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# EFFECTS OF NITROGEN AND POTASSIUM FERTILIZATION ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF GARDEN ROCKET

Renata Nurzyńska-Wierdak, Katarzyna Dzida, Ewa Rożek, Zbigniew Jarosz

University of Life Sciences in Lublin

**Abstract**. Plants of the family *Brassicaceae* are characterized by high nutritional and fertilization requirements, in particular with respect to nitrogen, potassium, and sulphur. The positive action of the above-mentioned nutrients on plant growth and yield is associated, among others, with their rate and form as well as with interrelationships between individual nutrients. The present experiment was conducted in a greenhouse during the period from March to May in the years 2010 and 2011. Garden rocket plants were seeded individually in 2dm$^3$ pots, with peat as the growing medium. The experimental design included three rates (g dm$^{-3}$ of medium) of potassium in the form of $K_2SO_4$: 0.3 K (and 0.34 S); 0.6 K (and 0.47 S); 0.9 K (and 0.6 S), in the form of KCl: 0.3 K (and 0.27 Cl); 0.6 K (and 0.54 Cl); 0.9 K (and 0.81 Cl), as well as two rates of nitrogen in the form of Ca $(NO_3)_2$: 0.3 N (and 0.37 Ca); 0.6 N (and 0.74 Ca). The following traits were determined: plant height (cm), number of leaves per rosette (pcs), plant weight (g), and fresh weight yield of leaf rosettes (g $\cdot$ pot$^{-1}$). The content of N, P, K, Ca and of Mg, S-$SO_4$, Cl was determined in dried plant material. The increase in the rate of nitrogen in the nutritional environment of rocket did not affect plant height and the number of leaves per rosette, but it caused a significant increase in fresh weight yield of leaf rosettes, as well as it resulted in an increase in calcium content and a decrease in chlorine concentration in the plants. The increased amount of potassium in the medium contributed to an increase in rocket yield as well as an increase in the concentration of potassium and chlorine. Potassium chloride proved to be a better source of K than sulphur due to the amount of fresh weight and yield of the plants studied. The plants fed with KCl were also characterized by a higher content of nitrogen, chlorine, calcium, and magnesium than after the application of $K_2SO_4$.

**Key words**: *Eruca sativa* Mill., N and K rate, potassium form, fresh weight yield, macroelements

Corresponding author – Adres do korespondencji: Renata Nurzyńska-Wierdak, Department of Vegetable Crops and Medicinal Plants, University of Life Sciences in Lublin, Leszczyńskiego 58, 20-068 Lublin, Poland, e-mail: renata.nurzynska@up.lublin.pl

## INTRODUCTION

Fertilization of horticultural plants, intended to provide necessary nutrients to them, is one of the most important agrotechnical problems. Plants take up more than 60 different elements, but not all of them are termed nutrients. Nitrogen (N) is one of essential nutrients used by plants to build numerous organic compounds and taken up throughout the entire growing period. Nitrogen fertilization has an important effect on plant growth as well as on yield and yield quality [Abou El-Magd et al. 2010, Barros Junior et al. 2011, Dong et al. 2012]. Plants use mainly nitrate and ammonium nitrogen, but the nitrate form is generally better utilised by plants than the ammonium form [Santamaria et al. 1999, Tian et al. 2003]. The use of nitrogen fertilization in horticultural crops can be associated with the problem of excessive accumulation of nitrates V ($NO_3$) in edible parts. An effective method to reduce the accumulation of these compounds in yields of some vegetables is to use fertilizers containing only a reduced form of nitrogen [Osmolovskaya and Kuchaeva 1994, Zhu and Jiang 1994, Rożek et al. 1995, Santamaria et al. 1998, Abu-Rayyan et al. 2004]. On the other hand, however, a higher yield of garden rocket was obtained when calcium nitrate and urea were used, as compared to ammonium sulphate [Nurzyńska-Wierdak 2006a, b]. Another method to reduce the amounts accumulated in edible parts of plants is to determine an appropriate rate of fertilizer nitrogen [Hanafy Ahmed et al. 2000, Lenzi and Tesi 2000, Ceylan et al. 2002, Nadasy 2002, Aslam et al. 2003]. A sufficient amount of nitrogen (N) in the nutritional environment of plants is very important for increasing yield. Increased N application generally increases fresh weight production and the content of nitrogen, proteins and nitrates V ($NO_3$) in plants [Nurzyńska-Wierdak 2006a, b, 2009, Omirou et al. 2011, Ehsanipour et al. 2012]. Thus, N fertilization affects both plant yield and its quality.

