ACTA Acta Sci. Pol., Hortorum Cultus 11(2) 2012, 275-288

GROWTH RESPONSE TO NITROGEN AND POTASSIUM FERTILIZATION OF COMMON BASIL (*Ocimum basilicum* L.) PLANTS

Renata Nurzyńska-Wierdak, Ewa Rożek, Katarzyna Dzida, Bartłomiej Borowski
University of Life Sciences in Lublin

Abstract. Curative and aromatic properties of basil herb make this species appear more and more frequently in field and glasshouse cultivations. Growth and yielding of basil plants depends, among others, upon the cultivar and fertilization. The experiment was conducted in a glasshouse, in the period from February to May 2009–2010. Plants were grown in pots of the capacity of 4 dm^3, filled with peat substrate. Nitrogen (administered in the form of ammonium saltpeter) concentration in the substrate was differentiated: 0,2; 0,4; 0,6; 0,9 g N. dm^3, as well as that of potassium: 0,4; 0,8 g K· dm^3, given in the form of a sulfate. The plants of three examined basil cultivars (Kasia, Wala, green leaved form) differed in average height, number of branchings, size of leaves, as well as the weight of fresh and air-dry herb. The application of nitrogen fertilization significantly differentiated the mean height and length and width of leaf blades in basil plants that decreased as the dose of this nutrient increased. Plants fed with the lowest and medium dose of nitrogen had significantly higher weight of fresh and air-dry herb, compared to the plants obtaining the highest dose. The amount of fresh herb of the examined plants remained under significant influence of the co-operation. The fresh herb weight of the examined plants remained under significant effect of cooperation between the cultivar and nitrogen dose. No significant effect of potassium dose was found upon the examined biometric features of basil plants. The interaction between nitrogen and potassium in the formation of basil growth and development was only demonstrated with reference to the height of plants and width of the leaf blade.

Key words: *Lamiaceae*, plant morphology, cultivars, fresh weight of herb, macronutrients

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

Common basil (*Ocimum basilicum* L.) is one of the most important species from the genus of *Ocimum*, grown in many countries of the world as a medicinal, seasoning and oleiferous plant. The curative properties of basil result from the presence of essential oil, phenolic compounds, flavonoids and other substances revealing antibacterial [Nour et al. 2009], anti-mycotic [Oxenham et al. 2005], antioxidant activities [Sekar al. 2009, Taie et al. 2010]. Valuable curative and aromatic properties of basil herb make this species occur more and more frequently in field and glasshouse cultivations. Basil growth and yielding depend upon a range of climatic and agrotechnical factors, one of the most important of which is fertilization. Basil is regarded as a species with quite substantial nutritional and fertilization needs. It responds extremely strongly to nitrogen fertilization [Golcz et al. 2006, Sifola and Barbieri 2006, Daneshian et al. 2009, Biesiada and Kuś 2010]. Nitrogen fertilization significantly increases the weight of basil leaves and affects the contents of chloroplast dyes and essential oil yield [Arabaci and Bayram 2004, Golcz et al. 2006]. The basil yield increases with the increased dose of nitrogen [Biesiada and Kuś 2010]. Foliar application of nitrogen in the form of urea causes the increase of fresh basil herb weight and yield with simultaneously increased concentrations of $N\text{-}NH_4$, $N\text{-}NO_3$, K and Ca, compared to control [Nurzyńska-Wierdak et al. 2011b]. Besides, foliar feeding with nitrogen contributed to the significant increase of plant height, as well as the length and width of basil leaf blade [Nurzyńska-Wierdak and Borowski 2011]. Potassium fertilization also affects the growth, as well as basil yield quantity and quality [Rao et al. 2007, Nguyen et al. 2010], and what is significant, are appropriate proportions between all nutrients accessible for plants [Suh et al. 1999, Singh et al. 2004, Geetha et al. 2009].

