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THE EFFECT OF NITROGEN AND POTASSIUM ON $N\text{-}NH_4$ AND $N\text{-}NO_3$ ACCUMULATION AND NUTRIENT CONTENTS IN ROCKET (*Eruca sativa* MILL.) LEAVES

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Abstract. Fertilization of horticultural plants significantly contributes to increased yield but also affects yield quality. Nitrogen, potassium, and sulphur, which belong to the main macronutrients, can have a large effect on the chemical composition of edible parts of plants. The aim of the present study was to determine the effect of the rate of nitrogen as well as of the rate and form of potassium on the accumulation of dry matter, $N\text{-}NH_4$, $N\text{-}NO_3$, Fe, Zn, Mn, and Cu in the leaves of garden rocket grown in a greenhouse during the spring period. These macronutrients were applied at the following rates (in $g \cdot dm^{-3}$ of medium): 0.3 and 0.6 N in the form of $Ca(NO_3)_2$; 0.3, 0.6, and 0.9 K in the form of K_2SO_4 and KCl; 0.4 P; 0.2 Mg; as well as the following micronutrients (in $mg \cdot dm^{-3}$ of medium): 8.0 Fe (EDTA); 5.1 Mn ($MnSO_4 \cdot H_2O$), 13.3 Cu ($CuSO_4 \cdot 5H_2O$), 0.74 Zn ($ZnSO_4 \cdot 7H_2O$), 1.6 B (H_3BO_3); 3.7 Mo $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$). The increased rates of nitrogen and potassium caused significant changes in dry weight (DW) of rocket plants; its higher proportion was found when the lower rate of N was applied, compared to the higher rate. The increased rate of N increased the content of $N\text{-}NH_4$ and $N\text{-}NO_3$, whereas the rising amount of K in the medium resulted in a decrease in the amount of $N\text{-}NO_3$ in the plant material studied. Plants fertilized with the lower rate of nitrogen accumulated more iron and zinc as well as less manganese than plants that received more of this nutrient. Plants fed with the highest rate of K accumulated the largest amount of iron, while the largest amount of manganese was found in plants that received the lowest amount of this nutrient. The application of K_2SO_4, as a source of potassium, contributed to an increased accumulation of iron, whereas the application of KCl resulted in an increased concentration of manganese in rocket leaves.

Key words: N and K rate, KCl and K_2SO_4, dry matter accumulation, microelements

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INTRODUCTION

Yield quality in crop plants primarily depends on the species and cultivar (genetic factors) as well as on the process of development, stresses experienced by plants, nutritional conditions, climate, and agricultural practice (ontogenetic and environmental factors). Nitrogen fertilization effectively increases yield and its quality in many crop plant species. Nitrogen, which is the most yield-enhancing of all nutrients, affects plant growth, root system development, seed filling, and the synthesis of proteins and other plant substances as well as it regulates the consumption of potassium, phosphorus, copper, calcium, and other nutrients. Nitrogen application in horticultural crops is sometimes associated with an increased accumulation of nitrates, compounds affecting the quality of edible parts. Some vegetables, in particular those with a short growing period, are characterized by a natural propensity to accumulate relatively large amounts of these coumpounds. Garden rocket (*Eruca sativa* Mill.), grown under field conditions, usually contains a lot of nitrates, from 7000 to 8000 mg $\cdot$ kg^{-1} FW [Santamaria et al. 1998a, b, Ferrante et al. 2003], but in soilless cultivation [Ferrante et al. 2003] and in greenhouse cultivation these amounts can be much lower [Nurzyńska-Wierdak 2006a, b]. In addition to low light intensity, the main factors contributing to nitrate accumulation also include high rates of nitrogen fertilization [Santamaria et al. 1997; Chen et al. 2004]. With the increasing amount of nitrogen in the nutritional environment of plants, nitrate content in their tissues increases [Hanafy Achmed 2000, Ceylan et al. 2002, Nadasy 2002, Wang and Li 2004, Nurzyńska-Wierdak 2006a].