Nitrogen uptake by plants from the soil solution in the form of $NO_3^-$ anion and $NH_4^+$ cation is associated with the mutual effects of other nutrients on inorganic nitrogen bonds. One of the essential conditions for good utilisation of soil nitrogen is good phosphorus and potassium availability in the soil. Potassium (K) usually occurs in the plant at a quite high concentration. Disturbances of nitrogen metabolism, resulting from potassium deficiency, are manifested in changes in the proportions of nitrogen fractions and in the accumulation of harmful amino substances in plants. The size of a single potassium dose is of great importance due to the antagonistic effect of this nutrient on the uptake of other cations ($Na^+$, $Ca^{+2}$, $Mg^{+2}$) by plants. It should be noted here that an increase in the rate of potassium contributes to a decrease in the concentration of nitrates V [Hanafy Ahmed et al. 2000, Nurzyńska-Wierdak 2006a], but the type of potassium fertilizer is important. Plants fed with potassium sulphate contain in their leaves more nitrates V and less calcium, magnesium, manganese, and molybdenum compared to those fertilized with potassium chloride [Nurzyński 1976, 1986a, b, Nurzyński et al. 1980, 1982a, b]. This relationship results from the antagonistic effect of sulphates on the uptake of molybdenum whose deficiency weakens the reducing power of nitrate reductase, which leads to the accumulation of nitrates V in the plant.

Sulphur, another nutrient necessary for plants, is taken up from the nutritional environment in an oxidized form as $SO_4^-$, whereas in small amounts it can be assimilated as $SO_2$ from the atmosphere. The importance of sulphur for the proper growth and development of plants is extremely high, but its most important role arises from its occurrence, mainly in a reduced form, in the sulfhydryl groups of amino acids: cysteine, cystine, and methionine, as well as in an oxidized form in sulpholipids. Sulphur is also found in various proteins as the SH group or forms S-S bridges as well as it is a component of glutathione performing the role of an antioxidant under stress conditions; sulphur is also a constituent of phytochelatins that bind heavy metals in plant tissues [Kopcewicz and Lewak 2002]. In plants of the family *Brassiceae*, sulphur is an essential component of glucosinolates, compounds exhibiting antitumor activity [Michael et al. 2011, Shapiro et al. 2011]. The amount of nitrogen (N) taken up by plants is dependent on the content of sulphur (S) in the nutritional environment. Some studies show the possible interaction between these nutrients [Catherine et al. 2006, Fazli et al. 2005, 2008], while a positive interaction between N and S has been particularly noticeable at a high level of nitrogen supply to plants and with no sulphur deficit [Salvagiotti and Miralles 2008].

The aim of the present study was to determine the relationship between growth and yield of garden rocket plants grown in a greenhouse during the early spring period and different levels of nitrogen and potassium fertilization at different soil sulphur contents.

## MATERIAL AND METHODS

A plant growth experiment was conducted in a detached greenhouse, situated in the north-south direction and belonging to the Department of Vegetable Crops and Medicinal Plants, during the period from March to May in the years 2010 and 2011. Garden rocket plants, coming from a seed production company PNOS Ożarów Mazowiecki, were seeded individually in 2dm$^3$ pots. Sphagnum peat with a pH of 5.5–6.0 was used as the growing medium. The experiment was set up as a completely randomized design in 12 replicates. One pot in which 3 plants were grown was one replicate. Seeds were seeded on 23 March (2010) and 22 March (2011), having been first dressed with Dithane Neo Tec 75 WG (3 g kg$^{-1}$ of seeds).