Nitrogen and potassium are important components, affecting growth, yield and composition of cultivable plants. Nitrogen is one of the basic nutrients used by plants to build many organic compounds, such as aminoacids, peptides, proteins, enzymes, or nucleic acids. Potassium, in turn, affects photosynthesis, breathing, water management and many enzymatic systems [Kaya and Higgs 2003, Ma and Shi 2011, Ma et al. 2012]. Growth and yielding of basil, like in other cultivated plants, depend upon the availability of all nutrients in the nutritional environment, besides, the yield quality is closely connected with macro- and microelements taken up [Zheljazkov et al. 2008, Dzida 2010a, b, Sharafzadeh et al. 2011]. Considering the small number of studies concerning the effect of potassium upon common basil growth and yield, a subject was undertaken, which concerns the response of this plant species to nitrogen and potassium applied in various doses. Including the differentiated nitrogen dose into the presented studies seemed necessary, because of the interaction between these components in creating growth and development of the plants, as well as yield quantity [Ali et al. 2003, Rao et al. 2007, Megda and Monteiro 2010]. The aim of the foregoing studies was also the assessment of the effect of cultivar upon plant growth and yield quantity of basil herb.

MATERIAL AND METHODS

The experiment was conducted in the period from February to May 2009–2010, in a detached glasshouse of the Vegetable Crops and Medicinal Plants Department of the University of Life Sciences in Lublin. The object is situated in north-south direction. The temperature in glasshouse ranged from 18–25ºC during the day and 12–15°C at night. Basil was grown from seedlings produced from seeds of two Polish cultivars Kasia and Wala (grower and distributor: Institute of Natural Fibers and Medicinal Plants in Poznań), as well as the green-leaved form, popular in the domestic horticular market (distributor: seed selling firm PNOS Ożarów Mazowiecki). Plants were grown in pots of the capacity of 4 dm^3, filled with sphagnum peat of pH 5.5–6.0. The experiment was conducted with the use of complete randomization method in 8 repetitions. In one pot basil was growing, which was an experimental unit. The basil seeds were sown on the 12^{th} day of March (2009) and 3^{rd} March (2010). Before sowing the seeds were treated with Dithane Neo Tec 75 WG fungicide. Seedlings appeared after 7–9 days. After about 18–20 days from sowing the plants were thinned into multi-pots (45 cm^3 capacity) filled with peat substrate. Studies were conducted in strictly controlled conditions. During vegetation no symptoms of diseases, or presence of pests were found on the plants, that is why no means of protection were applied. Plants were put into pots after about 25 days from sowing, in the phase of four true leaves (Photo 1).

Photo 1. The sweet basil plants after the planting into the pots, from the left: Kasia cv., Wala cv. and green-leaved form (photo B. Borowski)

Fot. 1. Rośliny bazylii po wysadzeniu do doniczek od lewej: Kasia, Wala, forma zielonolistna (fot. B. Borowski)

The following amounts of nutrients, expressed in g per 1 dm^3 of substratum were applied in the experiment: 0.2; 0.4; 0.6; 0.9 N in the form of ammonium saltpeter; 0.4; 0.8 K as potassium sulfate; 0.4 P as superphosphate 20% P; 0.3 Mg in the form of one-water magnesium sulfate, as well as microelements in mg per 1dm^3 of substrate: 8.0 Fe [EDTA]; 5.1 Mn [$MnSO_4 \cdot H_2O$]; 13.3 Cu [$CuSO_4 \cdot 5H_2O$]; 0.7 Zn [$ZnSO_4 \cdot 7H_2O$]; 1.6 B [H_3BO_3] and 3.7 Mo [$(NH_4)_6Mo_7)_{24} \cdot 4H_2O$]. During the experiment the plants were watered with the same amount of water every 1–2 days. The plant harvest was conducted at the beginning of flowering (on the 25th May in the year 2009 and on the 27th May in 2010) (Photo 2), cutting off the overground part of the stem above its lignified fragments. During harvest height and diameter of plants, as well as number of branchings in the first row of main stem were measured, as well as length and width (measured in the widest place) of the leaf blade (organs sampled from the medium part of the plant) and also the weight of plant overground part. Then the herb was dried in thermal drying compartment in the temperature of 35ºC and the air-dry herb weight was determined.

