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ORIGINAL PAPER

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EFFECT OF POTASSIUM FERTILIZATION ON YIELD, GROWTH AND CHEMICAL COMPOSITION OF BASIL HERB

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ABSTRACT

In the cultivation of herbal plants, besides the size of the crop, the quality of obtained raw material is extremely important, which is proven not only by the appearance and taste, but also biological value. Factors that affect these parameters include plant nutrition. The main nutrient affecting the correct course of metabolic processes in a plant is potassium. To obtain high yield in terms of quantity and quality, the nutritional requirements of plants must be met. The aim of the study was to determine the effect of potassium nutrition on the quality of basil herb. The experiment was established in a two-factor scheme, in which the factors were: potassium dose (0.5, 1.0, 1.5 g K·dm^{-3}) and the type of potassium fertilizer (KCl, K_2SO_4, KCl + K_2SO_4). The yield of basil plants was influenced by the dose and type of potassium fertilizers used (0.5 g K·dm^{-3} – 92.5; 1.0 g K – 67.3; 1.5 g K – 69.75 g·plant^{-1}). The highest content of L-ascorbic acid was found in basil plants fed with the average potassium dose (65.9 mg·100 g^{-1} FW). The least nitrates (V) were contained in basil fertilized with KCl in the highest dose of K (63 mg·100 g^{-1} FW). No effect of the dose and type of potassium fertilizer on the content of phosphorus and sulfur in the plant material, was recorded. The content of Ca and Mg was influenced by both the potassium dose and the type of potassium fertilizer. The most of these components was revealed by plants fed with KCl, and with the increase of the dose, the content of both these mineral components decreased. Chlorine content in the herb increased with the applied potassium dose, the effect on the concentration of chlorine in the plant material was exerted by the type of potassium fertilizer applied – the highest concentration of this element was recorded. The content of macroelements in the substrate from basil cultivation was influenced by the dose and type of potassium fertilizers used. The best quality parameters of basil were obtained after application of 1.0 g K·dm^{-3} substrate in the form of KCl + K_2SO_4.

Key words: *Ocimum basilicum*, potassium, biological value, macro-nutrients

INTRODUCTION

In the cultivation of herbal plants, it is important that the raw material obtained from them was characterized not only by high quantitative yield, but also met high quality criteria, which in these plants are extremely important. The quality of cultivated plants is affected by a number of factors, the most important of which are: proper lighting, thermal and humidity conditions, as well as nutritional status of plants. Nutrition of plants directly affects the yield, both in quantitative and qualitative terms. Plants

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provided with an optimal amount of nutrients not only grow and yield better, but are also better prepared for various environmental stresses.

One of the main nutrients that plays a leading role in the growth and development of plants is potassium [Lester et al. 2010]. Potassium is a factor regulating the water management in a plant, increasing resistance to stress and activating about 50 enzymes. The presence of potassium in plant cells guarantees correct course of metabolic processes, which results in a high yielding [Syers 2005]. Its important role in the biochemical processes taking place in a plant is catalysis of many enzymatic transformations necessary for its proper growth [Wang and Wu 2017, Li et al. 2018]. The lack of K^+ ions is a factor inhibiting the protein synthesis, which leads to the accumulation of organic nitrogen connections in the plant in favor of reducing the content of protein compounds. Potassium deficiency affects the limitation in the transformation of mineral nitrogen into proteins. Plants insufficiently nourished by this component cease to grow, their gains are small, and internodes shortened. This is especially important for herbal plants, because it is related to the quality standard of the raw material [Lebaudy et al. 2007, Dzida 2013]. In potassium nutrition, the accompanying anion, i.e. chloride or sulfate, plays an important role. Chlorine introduced along with potassium is easily absorbed by plants, even in amounts greater than their nutritional needs. Chlorine regulates the ionic economy within the plant, it can also be a limiting factor in the uptake of nitrates. Sulfur is taken up by plants in the form of SO_4^{2-} and then is transported through xylem from roots to the shoot. In chloroplasts of young leaves, SO_4^{2-} ion reduction takes place, sulfur is incorporated into protein structures; it is a very complex process. This element is a component of amino acids: cystine, cysteine and methionine. It takes part in the synthesis of lignin and fatty acids, and is a component of vitamins: B_1 and H. Sulfur deficiency in plants leads to a reduction of plant resistance to stress factors [Klikocka 2005, Gaj and Klikocka 2011].