The experimental design included three rates (g dm$^{-3}$ of medium) of potassium in the form of $K_2SO_4$: 0.3 K (and 0.34 S); 0.6 K (and 0.47 S); 0.9 K (and 0.6 S), in the form of KCl: 0.3 K (and 0.27 Cl); 0.6 K (and 0.54 Cl); 0.9 K (and 0.81 Cl), as well as two rates of nitrogen in the form of Ca $(NO_3)_2$: 0.3 N (and 0.37 Ca); 0.6 N (and 0.74 Ca). In addition, P – 0.4; Mg – 0.2 as well as the following micronutrients (mg dm$^{-3}$ of medium): Fe – 8.0; Cu – 13.3; Mn – 5.1; B – 1.6; Mo – 3.7; Zn – 0.74. Phosphorus was applied in the form of granulated triple superphosphate (20% P), magnesium as $MgSO_4$ $H_2O$, iron in the form of chelate, copper, manganese, zinc as sulphates, boron – boric acid, molybdenum – ammonium molybdate. Thus, sulphur was supplied from $K_2SO_4$ and $MgSO_4$ $H_2O$ as well as in a small amount as sulphates of Mn, Cu, and Zn. The reason for the application of potassium in the form of $K_2SO_4$ and KCl was the need to provide an increasing amount of sulphur ($K_2SO_4$) and the uptake of a significant amount of chlorine by garden rocket plants without a negative effect on their yield, which had been found in a previous study. Nitrogen doses were divided into 3 equal parts and applied as follows: one day before seeding, 30 days from seeding, and 10 days before harvest. The nutrient supplement was applied to the roots. The other nutrients were applied only once before seeding without differentiating their amount and form. The plants were watered once or twice a day with the same amount of water, using each time 250–300 ml of water. Leaf rosettes were harvested on 10 May (2010) and 16 May (2011). The following traits were determined: plant height (cm), number of leaves per rosette (pcs), plant weight (g), and fresh weight yield of leaf rosettes ($g \cdot pot^{-1}$).

Plant material samples were collected immediately after plant harvest; the plant material was dried at a temperature of 60°C and grounded to prepare it for determinations of the mineral composition of the plants. Total N was determined by the Kjeldahl method, after burning the material in $H_2SO_4$ in a Kjel-Foss automatic analyser. To determine P, K, Ca, and Mg, the plant material was 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 above-mentioned nutrients was determined in it. Phosphorus was determined with ammonium metavanadate, sulphur with barium chloride, and chlorine with silver nitrate. The content of K, Ca, and Mg was determined by atomic absorption spectrometry (ASA) (Aanalyst 300, Perkin Elmer). Moreover, the content of $S\text{-}SO_4$ and Cl was analysed in a 2.0% acetic acid extract: sulphates with barium chloride, chlorine with silver nitrate colourimetrically. The growing medium was analysed after plant harvest: mineral nitrogen was determined in a 0.03M acetic acid extract using the Bremner distillation method modified by Starck, phosphates with ammonium metavanadate, sulphates with barium chloride, chlorine with silver nitrate colourimetrically as well as potassium, calcium, magnesium by the ASA method using a Perkin-Elmer Aanalyst 300 spectrometer. In addition, medium pH ($pH_{H2O}$) was determined as well as the ion concentration (EC) in $mS \cdot cm^{-1}$, in a suspension being a mixture of distilled water and the examined medium at a volume ratio of 2:1.