Photo 2. The sweet basil plants at the beginning of full blooming, from the left: Kasia cv., green-leaved form and Wala cv. (photo B. Borowski)

Fot. 2. Rośliny bazylii w fazie początku pełni kwitnienia od lewej: Kasia, forma zielonolistna, Wala (fot. B. Borowski)

Directly after plant harvest substrate samples were collected for chemical analyses, in which the following were determined: in 0.03M extract of acetic acid – the content of mineral nitrogen, using Bremner's distilation method in Starck's modification, potassium with the use of atomic absorption, substrate pH – potentiometrically in H_2O, and total ion concentration (EC) – conductometrically. The obtained analyses results were statistically elaborated with the uses of variance analysis method for triple cross classification, assessing the significance of differences using Tukey's confidence intervals and making LSD calculations with significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

The examined basil cultivars had significant mean plant height (78.6 cm), similar to Genovese basil grown in Egypt [Kandil et al. 2009] and more or less comparable with other cultivars [Sifola and Barbieri 2006, Chang et al. 2008, Abduelrahman et al. 2009, Said-Al Ahl and Mahmoud 2010, Svecova and Neugebauerova 2010, Nurzyńska-Wierdak and Borowski 2011]. The plants of Wala cultivar were taller than those of Kasia cultivar (tab. 1), which confirms the results obtained by Dzida [2010b]. The ap-

Table 1. The plant height (cm) and number of branches (per plant) in dependence on the nitrogen and potassium fertilization (mean for 2009–2010)
Tabela 1. Wysokość rośliny (cm) i liczbę rozgałęzień (na roślinie) w zależności od nawożenia azotem i potasem (średnio z 2009–2010)

Cultivar Odmiana	Dose – dawka ($g \cdot dm^{-3}$) N	Dose – dawka ($g \cdot dm^{-3}$) K	Height Wysokość	No of branches Liczba rozgałęzień
Kasia	0.2	0.4	76.1	12.2
		0.8	83.9	11.9
	0.4	0.4	75.8	12.7
		0.8	77.1	12.7
	0.6	0.4	72.0	13.2
		0.8	72.2	12.4
	0.9	0.4	69.7	12.6
		0.8	70.7	13.0
Wala	0.2	0.4	79.8	12.8
		0.8	81.4	13.1
	0.4	0.4	77.0	13.3
		0.8	81.2	13.0
	0.6	0.4	74.1	12.3
		0.8	74.8	12.4
	0.9	0.4	75.1	13.5
		0.8	73.7	13.3
Green leaved form Forma zielonolistna	0.2	0.4	89.4	11.3
		0.8	89.5	12.6
	0.4	0.4	83.1	12.6
		0.8	86.4	12.4
	0.6	0.4	83.2	12.2
		0.8	79.9	11.7
	0.9	0.4	80.9	12.0
		0.8	80.0	12.6
Mean – Średnio	Kasia		74.0	12.6
	Wala		80.2	12.9
	Green leaved form		84.1	12.2
Mean N dose Średnio dawka N	0.2		82.4	12.3
	0.4		80.1	12.8
	0.6		76.6	12.4
	0.9		75.0	12.8
Mean K dose – Średnio dawka K		0.4	79.2	12.6
		0.8	80.0	13.1
Mean – Średnio			78.6	12.5
$LSD_{0.05}$ $NIR_{0,05}$	A – cultivar – odmiana		2.95	0.54
	B – N dose – dawka		3.73	0.69
	C – K dose – dawka		n. s.	n. s.
	A × B		n. s.	n. s.
	A × C		n. s.	n. s.
	B × C		2.51	n. s.
	A × B × C		n. s.	n. s.

plication of nitrogen fertilization significantly differentiated mean height of basil plants, which decreased with the increase of this nutrient's dose. Similar dependencies were demonstrated in marjoram growing [Dzida and Jarosz 2006]. The reverse relationship was demonstrated in the previous work applying foliar feeding of basil with nitrogen [Nurzyńska-Wierdak and Borowski 2011], which can be explained with better and faster urea absorption through leaves, compared to unlimited forms of nitrogen applied into the soil [Wójcik 2004]. Lack of significant effect of potassium dose upon mean height of basil plants was demonstrated. Besides, the significance of coeffect of examined factors upon the examined feature was not found.

