a	0.52 a	0.62 a	3.31 b	2.28 a	2.28 a	2.47 a	0.30 a	0.20 a
	0.6	0.75	31.9 a	41.9 a	0.67 a	1.25 a	5.09 a	6.67 a	0.53 a	0.59 a	3.78 a	2.53 a	2.47 a	2.30 a	0.22 b	0.22 a

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Table 3. Nutrient content ($mg \cdot dm^{-3}$), pH_{H_2O} and EC ($mS \cdot cm^{-1}$) of substrate after the harvest

Tabela 3. Zawartość składników pokarmowych ($mg \cdot dm^{-3}$) w podłożu po zbiorze roślin oraz wartość pH_{H_2O} and EC ($mS \cdot cm^{-1}$)

Kind of fertilizer Rodzaj nawożenia	Dose N Dawka N $g \cdot dm^{-3}$		$N\text{-}NH_4$		$N\text{-}NO_3$		$N\text{-}NH_4$ + $N\text{-}NO_3$		P		K		Ca		Mg		pH		EC	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
$Ca(NO_3)_2$	0.2	0.25	12	14	35	36	47	50	90	125	347	669	720	1809	176	269	6.5	6.5	1.8	1.5
	0.4	0.50	16	7	158	93	173	100	95	120	430	649	666	1704	277	307	6.3	6.3	2.5	1.6
	0.6	0.75	26	25	320	215	347	240	106	117	437	680	766	1881	274	304	6.3	6.3	2.5	1.8
	mean – średnio		18c*	15 c	171a	115a	189	130c	97 a	121a	405b	666b	718b	1798c	242a	293b	6.3-6.5	6.3-6.5	2.3 a	1.6 b
$CO(NH_2)_2$	0.2	0.25	109	84	28	35	137	119	105	130	422	701	622	2011	219	327	6.5	6.5	1.6	1.6
	0.4	0.50	170	154	56	42	226	196	160	120	407	694	825	1918	183	370	6.7	6.7	2.0	1.5
	0.6	0.75	182	161	63	63	245	224	100	103	483	728	832	1989	223	289	6.7	6.7	2.4	1.6
	mean – średnio		153b	133b	49 b	47 b	202b	180b	122a	118a	437b	707a	760b	1969b	208b	329a	6.5-6.7	6.5-6.7	2.0 b	1.6 b
$(NH_4)_2SO_4$	0.2	0.25	168	154	39	28	207	182	135	98	459	657	1086	2010	228	372	6.3	6.3	1.7	1.6
	0.4	0.50	406	246	35	35	441	281	115	112	533	674	1160	2172	234	290	6.2	6.2	1.9	1.8
	0.6	0.75	322	241	21	42	343	283	90	90	518	722	994	2200	200	334	6.2	6.2	2.4	2.3
	mean – średnio		298a	214a	32 b	35 b	330a	249a	113a	100b	503a	685b	1080a	2127a	221a	332a	6.2-6.3	6.2-6.3	2.0ab	1.9 a
Average for N dose Średnio dla dawki N	0.2	0.25	96 b	84 b	34 c	33 c	130c	117c	110a	118a	409b	676b	810b	1943a	208b	323a	6.3-6.5	6.3-6.5	1.7c	1.6 b
	0.4	0.50	197a	136a	83 b	57 b	280b	193b	123a	117a	457a	673b	884a	1931a	232a	322a	6.2-6.7	6.2-6.7	2.1b	1.6 b
	0.6	0.75	177a	142a	135a	107a	312a	249a	99 a	103a	479	710a	864a	2023a	232a	309b	6.2-6.7	6.2-6.7	2.4a	1.9 a

*Means followed by the same letters do not differ significantly at 0.05 level of probability.

*Średnie oznaczone tymi samymi literami nie różnią się miedzy sobą istotnie przy α = 0,05

In 2002 the concentration of vitamin C was also high and significantly related to the form of applied nitrogen. The highest amount of vitamin C (186.2 mg·100g^{-1} f.w.) was accumulated by urea fertilized plants. No significant effect of the dose of nitrogen on the content of vitamin C in garden rocket was found; however, a clear tendency was observed for a decrease of its amount together with an increased of N dose.

The content of protein and total nitrogen in the studied plants was high and it was significantly related to the applied nitrogen fertilization (tab. 2). The lowest concentrations of this compound were characteristic of plants fertilized with lime saltpetre (2001) and ammonium sulphate (2002).