## RESULTS AND DISSCUSSION

**Morphological characters and yield of rocket.** The growth and development of the rocket plants was correct throughout the entire growing period. The average height of the studied plants was 31.5 cm, while the number of leaves per rosette 11.9 pieces, which is in agreement with the results of a previous study [Nurzyńska-Wierdak 2006a, b]. The above-mentioned characters were not dependent on fertilization (tab. 1). Differently, plant weight and fresh weight yield were significantly affected by nitrogen and potassium. The increasing rates of nitrogen and potassium contributed to an increase in plant weight and fresh weight yield, but the differences between weight and yield in the plants in which the second and third rate of K (weight), the first and second rate of K as well as the second and third rate of K (yield) had been applied were not statistically significant. Nitrogen, which is an important yield-increasing nutrient for plants, has a positive effect on their growth and fresh weight yield [Nurzyńska-Wierdak 2001, Cavarianni et al. 2008, Chochura and Kołota 2011]. However, yield of crop plants does not always increase under the influence of the increasing rate of nitrogen. An excessive amount of this nutrient can inhibit plant growth to a lesser or greater extent [Wang and Li 2004, Salvagiotti and Miralles 2008], which leads to a decrease in fresh weight yield when the highest rate of this nutrient is applied [Smatanowa et al. 2004, Dzida and Pitura 2008, Biesiada and Kołota 2010]. The determination of an appropriate amount of fertilizer nitrogen for individual crop plant species is particularly important in the aspect of yield quality [Nurzyńska-Wierdak 2006b]. The presented results of this study show high nutritional requirements of garden rocket, in particular in relation to nitrogen. The plants fertilized with a higher rate of nitrogen were characterized by higher weight and fresh weight yield, but the application of an increased amount of nitrogen had no negative effect on their growth. The obtained results are confirmed by Barros Junior et al. [2011] in their study. It should be pointed out here that the increased rate of nitrogen significantly influences the content of glucosinolates in rocket garden [Omirou et al. 2011].

Table 1. Morphological features of rocket plants and yield of fresh weight upon supply fertilization (2010–2011)
Tabela 1. Cechy morfologiczne roślin rokietty oraz plon świeżej masy pod wpływem zastosowanego nawożenia (2010–2011)

| N rate<br>Dawka N<br>g dm$^{-3}$ | K rate<br>Dawka K<br>g dm$^{-3}$ | K source<br>Źródło K | Height<br>Wysokość<br>cm | No of leaves<br>Liczba liści<br>per plant | Weight<br>Masa<br>g · plant$^{-1}$ | Yield<br>Plon<br>g pot$^{-1}$ |
|---|---|---|---|---|---|---|
| 0.3 | 0.3 | KCl | 31.0 | 11.9 | 37.1 | 103.9 |
| | 0.6 | | 30.8 | 12.1 | 39.7 | 113.3 |
| | 0.9 | | 29.9 | 13.1 | 37.9 | 111.7 |
| 0.6 | 0.3 | | 32.9 | 11.6 | 49.0 | 145.0 |
| | 0.6 | | 35.9 | 12.6 | 58.7 | 149.8 |
| | 0.9 | | 33.5 | 11.8 | 56.6 | 153.9 |
| Mean – Średnio KCl | | | 32.3a | 12.3a | 46.5b | 129.6b |
| 0.3 | 0.3 | $K_2SO_4$ | 31.2 | 11.4 | 34.9 | 112.0 |
| | 0.6 | | 30.8 | 12.1 | 41.9 | 106.3 |
| | 0.9 | | 29.2 | 10.9 | 34.3 | 101.5 |
| 0.6 | 0.3 | | 31.9 | 11.5 | 36.2 | 112.6 |
| | 0.6 | | 30.1 | 11.2 | 46.1 | 120.4 |
| | 0.9 | | 31.6 | 12.3 | 50.8 | 136.5 |
| Mean – Średnio $K_2SO_4$ | | | 30.8a | 11.5a | 40.7a | 114.9a |
| Mean N – Średnio N | | 0.3 | 30.5a | 11.9a | 32.6a | 108.1a |
| | | 0.6 | 32.7a | 12.0a | 49.6b | 136.4b |
| Mean K – Średnio K | | 0.3 | 31.7a | 11.6a | 39.3a | 118.4a |
| | | 0.6 | 31.9a | 12.0a | 46.6b | 122.4ab |
| | | 0.9 | 31.0a | 12.1a | 44.9b | 125.9b |