Potassium regulates plant water management, transpiration as well as the development of root pressure; it also participates in transport, photosynthesis, respiration, and the synthesis of different substances in other plant life processes. Disturbances of nitrogen metabolism can also result from potassium deficiency. The application of a double rate of phosphorus and potassium contributed to a reduction in nitrate concentration in rocket plants, even at high rates of nitrogen [Hanafy Ahmed et al. 2000]. Likewise in other vegetables, increased potassium fertilization had an effect on the decrease in nitrate accumulation in yield [Ali et al. 1985, Wu and Wang 1995, Hanafy Achmed et al. 1997, Zhong et al. 1997]. The presence of potassium enhances the process of nitrate reduction; moreover, potassium is a necessary activator of the enzymes catalyzing the biosynthesis of peptide bonds. In addition to the rate of potassium, its form is also important. In horticultural crops, potassium is most frequently applied as KCl and K_2SO_4, but potassium chloride arouses more controversy due to the opinion about the harmfulness of chlorine to plants. Nurzyński et al. [1980] obtained higher tomato yield by applying KCl than K_2SO_4, while plants fed with potassium sulphate contained in their leaves more nitrates and less Ca, Mg, Mn, and Mo in comparison to those fertilized with KCl. Compared to KCl, fertilization with K_2SO_4 caused a reduction in total nitrogen, calcium, magnesium, and chlorides in the leaves and fruit of pepper [Golcz et al. 2004]. Tomato fruit yield in soilless cultivation did not differ significantly when potassium sulphate and chloride were applied, but in the case of application of K_2SO_4 the net photosynthesis rate was higher compared to KCl [Borowski et al. 2000]. The application of KCl and K_2SO_4 in greenhouse rocket growing did not differentiate fresh matter yield, but more potassium and calcium in the leaves of the plants under study were found when they were fertilized with potassium chloride than it was in the case of potassium sulphate [Nurzyńska-Wierdak 2006a, b, 2009]. Thus, the role of potassium salt in greenhouse vegetable growing is of essential importance, similarly to the amount of macronutrient applied. The aim of the present study was to determine the effect of the rates of nitrogen and potassium as well as of the type of potassium fertilizer on the accumulation of ammonium nitrogen, nitrate nitrogen, and some micronutrients in the leaves of garden rocket grown in a greenhouse during the spring period. Moreover, the study analysed the accumulation of dry matter and macronutrients in plants as influenced by different amounts of sulphur in the growing medium, differentiated by the rate of potassium (K_2SO_4).

MATERIAL AND METHODS

The study was conducted in a greenhouse of the Department of Vegetable Crops and Medicinal Plants of the University of Life Sciences in Lublin during the period from March to May in the years 2010–2011. Garden rocket (*Eruca sativa* Mill.) seeds, coming from a seed production company PNOS Ożarów Mazowiecki, were planted individually in pots (2 dm^3 in volume) filled with peat substrate. Substrate pH was in the range of 5.5–6.5. The experiment was set up as a completely randomized design in 12 replicates (one pot in which 3 plants were grown was one replicate). Before sowing (23 March 2010 and 22 March 2011), seeds were dressed with the fungicide Dithane Neo Tec 75 WG (3 $g \cdot kg^{-1}$ of seeds). The following amounts of nutrients were applied ($g \cdot dm^{-3}$ of medium): 0.3 and 0.6 N in the form of $Ca(NO_3)_2$ – introducing, respectively: 0.37 and 0.74 Ca; 0.3, 0.6, and 0.9 K in the form of K_2SO_4 (44.9% K; 18.4% S) introducing, respectively: 0.34, 0.47, and 0.60 S, and KCl (52.4% K; 47.5% Cl) introducing, respectively: 0.27, 0.54, and 0.81 Cl; 0.4 P; 0.2 Mg; as well as the following micronutrients ($mg \cdot dm^{-3}$ of medium): 8.0 Fe (EDTA); 5.1 Mn ($MnSO_4 \cdot H_2O$); 13.3 Cu ($CuSO_4 \cdot 5H_2O$); 0.74 Zn ($ZnSO_4 \cdot 7H_2O$); 1.6 B (H_3BO_3); 3.7 Mo $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$). Phosphorus was applied in the form of granulated superphosphate (20% P), magnesium as $MgSO_4 \cdot H_2O$. In applying potassium sulphate at different rates, different amounts of sulphur were introduced, too; sulphur was also introduced as sulphate of magnesium, manganese, copper, and zinc (at the same amount for all experimental series). Fertilizers were divided into 3 equal parts and applied before seeding, 30 days from seeding, and 10 days before harvest. Salts were dissolved in distilled water and supplied to the plants by root application. The plants were watered every day, using each time 250–300 ml of water.