Common basil (*Ocimum basilicum* L.) is a species of annual herbaceous plant of the *Lamiaceae* family. It comes from tropical areas of Southeast Asia and Africa. Currently in the world, it is cultivated in subtropical climate of Asia, Africa and America, in Mediterranean climate of southern Europe, as well as in temperate zones (western, central and northern Europe) [Gill and Randhawa 1992]. The origin of basil from tropical areas of the world determines the high thermal requirements of this species. The optimal temperature for growing basil is 20–25°C. Field cultivation of basil in temperate climate is limited by spring and autumn frosts, temperature 1–2°C causes plants to die [Hołubowicz-Kliza 2012, Nurzyńska-Wierdak 2012]. Basil raw material is herb – *Basilici herba* – which contains 0.5–2.5% of essential oil, as well as: alkaloids, flavonoids, saponin compounds, tannins, anthraquinones, steroids, terpenoids, phenolic compounds, anthocyanins and mineral compounds. In addition, in basil herb, there is 16.3% protein, 4.7% fat, 12.6% fiber, 17.1% starch, 9.1% ash, and 2–5% tannins. The herb of basil also contains vitamins C and E, provitamin A, rutin, carotenoid and chlorophyll pigments [Biesiada and Kuś 2010, Dzida 2010, Taie et al. 2010]. Vitamin C is the most well-known antioxidant. Due to its antioxidant properties, this vitamin has a protective role in heart and blood vessel diseases. Ascorbic acid protects against the formation of mutagenic N-nitroso compounds by blocking the conversion of nitrates to carcinogenic nitrosamines. In the stomach, nitrates with the participation of *Helicobacter pylori* bacteria are transformed into nitrites, and these in turn during the nitrosation reaction – into nitrosamines. Ascorbic acid inhibits the activity of both bacteria in the stomach and nitrosation process. It reduces dangerous nitrites to nitric oxide [Szymańska-Pasternak et al. 2014, Janda et al. 2015].

The aim of this study is to determine the effect of potassium nutrition on the quality of basil herb grown in a greenhouse.

MATERIAL AND METHODS

The vegetation experiment with common basil (*Ocimum basilicum* L.) was carried out in the spring of 2015 and 2016 in the experimental greenhouse of the Department of Plant Cultivation and Nutrition of the University of Life Sciences in Lublin. The experiment was established in a two-factor scheme: 1. Type of potassium fertilizer; 2. Potassium dose. Basil seeds were sown at the beginning of March into the peat substrate, then at the end of March, plants were primed into multiplates, and the seedlings were planted in permanent place at the beginning of April.

Plants were grown in pots with a capacity of 2 dm^3, filled with high peat, limed with fertilizer chalk in an amount of 15 g $CaCO_3 \cdot dm^{-3}$ to pH 6.0. The experiment included 54 plants – 9 series in 6 replications. The harvest was carried out at the end of May by cutting above ground parts. Following mineral fertilization ($g \cdot dm^{-3}$ substrate) was used: N – 0.6 in the form of ammonium nitrate (NH_4NO_3 – 34% N), P – 0.4 in the form of granulated triple superphosphate ($Ca(H_2PO_4)_2$ – 20% P), K – 0.5, 1.0, 1.5 in the form of potassium salt (KCl), potassium sulfate (K_2SO_4 – 42% K) and a mixture of potassium salt with potassium sulfate (1 : 1 K); Mg – 0.4 in the form of magnesium sulfate monohydrate ($MgSO_4 \times H_2O$ – 15.6% Mg). The micronutrients were administered once to the substrate in the form of a solution before the seedling was planted, in quantities ($mg \cdot dm^{-3}$): Fe – 8.0, Cu – 13.3, Mn – 5.1, B – 1.6, Mo – 3.7, Zn – 0.74, Fe – as chelate, Cu, Mn, Zn in a form of sulfates, B as boric acid, Mo – ammonium molybdate. Prior to planting, ¼ doses of nitrogen, potassium and magnesium and the entire dose of phosphorus were applied. The remaining part of nutrients N, K, Mg was supplemented as a solution in three equal doses. Plants were irrigated depending on the temperature in the greenhouse.