The plants fed with potassium chloride were marked by higher weight and yield than those fertilized with potassium sulphate (tab. 1). It should be indicated here that rocket fertilized with $K_2SO_4$ received more sulphur than in the case of application of KCl. In many plant species, in particular those from the family *Brassicaceae*, sulphur application increases dry matter yield of plants and stimulates their growth [Asare and Scarisbrick 1995, Shaheen et al. 2007, Mathot et al. 2008]. The lack of a significant effect of the type of sulphur-containing potassium fertilizer on rocket yield can be explained by additional increased nitrogen fertilization due to the interaction between S and N [Scherer 2001, Fazli al. 2005, Salvagiotti and Miralles 2008]. The relationship between yield of crop plants and type of potassium fertilizer applied is not unambiguous. KCl, as a source of potassium, contributes to an increase in chard yield [Dzida et al. 2011] and eggplant fruit yield [Marques et al. 2011]. In turn, potassium sulphate is preferred as a source of potassium in fertilization of medicinal poppy, in particular as regards seed yield and morphine content [Losak et al. 2005]. Furthermore, the net photosynthesis rate in tomato plants fed with $K_2SO_4$ was higher than in the case of application of KCl, but no significant differences were found in fruit yield, while specific leaf weight (SLW) was higher in the treatments with KCl compared to $K_2SO_4$ [Borowski et al. 2000]. The above correlation shows that the plants fed with KCl used more $CO_2$ assimilation products for building vegetative organs than for generative ones – conversely than the plants fertilized with $K_2SO_4$. The above relationships result from specific nutritional requirements of particular crop plant species and type of plant production as well as they are driven by cropping and environmental factors.

**Mineral nutrients in plant material.** The mineral composition of the rocket plants under study was dependent on fertilization, but significant differences related only to the content of some nutrients (tab. 2). The increasing rate of nitrogen caused an increase

Table 2. Chemical composition of rocket upon supply fertilization (2010–2011)
Tabela 2. Skład chemiczny rokietty pod wpływem zastosowanego nawożenia (2010–2011)

| N rate Dawka N g dm$^{-3}$ | K rate Dawka K g dm$^{-3}$ | K source Źródło K | N-total N-og. | P | K | S | Cl | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|
| | | | | % s.m. – % d.w. | | | | | |
| 0.3 | 0.3 | KCl | 3.60 | 0.45 | 4.49 | 0.67 | 1.95 | 2.27 | 0.32 |
| | 0.6 | | 5.22 | 0.53 | 5.47 | 0.72 | 2.61 | 2.16 | 0.28 |
| | 0.9 | | 5.05 | 0.46 | 5.70 | 0.64 | 2.87 | 2.16 | 0.26 |
| 0.6 | 0.3 | | 5.09 | 0.50 | 4.51 | 0.68 | 1.66 | 2.95 | 0.35 |
| | 0.6 | | 4.78 | 0.38 | 5.78 | 0.74 | 2.20 | 2.51 | 0.28 |
| | 0.9 | | 4.62 | 0.39 | 6.18 | 0.87 | 2.64 | 2.57 | 0.28 |
| Mean – Średnio KCl | | | 4.73b | 0.45a | 5.36a | 0.72a | 2.32b | 2.44b | 0.30b |
| 0.3 | 0.3 | $K_2SO_4$ | 4.56 | 0.58 | 4.75 | 0.88 | 1.04 | 2.37 | 0.30 |
| | 0.6 | | 5.37 | 0.48 | 5.04 | 0.97 | 1.08 | 1.76 | 0.25 |
| | 0.9 | | 3.63 | 0.55 | 5.68 | 0.95 | 1.35 | 1.01 | 0.15 |
| 0.6 | 0.3 | | 3.44 | 0.46 | 3.93 | 0.69 | 0.87 | 1.74 | 0.18 |
| | 0.6 | | 2.59 | 0.45 | 5.57 | 0.90 | 0.93 | 2.84 | 0.28 |
| | 0.9 | | 3.95 | 0.43 | 6.13 | 0.89 | 0.83 | 2.41 | 0.26 |
| Mean – Średnio $K_2SO_4$ | | | 3.92a | 0.49a | 5.18a | 0.88a | 1.02a | 2.02a | 0.24a |
| Mean N – Średnio N | | 0.3 | 4.57b | 0.51a | 5.19a | 0.80a | 1.82b | 1.95a | 0.26a |
| | | 0.6 | 4.08a | 0.44a | 5.35a | 0.79a | 1.52a | 2.50b | 0.27a |
| Mean K – Średnio K | | 0.3 | 4.17a | 0.50a | 4.42a | 0.73a | 1.38a | 2.33a | 0.29a |
| | | 0.6 | 4.49a | 0.46a | 5.46b | 0.83a | 1.71b | 2.32a | 0.27a |
| | | 0.9 | 4.31a | 0.46a | 5.92b | 0.83a | 1.92c | 2.04a | 0.24a |