Leaf rosettes were harvested on 10 May. Fresh plant material was analysed to determine the proportion of dry weight (DW) (using the gravimetric method). Next, the collected plant material was dried at a temperature of 60°C, grounded to prepare it for the determination of the mineral composition and burnt dry at a temperature of 550°C. After cooling, the ash was acidified with hydrochloric acid diluted at a ratio of 1:2 and the content of the following nutrients was determined in it: Fe, Cu, Zn, and Mn. The content of N-NH_4, N-NO_3 was analysed in a 2.0% acetic acid extract using the Bremner microdistillation method modified by Starck. Iron, copper, zinc, and manganese contents were determined by atomic absorption spectrometry (AAS) (Aanalyst 300 Perkin

Elmer). At the termination of the experiment, medium samples were collected for chemical analysis. Subsequently, the content of N-NH_4, N-NO_3 was determined in a 0.03 M acetic acid extract, with a 10:1 volume ratio of solution to medium, with the addition of active carbon. Ammonium nitrogen and nitrate nitrogen were determined following the same method as for the plant material. Medium pH – pH-metrically (pH_{H_2O}) – and the ion concentration (EC) – conductometrically ($mS \cdot cm^{-1}$) – were also determined.

RESULTS AND DISCUSSION

The increased rates of nitrogen (N) and potassium (K) caused significant changes in dry weight (DW) of rocket plants, but a higher proportion of DW was found when the lower rate of N was applied, compared to the higher rate (tab. 1). The effect of increased dry matter accumulation by plants under the influence of an increased rate of nitrogen is generally positive [Asare and Scarisbrick 1995, Santamaria et al. 2002, Salvagiotti and Miralles 2008, Nurzyńska-Wierdak et al. 2011, Omirou et al. 2011]. On the other hand, however, increased rates of nitrogen and urea reduced dry weight and nutrient content in eucalyptus leaves [Carvalho Neto et al. 2011]. Furthermore, our earlier study [Nurzyńska-Wierdak 2006a, b, 2009] showed no significant effect of the rate of nitrogen on dry matter accumulation by rocket. The increased rate of potassium modified dry weight of rocket in an undirected way, though significantly (tab. 1). Plants fed with potassium sulphate accumulated more DW than those fertilized with potassium chloride. Thereby, plants receiving more sulphur, which was differentiated by the rate of potassium sulphate, were characterized by a higher proportion of DW than the other plants. These relationships should be attributed to a high requirement for nitrogen and sulphur of plants from the family Brassicaceae. Protein of rocket fertilized with potassium sulphate is characterized by a higher proportion of methionine and cysteine compared to plants supplied with potassium chloride [Nurzyńska-Wierdak 2006a]. Similarly, the total of sulphur and aromatic amino acids of protein in kohlrabi was higher in the case of application of K_2SO_4 than it was for KCl [Nurzyńska-Wierdak 2006a]. Nitrogen and sulphur also contribute to an increase in wheat biomass; besides, a positive interaction between nitrogen and sulphur was found at a high level of nitrogen fertilization and when there was no sulphur deficiency [Salvagiotti and Miralles 2008]. The positive effect of nitrogen and sulphur on dry matter accumulation in seeds was also confirmed in *Brassica campestris* L. and *Eruca sativa* Mill. [Fazli et al. 2005]. The application of nitrogen increases total dry matter yield in *Brassica napus* L., but the positive effect of nitrogen and sulphur on plant dry matter yield was dependent on meteorological conditions of the crop [Asare and Scarisbrick 1995]. Likewise, dry matter accumulation by rocket plants under the influence of nitrogen varies depending on the cropping period (spring or autumn) [Nurzyńska-Wierdak 2006a, b, 2009], which should be associated primarily with light and thermal conditions. Dry matter accumulation in garden rocket is significantly dependent on nitrogen application, but also on the plant growth stage and the interaction of these factors [Omirou et al. 2011].