During liquidation of the experiment, soil samples were collected, in which the macroelement content was determined using a universal method. The ammonium and nitrate nitrogen were determined by Bremner's micro-distillation modified by Starck, phosphorus with ammonium vanado-molybdate, sulfur with barium chloride and chlorine with silver nitrate was determined by colorimetry (Nicolet Evolution 300 spectrometer). Contents of K, Ca, Mg were determined by atomic spectrophotometry AAS (Analyst 300 Perkin Elmer). The pH (H_2O) and EC ($mS \cdot cm^{-1}$) were determined in the suspension of substrate and distilled water in a ratio of 1 : 2 [Nowosielski 1988].

A harvest of basil herb was made at the initial stage of plant flowering. The height of plants was measured, the mass of aboveground parts was determined, the dry mass was evaluated by means of drying method and the content of L-ascorbic acid and nitrates(V) in fresh material were evaluated. L-ascorbic acid was determined by Tillmans method [PN-A-04019:1998], and nitrates(V) by the reflectometric method using RQflex instrument. After drying and grinding the plant material of basil, the N-total was determined by Kjeldahl method on the Kjeltec System 2002 Distilling Unit apparatus. Plant material was combusted at 200°C, then burned dry at 450°C [Ostrowska et al. 1991]. After combustion, the ash was treated with 1 : 2 dilute hydrochloric acid. In this extract, P, K, Ca, Mg, were determined. In addition, the content of $N\text{-}NH_4$, $N\text{-}NO_3$, $S\text{-}SO_4$, Cl was determined in the plant material. The analysis of macronutrients content was made using methods as during the analysis of the substrate.

The results obtained were statistically analyzed using the variance analysis. Applying Tukey test, the least significant difference (LSD) was determined at the significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

Yield and biological value of basil herb

In an experimental study, to assess the effect of the potassium dose and the type of potassium fertilizer on the quality of basil herb, interesting results were obtained regarding the mineral nutrition of this plant with potassium. The amount of basil yield and its quality is influenced by various factors, including fertilization with nitrogen, phosphorus, potassium and calcium [Biesiada and Kuś 2010, Nguyen and Niemeyer 2008, Omer et al. 2008, Nurzyńska-Wierdak et al. 2012, Matsumoto et al. 2013, Ghahremani et al. 2014, Rahimi et al. 2014], as well as grown variety and cultivation system [Rahimi et al. 2014, Saha et al. 2016, Salas-Pérez et al. 2018]. When analyzing the impact of studied factors, a significant effect of the potassium dose on the yield and its biological value was recorded. There was no significant influence of the type of potassium fertilizer on the height as well as on the yield of plants. The highest yield of basil plants was recorded after application of 0.5 g $K \cdot dm^{-3}$ substrate (92.50 g), while the lowest mass of plants was obtained using a dose of 1.0 g $K \cdot dm^{-3}$ substrate (67.33 g). On average, the highest plants (45.17 cm) and the highest yield (78.92 $g \cdot plant^{-1}$) were obtained in combinations fertilized with a mixture of KCl + K_2SO_4 (Tab. 1). Ghahremani et al. [2014], after applying the foliar nano-potassium fertilizer, obtained an increase in the yield of fresh weight and leaf area along with increasing potassium dose. Studies have

Table 1. Effect of potassium dose and type of potassium fertilizer on the height and yield of fresh basil mass, average from 2015 and 2016