in calcium content and a decrease in chlorine concentration in the herb of the investigated plants. Similar relationships concerning the effect of nitrogen on the mineral composition of rocket plants have been shown in previous N-fertilization studies [Nurzyńska-Wierdak 2006a, b, Cavarianni et al. 2008, Biesiada and Kołota 2010]. The content of potassium and chlorine in the plant material studied increased with an increasing amount of potassium in the nutritional environment of the plants, which is confirmed by the results of an earlier study [Nurzyńska-Wierdak 2006b]. The increase in the concentration of both potassium and chlorine was associated with the increased amount of potassium chloride applied. The lack of such correlations as regards sulphur, supplied at a significant amount in the treatments with $K_2SO_4$, can be explained by a large proportion of this nutrient in specific sulphur compounds in plants of the family *Brassicaceae* [Michael et al. 2011, Shapiro et al. 2011]. It should be noted here that there was no significant influence of the increasing rate of potassium on the magnesium concentration in the plant material studied, which does not confirm the antagonistic effect of potassium on magnesium uptake. These relationships have also been confirmed in earlier studies [Nurzyńska-Wierdak 2006a, b, 2009].

Interesting relationships were shown concerning the accumulation of mineral nutrients by garden rocket under the influence of potassium supplied in the form of chloride and sulphate. The plants fertilized with potassium chloride contained more chlorine, calcium, and magnesium in the herb compared to the plants fed with potassium sulphate. In turn, the application of potassium in the form of chloride and sulphate did not result in significant differences in sulphur concentration in the plants studied. This should be explained by a high requirement for sulphur in plants of the family *Brassicaceae*, which is used in the biosynthesis of glucosinolates [Michael et al. 2011, Omirou et al. 2011] and other biologically active substances [De Pascale et al. 2007]. On the other hand, however, the plants that had received more sulphur (K as $K_2SO_4$) took up this nutrient similarly to those in which a smaller amount of sulphur had been applied (K as KCl), as evidenced by residual sulphates in the medium after plant harvest (tab. 3). Additionally, the increased amount of nitrates and chlorides did not reduce $SO4^{-2}$ uptake by the rocket plants, which confirms the conclusion that the sulphate ion has its separate carrier and that nitrates, phosphates, and chlorides do not inhibit its uptake by plants [Nowotny-Mieczyńska 1965].

**The chemical composition of the medium.** The pH of the medium in which rocket was grown was optimal for plant development and it was in the range of 5.90–6.36 (tab. 3). The concentration of salts in the medium after plant harvest was within the permissible range (0.85–1.67 $mS \cdot cm^{-1}$) and significantly dependent on fertilization. The increase in the rate of potassium contributed to an increase in the value of EC, which was not found in the case of the nitrogen rate. Furthermore, a higher salt concentration was found when potassium sulphate was applied, compared to potassium chloride. Similar relationships have been shown in an earlier study [Nurzyńska-Wierdak 2006a, b]. Thus, it seems that chloride anions affect the value of EC of the medium to a lesser extent than sulphates. The present study showed a relationship between nitrogen and potassium fertilization and the chemical composition of the medium (tab. 3). More mineral nitrogen and chlorine as well as less potassium, sulphates, and magnesium remained in the medium fertilized with the higher rate of nitrogen compared to the other media. In turn, the increasing rate of potassium contributed to an increased amount of potassium (K), chlorine (Cl) and sulphates ($SO_4$) in the medium after plant harvest, which should be attributable to both the amount of potassium (K) applied and its form (Cl, $SO_4$). In comparing the action of KCl and $K_2SO_4$ on the chemical composition of the medium after harvest of the rocket plants, significant differences were found in the