Table 1. Dry weight and nutrient contents of garden rocket's edible parts upon nitrogen and potassium fertilization (2010–2011)
Tabela 1. Sucha masa oraz zawartość składników pokarmowych w częściach jadalnych rokietty pod wpływem nawożenia azotem i potasem (2010–2011)

Fertilization Nawożenie		Dry weight Sucha masa %	N-NH_4	N-NO_3	Fe	Zn	Mn	Cu
			% d. w. – % s. m.		mg · kg^{-1} d.w. – mg · kg^{-1} s. m.			
KCl	N_1K_1	9.23	0.093	1.147	171.68	57.45	55.05	3.56
	N_1K_2	9.24	0.074	0.734	238.38	74.33	82.90	4.04
	N_1K_3	9.39	0.060	0.544	388.03	76.28	64.03	5.86
	N_2K_1	8.52	0.134	1.451	294.33	77.78	100.43	7.41
	N_2K_2	8.04	0.129	1.537	141.30	57.68	69.20	4.27
	N_2K_3	8.35	0.138	1.317	150.88	67.08	74.23	4.51
K_2SO_4	N_1K_1	9.18	0.114	0.926	281.00	77.15	79.65	4.56
	N_1K_2	9.55	0.065	0.638	263.95	75.98	52.93	5.02
	N_1K_3	9.26	0.058	0.499	295.75	86.35	51.63	4.34
	N_2K_1	7.83	0.128	1.523	219.30	66.50	88.53	4.82
	N_2K_2	10.12	0.106	1.574	205.50	62.43	67.68	5.04
	N_2K_3	8.17	0.122	1.516	255.70	59.60	54.85	4.26
Mean Średnio	N_1	9.31b	0.077a	0.748a	273.13b	74.59b	64.36a	4.56a
	N_2	8.51a	0.126b	1.486b	211.17a	65.18a	75.82b	5.05a
	K_1	8.69a	0.117a	1.261b	241.58b	69.72a	80.91c	5.09a
	K_2	9.24b	0.094a	1.121a	212.28a	67.60a	68.18b	4.59a
	K_3	8.79ab	0.094a	0.969a	272.59c	72.33a	61.18a	4.74a
	KCl	8.79a	0.105a	1.121a	230.76a	68.43a	74.30b	4.94a
	K_2SO_4	9.02a	0.099a	1.113a	253.53b	71.33a	65.88a	4.67a

Means in columns followed by the same letter are not significantly different at $\alpha = 0.05$
Średnie w kolumnach oznaczone tą samą literą nie różnią się pomiędzy sobą istotnie przy $\alpha = 0{,}05$