Type of fertilizer (A)	Yield ($g \cdot plant^{-1}$)				Height (cm)			
	dose of K ($g \cdot dm^{-3}$) (B)							
	0.5	1.0	1.5	mean for fertilizer	0.5	1.0	1.5	mean for fertilizer
KCl	92.25	67.00	61.25	73.50	47.5	42.5	40.0	43.3
K_2SO_4	87.75	70.75	73.00	77.17	44.25	38.25	43.75	42.08
KCl + K_2SO_4	97.50	64.25	75.00	78.92	53.75	41.00	40.75	45.17
Mean for dose	92.50	67.33	69.75		48.5	40.58	41.5	
$LSD_{\alpha = 0.05}$								
A				n.s.				n.s.
B				14.375				3.677
A × B				n.s.				8.614

n.s. – non-significant differences

shown that the amount of plants was significantly affected by the potassium dose. There was also a significant influence of the interaction of examined factors on the height of basil. The highest plants were obtained when a dose of 0.5 g $K \cdot dm^{-3}$ of the substrate was administered in all fertilizer variants, while the lowest when using a dose of 1.0 g $K \cdot dm^{-3}$ substrate as KCl and KCl + K_2SO_4. Rahimi et al. [2014], using increasing doses of potassium and phosphorus, achieved a decrease in the yield of fresh basil mass, leaf surface and plant height along with the increase in the potassium doses used. In the studies of Dzida and Jarosz [2006] regarding the marjoram yielding, it was found that plants of this species gave significantly higher yield when fertilized with potassium chloride as compared to marjoram plants fertilized with a mixture of potassium chloride and potassium sulfate.

When analyzing results from the research it was found that the dose and type of potassium fertilizer have significant impact on the content of nitrates(V) in fresh basil herb. Most nitrates(V) were contained in plants fed with K_2SO_4 in a dose of 1.0 g $K \cdot dm^{-3}$ substrate (219 $mg \cdot 100\ g^{-1}$ FW). The sulfate form of the fertilizer influenced the accumulation of nitrates(V) in fresh herb. Increased accumulation of nitrates with an increased sulfate content in the substrate results from antagonism between NO_3^- and SO_4^{2-} ions at the uptake stage, antagonism between SO_4^{2-} and Mo^{2+} uptake – an important component of nitrate reductase, as well as competition for energy for the reduction of NO_3^- and SO_4^{2-} in a plant [Buczak and Marciniak 1990]. Significantly lower content of nitrates(V) in fresh basil herbs was recorded when plants were fed with the highest dose of potassium (1.5 g $K \cdot dm^{-3}$ substrate) in the form of potassium chloride (63 $mg \cdot 100\ g^{-1}$ FW) (Tab. 2). Dependence of the concentration of nitrates(V) in the fresh mass of plants on the dose and type of potassium fertilizer is also confirmed by studies of Nurzyńska et al. [2012]. The authors found that the use of increased potassium fertilization has a significant effect on reducing the concentration of nitrates(V). Depending on the harvest date, irrigation and doses of nitrogen and calcium in the basil herb, there may be 404–783 mg of nitrates(V)$\cdot kg^{-1}$ FW [Nurzyńska-Wierdak 2012]. In the experiment of Jarosz and Dzida [2006] with lettuce, the content of nitrates(V) was lower in leaves of this species, when KCl was used, as compared to plants fed with K_2SO_4 and KNO_3. Confirmation of the obtained results is the research by Dzida et al. [2011] with leaf beet, in which it was found that the least nitrates were accumulated by leaves of beet fertilized with potassium chloride, and much more when fertilized with potassium sulfate and a mixture of potassium chloride and sulfate.

Applied research factors slightly differentiated the protein content in basil. The protein concentration in plants ranged from 21.47 to 26.23% (Tab. 2).