Table 3. Chemical composition of substratum (mg dm$^{-3}$) as well as pH and EC (mS cm$^{-1}$) values (2010–2011)
Tabela 3. Skład chemiczny podłoża (mg dm$^{-3}$) po zbiorze rokietty oraz wartości pH i EC (mS cm$^{-1}$) (2010–2011)

| N rate Dawka N g dm$^{-3}$ | K rate Dawka K g dm$^{-3}$ | K Source Źródło | $pH_{H2O}$ | EC | $N\text{-}NH_4^+$ $N\text{-}NO_3$ | K | $P\text{-}PO_4$ | $S\text{-}SO_4$ | Cl | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.3 | | 6.36 | 0.89 | 74.75 | 48.00 | 70.75 | 276.25 | 230.00 | 1723 | 230.00 |
| 0.3 | 0.6 | | 6.27 | 1.15 | 81.00 | 239.50 | 114.5 | 253.00 | 365.00 | 1560 | 203.75 |
| | 0.9 | KCl | 6.30 | 1.55 | 73.00 | 593.25 | 70.25 | 292.50 | 592.50 | 1410 | 202.25 |
| | 0.3 | | 6.25 | 0.87 | 131.00 | 64.75 | 98.50 | 190.00 | 320.00 | 1675 | 195.75 |
| 0.6 | 0.6 | | 6.20 | 1.13 | 115.25 | 223.50 | 67.75 | 120.50 | 466.00 | 1445 | 183.00 |
| | 0.9 | | 6.24 | 1.65 | 114.50 | 591.50 | 71.25 | 85.00 | 734.00 | 1422 | 172.00 |
| Mean – Średnio KCl | | | | 1.21a | 102.96b | 293.42b | 82.17b | 202.88a | 451.25b | 1539a | 197.79a |
| | 0.3 | | 6.12 | 0.85 | 69.00 | 45.25 | 72.00 | 340.00 | 55.00 | 1351 | 206.50 |
| 0.3 | 0.6 | | 6.26 | 1.21 | 58.75 | 221.25 | 65.50 | 451.25 | 55.00 | 1359 | 203.25 |
| | 0.9 | $K_2SO_4$ | 6.26 | 1.67 | 57.25 | 644.25 | 81.00 | 610.00 | 50.00 | 1489 | 237.00 |
| | 0.3 | | 5.90 | 1.09 | 124.00 | 47.00 | 74.25 | 391.25 | 50.00 | 1513 | 192.50 |
| 0.6 | 0.6 | | 6.12 | 1.22 | 110.00 | 99.00 | 71.75 | 383.75 | 60.00 | 1443 | 186.00 |
| | 0.9 | | 6.20 | 1.39 | 105.50 | 501.00 | 62.00 | 460.00 | 56.00 | 1529 | 178.75 |
| Mean – Średnio $K_2SO_4$ | | | | 1.24a | 87.42a | 259.6a | 71.08a | 439.38b | 54.33a | 1447a | 200.67a |
| Mean N – Średnio N | | 0.3 | | 1.22a | 68.96a | 298.58b | 79.00a | 370.50 | 224.58a | 1482a | 213.79b |
| | | 0.6 | | 1.23a | 121.42b | 254.46a | 74.25a | 271.75 | 281.00b | 1504a | 184.67a |
| | | 0.3 | | 0.92a | 99.69a | 51.25a | 78.88b | 299.38 | 163.75a | 1565a | 206.19a |
| Mean K – Średnio K | | 0.6 | | 1.18b | 92.50a | 195.81b | 79.88b | 302.13 | 236.50b | 1451a | 194.00a |
| | | 0.9 | | 1.57c | 93.38a | 582.50c | 71.13a | 361.88 | 358.13c | 1462a | 197.50a |

residues of particular nutrients, in spite of the fact that N, P, K, Ca, and Mg fertilization was at the same level and only potassium was bonded to another anion. The medium fertilized with potassium chloride contained more residual mineral nitrogen, potassium, phosphates, and chlorine as well as less sulphates than that fertilized with potassium sulphate, which has been partially confirmed in earlier studies [Nurzyńska-Wierdak 2006a, b, 2009].