The number of basil plant branchings was on average 12.5 pcs per plant and significantly depended upon the cultivar and dose of applied nitrogen (tab. 1). The basil plants had different numbers of branchings (5.2–45.5 pcs per plant) [Kandil et al. 2009, Said-Al Ahl and Mahmoud 2010, Nurzyńska-Wierdak and Borowski 2011], which was related to their height and habit. The applied nitrogen doses differently stimulated basil branching, and the greatest number of branchings (12.8 pcs per plant) was reported at medium and the highest nitrogen doses. The increased amount of NPK causes the increased number of basil branching [Kandil et al. 2009], on the other hand, however, that number decreased as an effect of salt stress [Said-Al Ahl and Mahmoud 2010], which proves the sensitivity of basil to excessive concentration of nutrients in the substratum. In the discussed experiment the EC value determined in the substratum after plant harvest did not indicate stress conditions for plants, so the obtained results can be exclusively referred to the applied fertilizer doses (tab. 4).

The examined basil cultivars differed as to the size of their leaves. On the basis of the analysis of the obtained results the significant effect of the cultivar upon mean length and width of basil leaf blade was found (tab. 2). Significantly the greatest length (13.3 cm) and width (8.5 cm) of leaf blade was that in the green-leaved form. The Wala cultivar was characterized with greater mean length of leaf blade than Kasia cultivar, which was also demonstrated in the previous paper [Nurzyńska-Wierdak and Borowski 2011]. A significant effect of nitrogen fertilization was demonstrated upon mean length and width of basil leaf blade (tab. 2). Both length and width of the leaf blade decreased as the nitrogen dose increased. A different relationship was demonstrated in the previous paper [Nurzyńska-Wierdak and Borowski 2011] with foliar feeding of basil plants with urea, where stronger and faster nitrogen absorption by the leaves contributed to the increased leaf size. The increased amount of NPK applied into the soil in basil cultivation, in turn, caused the increase of leaf weight [Kandil et al. 2009], which might have also resulted from the increased leaf blade thickness, and not only its size. The applied potassium doses did not significantly affect the mean length and width of the leaf blade (tab. 2)

The mean fresh basil herb weight equaled 165.2 g and was comparable with that presented by Dzida [2010b], as well as Said-Al Ahl and Mahmoud [2010], and less than that described in previous studies [Nurzyńska-Wierdak et al. 2011b], as well as by Kandil et al. [2009], which, most probably, resulted from the dependence of plant weight upon the soil and nutritional conditions. A significant effect of cultivar and nitrogen dose upon the weight of fresh and air-dry basil herb was demonstrated (tab. 3). Plants fed with the lowest and medium nitrogen dose had significantly greater weight of

Table 2. Effect of cultivar, nitrogen and potassium fertilization on the length and width of leaf blades of basil (mean for 2009–2010)
Tabela 2. Wpływ odmiany, nawożenia azotem i potasem na długość i szerokość blaszki liściowej bazylii (średnio z 2009–2010)

Cultivar Odmiana	Dose – dawka ($g \cdot dm^{-3}$)		Length Długość	Width Szerokość
	N	K	cm	
Kasia	0.2	0.4	10.0	6.3
		0.8	11.0	6.6
	0.4	0.4	10.3	6.2
		0.8	10.6	6.4
	0.6	0.4	10.4	6.5
		0.8	10.5	6.4
	0.9	0.4	10.2	6.2
		0.8	9.8	6.1
Wala	0.2	0.4	10.4	6.3
		0.8	10.7	5.7
	0.4	0.4	9.8	5.5
		0.8	10.0	5.7
	0.6	0.4	10.1	5.8
		0.8	9.6	5.4
	0.9	0.4	9.0	5.2
		0.8	9.5	5.7
Green leaved form Forma zielonolistna	0.2	0.4	14.1	8.9
		0.8	14.0	8.1
	0.4	0.4	13.7	8.6
		0.8	13.7	9.0
	0.6	0.4	13.5	9.0
		0.8	13.4	8.4
	0.9	0.4	13.1	8.5
		0.8	12.6	8.0
Mean – Średnio	Kasia		10.3	6.3
	Wala		9.9	5.7
	Green leaved form		13.6	8.5
Mean N dose Średnio dawka N	0.2		11.7	7.0
	0.4		11.4	7.0
	0.6		11.2	6.9
	0.9		10.7	6.6
Mean K dose – Średnio dawka K		0.4	11.3	6.9
		0.8	11.3	6.8
Mean – Średnio			11.2	6.9
$LSD_{0.05}$ $NIR_{0,05}$	A – cultivar – odmiana		0.48	0.35
	B – N dose – dawka		0.61	0.22
	C – K dose – dawka		n. s.	n. s.
	A × B		n. s.	n. s.
	A × C		n. s.	n. s.
	B × C		n. s.	0.36
	A × B × C		n. s.	n. s.