The increased rate of N increased N-NH_4 and N-NO_3 content in garden rocket plants (tab. 1). This relationship has been shown in our earlier studies [Nurzyńska-Wierdak 2001, 2006a, 2009] and in other plants [Elia et al. 1999, Gülser 2005; Dzida and Pitura 2008, Biesiada and Kołota 2010, Nurzyńska-Wierdak et al. 2011, Omirou et al. 2011]. Nitrate content in rocket leaves increases under the influence of an increased amount of nitrogen in the nutrient solution or in the medium [Ceylan et al. 2002, Santamaria et al. 2002, Nicola et al. 2003]. The increase in total nitrogen concentration in rocket leaves is not necessarily associated with increased nitrate content in the plant [Hanafy Ahmed et al. 2000, Nurzyńska-Wierdak 2006a]. The concentration of N-NO_3 in rocket leaves may decrease with a simultaneous increase in total nitrogen (under the influence of an increasing rate of N) [Nurzyńska-Wierdak 2006a]. This is confirmed by the results of this study, shown in table 1, and our earlier study [Nurzyńska-Wierdak et al. 2012]. The obtained results show the possibility of utilisation of nitrogen and its transformations from simpler forms (nitrates) to more complex ones (amino acids, proteins). The application of potassium significantly contributed to the amount of N-NO_3 in edible parts of rocket (tab. 1), but significant differences only related to the rate of K. The increasing amount of K caused a reduction in the amount of N-NO_3, but no significant differences were found in the series with the medium and highest rates of K. Increased potassium fertilization has an effect on the reduction in nitrate accumulation in plants [Ali et al. 1985, Wu and Wang 1995, Hanafy Achmed et al. 1997, Zhong et al. 1997, Nurzyńska--Wierdak 2006a, Nurzyńska-Wierdak et al. 2011]. Moreover, the interaction of the rates of nitrogen and potassium significantly affects the activity of nitrate reductase [Silva et al. 2011]. Disturbances of nitrogen metabolism, resulting from potassium deficiency, are manifested, among others, in changes in the proportions of nitrogen fractions and in the accumulation of harmful amino substances in plants: agmatine, N-carbamoyl putrescine or putrescine as well as ammonium ions [Nowacki 1980]. The absence of significant accumulation of $N\text{-}NH_4$ in the plant material studied resulted most probably from the absence of potassium stress. Plants receiving the lowest rate of K most probably did not feel the lack of this nutrient and nitrogen metabolism occurred in them without major disturbances. Moreover, an excessive accumulation of $N\text{-}NH_4$, at a level harmful to the plant, takes place primarily when the plant is supplied with ammonium salts or urea [Nowacki 1980] – which were not used in the present study. In discussing the reduced concentration of $N\text{-}NO_3$ in the studied plant material under the influence of the increased rate of potassium, one should also take into account the effect of sulphur (S) supplied to the plants mainly as K_2SO_4. There was a clear tendency towards a positive effect of S on the decrease in $N\text{-}NO_3$ accumulation in the rocket plants under study. Likewise, spinach plants accumulated the highest amount of nitrates when sulphur was not applied [Smatanova et al. 2004], while in *Brassica napus* the highest amount of nitrates was found at a low level of S [Schnug and Haneklaus 1994]. As suggested by other authors [Marschner 1995], sulphur enhances the incorporation of N into organic compounds and consequently reduces the leaf nitrate concentration. Nitrate-N content in the leaves of rapeseed and rocket plats grown with only n (without S) was higher compared to those grown with both S and N, showing that combined application of S along with N appreciably reduced the nitrate content in the leaves due to higher NR activity [Fazli et al. 2008]. Sulphur application increases the content of chlorophyll and phenolic acids as well as it reduces nitrate concentration in the leaves of *Brassica rapa* L. subsp. *sylvestris* [De Pascale et al. 2007]. The above results show the significant role of sulphur in determining the quality of yield in crop plants, in particular those of the family Brassicaceae [Asare and Scarisbrick 1995, Scherer 2001, Fazli et al. 2005, Omirou et al. 2009].