The studied plants accumulated the greatest amounts of nitrates (0.40% d.m.) with the use of lime saltpetre as compared to the plants fertilized with urea and ammonium sulphate (tab. 2). The plants fertilized with the highest dose of nitrogen were characterized by the highest content of protein and nitrates, which should be expected, but it is of interest to note that in 2001 the content of total nitrogen was similar in the case of applying the medium and the highest tested doses of nitrogen, and in 2002 – in all doses.

In the studies there was found no significant effect of the form or the dose of nitrogen on the content of phosphorus, potassium, calcium and magnesium in garden rocket leaves (tab. 2). Garden rocket fertilized with ammonium sulphate accumulated the greatest amount of potassium, while plants supplied with lime saltpetre accumulated the most of calcium.

The analyses of the substrate after the harvest of garden rocket showed significant differences in the content of nitrogen, phosphorus, potassium and magnesium (tab. 3). The studied substrate was characterized by the pH ranged between 6.2 and 6.7, depending on the applied fertilizer. The concentration of nutrients was significantly related to the form and dose of nitrogen. Increased doses of applied nitrogen caused a significant increase of the concentration of mineral elements in the substrate; however, EC value remained within the optimum range for the growth and development of garden rocket plants. The concentration of nutrients ranged from 1.6 to 2.0 mS·cm^{-1} and it was significantly the highest when ammonium sulphate was used as compared to the others.

DISCUSSION

The present studies found out a significant decrease of fresh weight yield of garden rocket under the effect of increased nitrogen doses. The highest yield was obtained using 0.4 g N·dm^{-3} (2001) and 0.25 g N·dm^{-3} (2002) of the substrate, independently of the form of applied nitrogen fertilizer. Applying an increased dose of nitrogen in the form of urea caused a decrease of the plants' height, while in case of the other fertilizers those changes were not distinct. This is confirmed by the results obtained by Ceylan et al. [2002], who found out an increased yield of garden rocket caused by increased nitrogen fertilization to 300 kg·ha^{-1} and a significant decrease after the application of 500 kg·ha^{-1}. Similarly, Chen et al. [2004] obtained an optimum yield of turnip, Chinese cabbage and spinach with the use of 0.3 N·kg^{-1} of the soil, while increasing the dose to 0.453 g N·kg^{-1} of the soil caused diminished height of the plants. The above mentioned authors at the same time showed increased accumulation of nitrates in plant tissues under the effect of increased nitrogen doses. This finding is in agreement with the results of studies presented in this paper, shown in earlier studies [Nurzyńska-Wierdak 2001] and confirmed by other authors [Michalik et al. 1980; Kozik, Gleń 1995; Santamaria et al. 1998, 1999a, 1999b; Custic et al. 2003].

Santamaria et al. [2002] found out an increased content of nitrates in the leaves of garden rocket by 52% under the effect of increased nitrogen concentration in the substrate. Nicola et al. [2003] obtained a two-fold increase of the quantity of nitrates in rocket leaves together with an increased dose of nitrogen from 30 to 60 $mM \cdot dm^{-3}$ of the substrate. Earlier studies [Nurzyńska-Wierdak 2001] proved an increased content of nitrates in the dry matter of leaves from 0.01 to 1.07% as a result of increased amount of applied nitrogen (from 0.2 to 0.6g $N \cdot dm^{-3}$ of the substrate). According to Rożek [2000], vegetable species with a short period of vegetation, such as spinach or lettuce, accumulate much less nitrates in the spring-summer season than those cultivated in autumn. This was also proved by Stępowska and Michalik [1996], Michałojć [2000] and Burns et al. [2002], who found out even twice as high content of nitrates in lettuce and radish cultivated in the autumn period as compared to the spring cultivation. Borkowski and Bereśniewicz [1991] observed that Chinese cabbage from the autumn cultivation had a lower content of nitrates and potassium than the plants grown in spring. At the same time in the autumn cultivation the mean weight of cabbage head was often twice as high as in spring season. This would explain nitrates concentration caused by intensive growth of plants and the increase of the head weight. On the other hand, however, low yields obtained in spring were mainly the result of fast shooting into inflorescences, and not of slower or poorer growth of those plants.