Human and some animals do not have metabolic pathways leading to the synthesis of vitamin C, therefore, it must be provided on a regular basis with food. Plants have the ability to biosynthesize this compound, most likely due to the presence of a catalyzing enzyme – galactono-lactone dehydrogenase [Moszczyński and Pyć 1999]. Vitamin C is found mainly in plant products: fruits, vegetables and herbs. The content of L-ascorbic acid in basil plants ranged from 40.9 to 82.52 mg·100 g^{-1} FW. A significant influence of the type of potassium fertilizer on the content of L-ascorbic acid in fresh herb of basil, was recorded. The most L-ascorbic acid was contained by plants fed with KCl + K_2SO_4 at a dose of 1.5 g K·dm^{-3} substrate. In the studies of Salas-Pérez et al. [2018], increasing doses of potassium have been shown to positively affect the content of vitamin C in basil. Applying increasing doses of potassium (7, 9, 11, 13 mmol·L^{-1}), the highest content of vitamin C was obtained after the application of 9 mmol K·L^{-1}; after administration of higher potassium doses, slight differences in vitamin C concentration in plants were recorded.

Significant effect of potassium dose on the concentration of dry matter in the plant was observed; along with the increase in the applied dose, a decrease in the dry matter content was found (Tab. 3).

Table 2. Influence of potassium dose and type of potassium fertilizer on the content of nitrates(V) and protein in basil herb, average from 2015 and 2016

Type of fertilizer (A)	Nitrates(V) (mg·100 g^{-1} FW)				Protein (%)			
	dose of K (g·dm^{-3}) (B)							
	0.5	1.0	1.5	mean for dose	0.5	1.0	1.5	mean for dose
KCl	180.0	84.5	63.0	109.17	23.91	24.58	26.23	24.91
K_2SO_4	143.0	219.0	175.0	179.00	23.63	22.91	23.27	23.27
KCl + K_2SO_4	132.3	139.5	105.0	125.61	21.47	23.17	22.83	22.49
Mean for fertilizer	151.78	147.67	114.33		23.01	23.56	24.11	
$LSD_{\alpha = 0.05}$								
A				10.481				n.s.
B				10.481				n.s.
A × B				24.943				n.s.

n.s. – non-significant differences

Table 3. Effect of potassium dose and type of potassium fertilizer on L-ascorbic acid and dry matter content in basil herb, average from 2015 and 2016

Type of fertilizer (A)	L-ascorbic acidy (mg·100 g^{-1} FW)				DM (%)			
	dose of K (g·dm^{-3}) (B)							
	0.5	1.0	1.5	mean for dose	0.5	1.0	1.5	mean for dose
KCl	46.46	56.96	40.90	48.11	30.68	30.87	25.54	29.03
K_2SO_4	50.74	66.92	66.90	61.52	30.80	34.34	29.76	31.63
KCl + K_2SO_4	53.20	73.82	82.52	69.85	40.80	28.37	25.45	31.54
Mean for fertilizer	50.13	65.90	63.44		34.09	31.19	26.91	
$LSD_{\alpha = 0.05}$								
A				18.965				n.s.
B				n.s.				5.187
A × B				n.s.				12.345

n.s. – non-significant differences

Chemical composition of basil depending on the dose and type of potassium fertilizer

The applied research factors did not significantly affect the nitrogen content in basil (Tab. 4). Plants fertilized with potassium salt showed higher total nitrogen content (3.98% DM) in comparison to those fed with potassium sulfate and a mixture of both fertilizers (3.72 and 3.71% DM). Basil plants that received potassium in a dose of 1.5 g $\cdot dm^{-3}$ substrate contained more total nitrogen (on average 3.86% DM) than those fed with lower potassium doses (average of 3.79 and 3.77% DM). Content of mineral nitrogen in plants ($N\text{-}NH_4$ + $N\text{-}NO_3$) was the lowest after the use of $KCl + K_2SO_4$ mixture, whereas in plants fertilized with potassium salt and K_2SO_4, this content remained at an even level. With the increase in the potassium dose, the average content of $N\text{-}NO_3$ in dry matter of plants decreased. Similar results were obtained by Dzida [2013] in experiments with thyme and savory. Under the influence of an increasing potassium dose, content of nitrates decreased, while their lowest content was recorded in plants fed with KCl. According to Matsumoto et al. [2013], growing doses of potassium affect the reduction of nitrate and ammonium nitrogen in basil herb. This conclusion is also confirmed by studies carried out by Nurzyńska-Wierdak et al. [2012], Hanafy Ahmed et al. [2000].