Iron, zinc, and manganese contents in edible parts of rocket depended on fertilization (tab. 1). Plants fertilized with the lower rate of nitrogen ($0.3\ g \cdot dm^{-3}$) accumulated more iron and zinc as well as less manganese than plants that received more N. It should be indicated here that plants in the series with the lower rate of N were characterized by a higher proportion of DW than the other ones. The decrease in the proportion of dry weight as well as in iron and zinc concentration with the increased application of nitrogen occurred due the dilution effect by increasing plant biomass [Nurzyńska-Wierdak et al. 2012] and this is in agreement with the results of other authors [Cil and Katkat 1995, Gülser 2005]. The rate of K significantly modified iron and manganese content in the plant material studied (tab. 1). Plants fertilized with the highest rate of K accumulated the largest amount of iron, while the highest amount of manganese was found in plants that received the lowest amount of this nutrient. Potassium fertilizers applied at different levels affected the accumulation of microelements by rocket plants. The application of K_2SO_4, as a source of potassium, contributed to an increased accumulation of iron, while the application of KCl caused an increased concentration of manganese in rocket. Zinc and copper content was not significantly dependent on the type of potassium fertilizer, thereby also on the amount of sulphur in the medium, which is in agreement with the results of Sirguey et al. [2006]. The above correlations can also be attributed to different amounts of sulphur in the medium. It is known that, present sulphur in the texture of soil had a reduction effect on the pH value of soil extract, thus improving the solubility and availability of many minerals in rooting zone, hence increasing their absorbing for plant feeding. Sulphur fertilization caused an enhancement in nutritional values of edible parts of artichoke yield [Shaheen et al. 2007], as well as of *Brassica rapa* L. subsp. *sylvestris* [De Pascale et al. 2007].

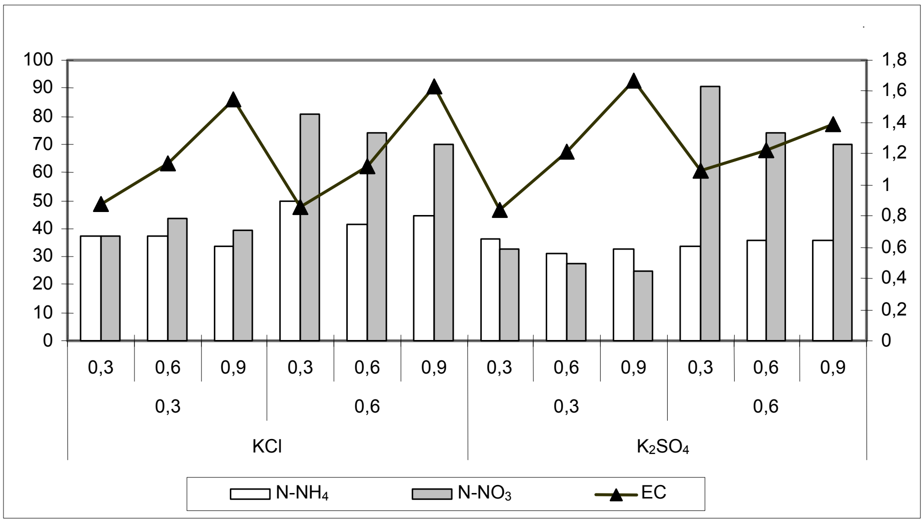

Fig. 1. N-NH_4 and N-NO_3 content (mg dm^{-3}) and EC (mS cm^{-1}) of growing medium after the rocket harvest (2010–2011)

Rys. 1. Zawartość N-NH_4 i N-NO_3 (mg dm^{-3}) oraz EC (mS cm^{-1}) podłoża po zbiorze rokietty (2010–2011)

The pH of the medium in which rocket was grown was in the optimal range from 6.20 to 6.36 (medium with KCl) and from 5.90 to 6.26 (medium with K_2SO_4) [Nurzyńska-Wierdak et al. 2012]. The applied rates of N and K only slightly modified the pH values for the media under study. The EC value for the investigated substrates was within the permissible range for plant growth and development and it was from 1.21 mS · cm^{-3} in the medium fertilized with KCl to 1.24 mS · cm^{-3} in the medium fertilized with K_2SO_4 (fig. 1). The salt concentration (EC) was not significantly dependent on the rate of N and the form of K, but it increased under the influence of the increased rate of K, which was also shown in our earlier studies [Nurzyńska-Wierdak 2006a, 2009, Nurzyńska-Wierdak et al. 2011]. In analysing residual ammonium nitrogen and nitrate nitrogen in the medium (fig. 1), as well as residues of other nutrients presented in our earlier paper [Nurzyńska-Wierdak et al. 2012], it can be noticed that potassium, sulphate and chloride ions had a greater effect on the value of EC than the other ions, since the increasing rate of potassium caused a significant increase in the value of EC and in residual potassium, sulphates and chlorides in the medium. Similar relationships, but with a higher proportion of ammonium and nitrate ions, were shown in chard cultivation [Dzida et al. 2011], which most probably resulted from differences in nutrient uptake by the plants under study.