The results of studies presented in this paper do not point to any considerable accumulation of nitrates in the leaves of garden rocket grown in autumn. With the application of the lowest dose of nitrogen (0.2 and 0.25 g $N \cdot dm^{-3}$ of the substrate), the plants on average accumulated 0.02 and 0.98% $N\text{-}NO_3$ in the leaf dry matter, which in conversion to fresh weight is 0.109 and 3.725 g $NO_3 \cdot kg^{-1}$ and is found within the permissible range of content for leafy vegetables cultivated in autumn in a greenhouse [Government Regulations and Law Gazette 2003]. The studied plants of rocket were characterized by a high nutrient content. Rocket leaves contained a lot of dry matter, vitamin C and protein, proving to be a valuable source of potassium and calcium. This is confirmed by the results obtained by Francke [2000], earlier studies [Nurzyńska-Wierdak 2001] and Frąszczak and Knaflewski [2004]. The concentration of the enumerated elements depended on the form and dose of the applied nitrogen and it did not change explicitly in particular study years. In 2002 the studies found out a higher content of vitamin C – 171.1–186.2 $mg \cdot 100g^{-1}$ fresh weight, protein 37.7–41.3% dry weight – and a smaller concentration of dry weight, potassium and calcium depending on the kind of the applied nitrogen fertilizer as compared to the year 2001.The studies showed a decreased concentration of vitamin C and an increased amount of protein and nitrates in rocket leaves under the effect of an increased dose of nitrogen. The content of the other elements did not change in an explicit manner. Similarly, Kozik and Ruprik [2000] and Golcz and Kozik [2004] found out a diminished concentration of vitamin C in lettuce cultivated in mixed substrates (peat + bark, soil + soil + sawdust), following increased doses of nitrogen.

CONCLUSIONS

1. The studies pointed out a possibility of cultivating garden rocket in autumn in an unheated greenhouse.

2. A higher yield of fresh weight was obtained in the objects with lime saltpetre and urea as compared with ammonium sulphate. Increased doses of nitrogen, independently of the kind of the applied fertilizer, caused a decrease of the yield of rocket fresh weight.

3. The studied plants of garden rocket were characterized by a high content of dry matter, vitamin C, protein, potassium and calcium. The chemical composition of the leaves was related to nitrogen fertilization and the year of studies.

4. The content of nitrates in the dry weight of leaves was within the range of 0.02–0.98%, depending on nitrogen dose and the year of studies. The highest content of nitrates was found out when the plants were fertilized with lime saltpetre, while the lowest – with the application of ammonium sulphate.

5. The studies found out an increased content of nitrates in rocket leaves under the effect of the amount of applied nitrogen.

6. The application of 0.2–0.25 g $N \cdot dm^{-3}$ of the substrate in the autumn cultivation of rocket proved to be the most advantageous in view of the highest yield of fresh weight, the highest content of vitamin C and the lowest proportion of nitrates in the leaf dry weight.

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WPŁYW ZRÓŻNICOWANEGO NAWOŻENIA AZOTOWEGO NA PLON I SKŁAD CHEMICZNY LIŚCI ROKIETTY SIEWNEJ (*Eruca sativa* Mill.) W UPRAWIE JESIENNEJ

Streszczenie. Badania przeprowadzone w latach 2001–2002 miały na celu określenie zależności pomiędzy formą oraz dawką stosowanego azotu a plonem i składem chemicznym liści rokietty uprawianej w szklarni nieogrzewanej w okresie jesiennym. Azot zastosowano w postaci saletry wapniowej, mocznika i siarczanu amonu w trzech dawkach: 0,2; 0,4; 0,6 g N dm^{-3} podłoża (2001) i 0,25; 0,50; 0,75 g N dm^{-3} podłoża (2002). Oceniono wzrost roślin, wielkość plonu oraz zawartość składników odżywczych, jak również dokonano analizy podłoża po zbiorze roślin. Wykazano możliwość uprawy rokietty na zbiór liści w okresie jesiennym w szklarni nieogrzewanej. W obiektach z saletrą wapniową i mocznikiem otrzymano większy plon świeżej masy w porównaniu z siarczanem amonu. Zwiększanie dawki azotu niezależnie od rodzaju stosowanego nawozu powodowało zmniejszenie plonu świeżej masy rokietty. Badane rośliny rokietty odznaczały się dużą zawartością suchej masy, witaminy C, białka, potasu i wapnia. Skład chemiczny liści był zależny od stosowanego nawożenia azotowego oraz roku badań. Zawartość azotanów w suchej masie liści mieściła się w zakresie 0,02–0,98% w zależności od dawki azotu i roku badań. Najwięcej azotanów stwierdzono przy żywieniu roślin saletrą wapniową, a najmniej przy zastosowaniu siarczanu amonu. Stwierdzono zwiększenie zawartości azotanów w liściach rokietty pod wpływem zwiększonej ilości stosowanego azotu. W uprawie jesiennej rokietty najkorzystniejsze okazało się stosowanie 0,2–0,25 g N dm^{-3} podłoża, z uwagi na największy plon świeżej masy liści, największą zawartość witaminy C oraz najmniejszy udział azotanów w suchej masie liści.

Słowa kluczowe: rokietta siewna, nawożenie azotowe, plon, skład chemiczny liści

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