Concentration of phosphorus in plants changed slightly under the influence of studied factors. Research carried out by Prakasa Rao et al. [2007], Nurzyńska-Wiedrak et al. [2012] and own research show that the use of increasing potassium dose has no significant effect on the accumulation of phosphorus in basil plants. Common basil is an abundant source of minerals. From research carried out by Kiczorowska et al. [2015], it follows that it is characterized by high content of such macro- and microelements as: Mg, Ca, K, Na, Fe, Cu and Mn. Rao et al. [2007], Geetha et al. [2009] as well as Biesiada and Kuś [2010] report that increased doses of nitrogen, potassium, phosphorus, sulfur and calcium modify the mineral composition of basil herb. In our study, the effect of K dose on the content of potassium, magnesium and chlorine in basil herb, was recorded. According to Gierth and Mäser [2007], potassium content in a plant can make up to 10% DM. In the experiment carried out, the concentration of potassium in basil was the highest among determined mineral components. The content of other macroelements was also differentiated by the applied research factors. Concentration of calcium, magnesium and chlorine significantly depended on the type of potassium fertilizer. The potassium dose had significant influence on the amount of magnesium and chlorine in plants. The amount of calcium and magnesium in the basil herb was influenced

Table 4. Effect of potassium dose and the type of potassium fertilizer on the content of various nitrogen forms in basil herb (% DM), average from 2015 and 2016

Type of fertilizer (A)	N-total				$N\text{-}NH_4$				$N\text{-}NO_3$			
	Dose of K ($g \cdot dm^{-3}$) (B)											
	0.5	1.0	1.5	mean for dose	0.5	1.0	1.5	mean for dose	0.5	1.0	1.5	mean for dose
KCl	3.83	3.93	4.20	3.98	0.08	0.17	0.04	0.09	0.24	0.16	0.19	0.20
K_2SO_4	3.78	3.67	3.72	3.72	0.04	0.07	0.06	0.06	0.24	0.24	0.21	0.23
$KCl + K_2SO_4$	3.75	3.71	3.65	3.71	0.06	0.05	0.04	0.05	0.16	0.13	0.07	0.12
Mean for fertilizer	3.79	3.77	3.86		0.06	0.09	0.05		0.21	0.18	0.16	
$LSD_{\alpha = 0.05}$												
A				n.s.				n.s.				n.s.
B				n.s.				n.s.				n.s.
A × B				n.s.				n.s.				n.s.

n.s. – non-significant differences

by the type of potassium fertilizer. With increasing K dose, the content of calcium in the herb decreases. The highest content of Ca and Mg was determined in plants fed with KCl. Magnesium content in plants from objects with K_2SO_4 and KCl + K_2SO_4 was on an even level. Nurzyńska-Wierdak et al. [2012], when analyzing the influence of tested basil variety and differentiated nitrogen and potassium fertilization on chemical composition of plants, recorded significant effect of the potassium dose on calcium and chlorine contents in plants. The authors state that the amount of sulfur in plants has changed under the influence of the applied dose of nitrogen, as well as variety cultivated; potassium administered in a diversified dose did not differentiate sulfur in basil. Similar results were obtained in our own research, where the sulfur content in basil was at an even level (Tab. 5). Nurzyńska-Wierdak [2013] found that the amount of a single potassium dose is important due to the antagonism between ions K^+ vs. Na^+, Ca^{2+}, especially Mg^{2+}. Studies performed by Nurzyńska-Wierdak et al. [2012] revealed that concentration of magnesium in dry mass of basil herb increases due to the increasing amount of potassium. In addition, the authors state that an increased dose of potassium causes a decrease in calcium content in dry herb, which is probably related to the antagonism between these components, which is confirmed by the present study. The increase in chlorine concentration in dry matter is associated with increasing doses of potassium, while higher dose of potassium has no effect on the content of phosphorus and sulfur in plants [Ali et al. 2003, Dzida 2010, Shehu et al. 2010, Nurzyńska-Wierdak et al. 2012].