CONCLUSIONS

To sum up, the present study shows certain correlations between the accumulation of dry matter, $N\text{-}NO_3$, $N\text{-}NH_4$ as well as Fe, Zn, and Mn in garden rocket as influenced by the rate of nitrogen, potassium, the amount of sulphur in the medium, as well as the type of potassium fertilizer. The increased rate of nitrogen resulted in an increased accumulation of $N\text{-}NO_3$ and $N\text{-}NH_4$, while a reverse effect was found in relation to the increased amount of potassium and sulphur in the medium. Plants fertilized with the lower rate of nitrogen accumulated more iron and zinc as well as less manganese than plants that were supplied with the higher rate. The increasing rate of potassium and the application of potassium sulphate contributed to an increased concentration of iron and a reduced content of manganese in the plant material studied. The differences in iron and manganese content in rocket were associated with different contents of potassium and sulphur in the medium. In the cultivation of garden rocket for leaf rosettes, the appropriate amounts of nitrogen, potassium, and sulphur should be applied; on the basis of the above study, the following amounts of the nutrients in question can be recommended per 1 dm^3 of peat substrate: 0.3 g N, 0.6 g K, and 0.5 g S.

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ODDZIAŁYWANIE AZOTU I POTASU NA GROMADZENIE SIĘ N-NH_4 I N-NO_3 ORAZ SKŁADNIKÓW POKARMOWYCH W LIŚCIACH ROKIETTY (*Eruca sativa* MILL.)

Streszczenie. Nawożenie roślin ogrodniczych przyczynia się w znacznym stopniu do zwiększenia wielkości plonu, ale ma wpływ również na jego jakość. Azot, potas i siarka, należące do głównych makroskładników mogą w dużym stopniu wpływać na skład chemiczny części jadalnych warzyw. Celem przedstawionych badań było określenie wpływu dawki azotu oraz dawki i postaci potasu na gromadzenie suchej masy, N-NH_4, N-NO_3, Fe, Zn, Mn i Cu w liściach rokietty siewnej, uprawianej w szklarni w okresie wiosennym. Zastosowano (w g · dm^{-3} podłoża): 0,3 i 0,6 N w formie $Ca(NO_3)_2$; 0,3, 0,6 i 0,9 K w postaci K_2SO_4 oraz KCl; 0,4 P; 0,2 Mg oraz mikroelementy (w mg · dm^{-3} podłoża): 8,0 Fe (EDTA); 5,1 Mn ($MnSO_4 \cdot H_2O$); 13,3 Cu ($CuSO_4 \cdot 5H_2O$); 0,74 Zn ($ZnSO_4 \cdot 7H_2O$); 1,6 B (H_3BO_3); 3,7 Mo $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$). Zwiększenie dawki azotu oraz potasu powodowało istotne zmiany suchej masy (DW) roślin rokietty, a większy jej udział stwierdzono przy mniejszej dawce N niż przy większej. Zwiększenie dawki N zwiększyło zawartość N-NH_4 i N-NO_3, a wzrastająca ilość K w podłożu powodowała zmniejszenie ilości N-NO_3 w badanym materiale roślinnym. Rośliny żywione mniejszą dawka azotu gromadziły więcej żelaza i cynku oraz mniej manganu niż rośliny otrzymujące więcej tego składnika. Najwięcej żelaza gromadziły rośliny żywione najwyższą dawką K, natomiast najwięcej manganu stwierdzono u roślin, które otrzymywały najmniej tego składnika. Aplikacja K_2SO_4 jako źródła potasu, przyczyniła się do zwiększonej kumulacji żelaza, natomiast zastosowanie KCl powodowało zwiększoną koncentrację manganu w liściach rokietty.

Słowa kluczowe: dawka N i K, KCl i K_2SO_4, gromadzenie suchej masy, mikroelementy

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