## CONCLUSIONS

The increase in the rate of nitrogen (N) in the nutritional environment of rocket did not affect plant height and the number of leaves per rosette, but it caused a significant increase in fresh weight yield of leaf rosettes. The increased amount of potassium (K) in the medium contributed to an increase in rocket yield. Potassium chloride, as a source of K, proved to be better than sulphate due to the amount of fresh weight and yield of the plants under study. The mineral composition of the plant material investigated was significantly dependent on fertilization. The increasing rates of N resulted in an increase in calcium content and a decrease in chlorine concentration in the plants, whereas the increase in the rate of K contributed to an increase in the concentration of potassium and chlorine. Moreover, the plants fed with KCl were characterized by a higher content of nitrogen, chlorine, calcium, and magnesium than after the application of $K_2SO_4$.

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## WPŁYW NAWOŻENIA AZOTEM I POTASEM NA WZROST, PLON I SKŁAD CHEMICZNY ROKIETTY SIEWNEJ

**Streszczenie**. Rośliny z rodziny *Brassicaceae* charakteryzują się dużymi potrzebami pokarmowymi i nawozowymi, szczególnie odnośnie azotu, potasu i siarki. Pozytywne działanie wymienionych składników pokarmowych na wzrost i plon roślin wiąże się m.in. z ich dawką i formą, oraz wzajemnymi relacjami pomiędzy poszczególnymi składnikami. Doświadczenie przeprowadzono w szklarni w okresie od marca do maja 2010 i 2011 r. Rośliny rokietty siewnej wysiewano punktowo do doniczek o pojemności 2 $dm^3$, podłożem był torf. W schemacie doświadczenia uwzględniono trzy dawki (g $dm^{-3}$ podłoża) potasu w postaci $K_2SO_4$: 0,3K (oraz 0,34 S); 0,6 K (oraz 0,47 S); 0,9 K (oraz 0,6 S), w postaci KCl: 0,3 K (oraz 0,27 Cl); 0,6 K (oraz 0,54 Cl); 0,9 K (oraz 0,81 Cl) oraz dwie dawki azotu w formie Ca $(NO_3)_2$: 0,3 N (oraz 0,37 Ca); 0,6 N (oraz 0,74 Ca). Określono wysokość rośliny (cm), liczbę liści w rozecie (szt.), masę rośliny (g) oraz plon świeżej masy rozet liściowych (g · doniczka $^{-1}$). W wysuszonym materiale roślinnym oznaczono zawartość: N, P, K, Ca i Mg, S-$SO_4$, Cl. Zwiększenie dawki azotu w środowisku odżywczym rokietty nie wpłynęło na wysokość roślin oraz liczbę liści w rozecie, natomiast powodowało istotny wzrost plonu świeżej masy rozet liściowych, jak również zwiększenie zawartości wapnia oraz zmniejszenie koncentracji chloru w roślinach. Zwiększona ilość potasu w podłożu przyczyniła się do wzrostu plonu rokiety, a także do zwiększenia koncentracji potasu i chloru. Chlorek potasu okazał się lepszym źródłem K, niż siarczan, z uwagi na wielkość świeżej masy oraz plonu badanych roślin. Rośliny żywione KCl odznaczały się także większą zawartością azotu, chloru, wapnia i magnezu niż po zastosowaniu $K_2SO_4$.

**Słowa kluczowe**: *Eruca sativa* Mill., dawka N i K, postać potasu, plon świeżej masy, makroelementy

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