Table 5. Influence of potassium fertilization on chemical composition of basil herb (% DM), average from 2015 and 2016

Potassium fertilizer (A)	Dose of K ($g \cdot dm^{-3}$) (B)	P	K	Ca	Mg	S	Cl
KCl	0.5	0.43	3.17	1.98	0.40	0.17	1.29
	1.0	0.43	3.62	1.86	0.34	0.17	2.34
	1.5	0.46	4.13	2.05	0.33	0.16	2.78
Mean for KCl		0.44	3.64	1.96	0.35	0.16	2.14
K_2SO_4	0.5	0.44	2.91	1.67	0.33	0.20	0.37
	1.0	0.40	3.76	1.40	0.26	0.22	0.28
	1.5	0.38	4.00	1.07	0.23	0.20	0.35
Mean for K_2SO_4		0.41	3.56	1.38	0.27	0.20	0.36
KCl + K_2SO_4	0.5	0.40	2.74	1.52	0.32	0.18	1.11
	1.0	0.41	3.77	1.54	0.26	0.19	1.33
	1.5	0.38	4.19	1.38	0.24	0.17	1.59
Mean for KCl + K_2SO_4		0.40	3.57	1.48	0.27	0.18	1.34
Mean for dose	0.5	0.42	2.94	1.72	0.35	0.18	0.92
	1.0	0.41	3.72	1.60	0.28	0.19	1.35
	1.5	0.41	4.10	1.50	0.27	0.17	1.57
$LSD_{\alpha = 0.05}$							
A		0.043	n.s.	0.541	0.049	n.s.	0.301
B		n.s.	0.527	n.s.	0.049	n.s.	0.301
A × B		n.s.	n.s.	n.s.	n.s.	n.s.	0.718

n.s. – non-significant differences

Influence of potassium dose and the type of potassium fertilizer on the content of nutrients in the substrate from basil cultivation

Diverse potassium fertilization significantly influenced the concentration of most macroelements in the substrate from basil cultivation. The amount of ammonium and nitrate nitrogen changed ambiguously under the influence of potassium dose and the type of potassium fertilizer. The highest content of mineral nitrogen ($N\text{-}NH_4 + N\text{-}NO_3$) in the medium with the highest dose of potassium in objects with KCl and K_2SO_4 was recorded.

Concentration of phosphorus in the substrate ranged from 94.5 to 131.5 mg·dm^{-3} and it was not significantly dependent on the factors used. There was no significant effect of differentiated potassium fertilization on magnesium content in the substrate, in which the average content of this element was 247.7 mg·dm^{-3}. Concentration of potassium in the substrate increased with the applied dose of this element in all objects, i.e. KCl, K_2SO_4 and KCl + K_2SO_4. Both the potassium dose and the type of potassium fertilizer, as well as the interaction between these factors, significantly differentiated the amount of sulfur and chlorine in tested substrate. Both elements changed according to the fertilizers used and their doses (Tab. 6). The pH of the test substrate was quite even, ranging from 6.52 to 6.89 pH. The EC value of the substrate from basil cultivation depended on the applied potassium dose. There was a significant increase in salt concentration in the substrate after application of higher potassium dose by 100% in relation to the initial dose in all research objects (Tab. 7). Studies have shown that the concentration of nutrients (EC) increased along with the increasing dose of used potassium fertilizers. The same dependence was indicated by Nurzyńska-Wierdak et al. [2012] and Dzida et al. [2011]. Esmaili et al. [2008] reported that excessive salt concentration in the substrate reduces the uptake of N, P, Ca and Mg, and the increasing concentration of Na and Cl in plant tissues, which is confirmed by this study.

Table 6. Influence of potassium dose and the type of potassium fertilizer on the content of macroelements in the substrate from basil cultivation, average from 2015 and 2016

Potassium fertilizer (A)	Dose of K (g·dm^{-3} substrate) (B)	$N\text{-}NH_4$	$N\text{-}NO_3$	$P\text{-}PO_4$	K	Ca	Mg	$S\text{-}SO_4$	Cl
		(mg·dm^{-3} substrate)							
KCl	0.5	26.7	154.3	110.7	118.2	2413	256.7	584.0	458.0
	1.0	18.8	355.0	121.5	446.5	2504	202.7	537.0	799.0
	1.5	48.3	479.3	80.75	993.2	2386	265.5	573.3	856.0
Mean for KCl		31.3	329.5	104.3	519.3	2434	241.6	564.7	704.3
K_2SO_4	0.5	21.8	370.0	94.5	183.7	2026	215.0	803.3	140.0
	1.0	23.2	456.2	102.5	491.0	2441	202.7	832.0	110,0
	1.5	28.3	477.2	125.7	979.5	2538	249.0	896.3	137.0
Mean for K_2SO_4		24.4	434.5	107.5	551.4	2335	222.2	843.8	129.0
KCl + K_2SO_4	0.5	35.2	273.0	107.2	173.2	2237	253.0	679.3	560.6
	1.0	19.4	392.5	131.5	582.2	2348	267.7	757.3	597.0
	1.5	18.9	363.5	104.2	773.5	2690	217.0	732.0	647.3
Mean for KCl + K_2SO_4		24.5	343.0	114.3	509.6	2425	279.4	722.8	601.6
Mean for potassium dose	0.5	27.9	265.7	104.1	158.4	2225	241.5	688.8	386.2
	1.0	20.4	401.2	118.5	506.5	2431	257.7	708.7	502.0
	1.5	31.8	440.0	103.5	915.4	2538	244.0	733.8	546.7
$LSD_{\alpha = 0.05}$									
A		n.s.	69.041	n.s.	n.s.	n.s	n.s.	3.299	2.910
B		9.736	69.041	n.s.	166.76	212.07	n.s.	3.299	2.910
A × B		22.808	161.73	n.s.	n.s.	n.s.	n.s.	7.852	6.927

n.s. – non-significant differences

Table 7. Influence of potassium dose and the type of potassium fertilizer on the pH and EC value of the substrate from basil cultivation, average from 2015 and 2016

Potassium fertilizer (A)	Dose of K ($g \cdot dm^{-3}$ substrate) (B)	pH_{H_2O}	EC ($mS \cdot cm^{-1}$)
KCl	0.5	6.73	1.50
	1.0	6.52	2.51
	1.5	6.66	3,06
Mean for KCl		6.52–6.73	2.36
K_2SO_4	0.5	6.74	1,92
	1.0	6.78	2.07
	1.5	6.64	2,63
Mean for K_2SO_4		6.64–6.78	2.21
KCl + K_2SO_4	0.5	6.89	1.84
	1.0	6.68	2,40
	1.5	6.80	2.65
Mean for KCl + K_2SO_4		6.68–6.89	2.29
Mean for potassium dose	0.5	6.73–6.89	1.75
	1.0	6.52–6.78	2.32
	1.5	6.64–6.8	2.78
$LSD_{\alpha = 0.05}$			
A			n.s.
B			0.746
A × B			n.s.

n.s. – non-significant differences

CONCLUSION

Based on the research and the results obtained, it can be stated that both the dose and type of potassium fertilizer affect the quality of basil herb. Fresh basil mass yield depended significantly on the potassium dose, but not on the type of potassium fertilizer used. The highest yield was obtained from basil plants fed with a mixture of KCl + K_2SO_4 at the lowest dose. Potassium dose and type of potassium fertilizer affected the content of nitrates in basil herb. The lowest quantities of nitrates were accumulated by plants fed with KCl in the highest dose. The highest content of L-ascorbic acid was found in basil plants fed with a mixture of KCl + K_2SO_4 at a dose of 1.5 $g \cdot dm^{-3}$ substrate. Concentration of nutrients in basil herb and in the soil has changed under the influence of applied research factors. The best quality parameters for basil were recorded after using 1.0 g $K \cdot dm^{-3}$ in the form of KCl + K_2SO_4.

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