fresh and air-dry herb (respectively: 171.2 g and 174.7 g, as well as 18.3 and 18.4 g) compared to the remaining ones. Besides, a significant interaction was found between the cultivar and nitrogen dose in the formation of the fresh basil herb weight. Fertilization, especially organic, combined with mineral, applied in appropriate dose and composition, affects growth, herb weight, as well as basil essential oil yield [Arabaci and Bayram 2004, Anwar et al. 2005, Geetha et al. 2009, Luz et al. 2009]. The increase of

Table 3. The fresh and air-dry weight (g · plant^{-1}) of basil herb in dependence on the nitrogen and potassium fertilization (mean for 2009–2010)

Tabela 3. Masa (g · rośl^{-1}) świeżego i powietrznie suchego ziela bazylii w zależności od nawożenia azotem i potasem (średnio z 2009–2010)

Cultivar Odmiana	Dose – dawka (g·dm^{-3}) N	K	Fresh weight Świeża masa	Air-dry weight Powietrznie sucha masa
Kasia	0.2	0.4	177.4	17.2
		0.8	169.7	14.2
	0.4	0.4	174.6	17.0
		0.8	189.2	16.7
	0.6	0.4	167.4	16.5
		0.8	170.6	15.3
	0.9	0.4	153.4	13.6
		0.8	153.6	15.0
Wala	0.2	0.4	169.6	18.7
		0.8	165.9	17.5
	0.4	0.4	173.5	19.2
		0.8	165.7	17.4
	0.6	0.4	150.1	15.7
		0.8	157.6	16.9
	0.9	0.4	148.4	18.9
		0.8	169.8	20.3
Green leaved form Forma zielonolistna	0.2	0.4	166.5	19.8
		0.8	178.1	22.5
	0.4	0.4	173.8	20.3
		0.8	171.4	19.9
	0.6	0.4	162.5	19.0
		0.8	160.5	17.8
	0.9	0.4	145.6	16.2
		0.8	151.0	19.3
Mean – Średnio	Kasia		169.5	15.7
	Wala		162. 6	18.1
	Green leaved form		163.7	19.3
Mean N dose Średnio dawka N	0.2		171.2	18.3
	0.4		174.7	18.4
	0.6		161.4	16.9
	0.9		152.1	17.2
Mean K dose – Średnio dawka K		0.4	163.6	17.7
		0.8	166.9	17.7
Mean – Średnio			165.2	17.7
$LSD_{0.05}$ $NIR_{0,05}$	A – cultivar – odmiana		3.77	2.18
	B – N dose – dawka		14.51	1.74
	C – K dose – dawka		n. s.	n. s.
	A × B		10.53	n. s.
	A × C		n. s.	n. s.
	B × C		n. s.	n. s.
	A × B × C		n. s.	n. s.

overground part yield usually takes place as early as after applying very small nitrogen doses, and as they increase, the quantity accretions are smaller and smaller – the effectiveness of fertilization decreases [Nurzyńska-Wierdak 2009]. On the other hand, however, the increased level of NPK fertilization significantly increases the biomass of basil [Kandil et al. 2009, Sharafzadeh et al. 2011], like the increased nitrogen dose stimulates fresh weight of basil overground parts [Golcz et al. 2006, Sifola and Barbieri 2006]. Besides, foliar feeding with nitrogen stimulates yield and accumulation of mineral components in basil herb [Nurzyńska-Wierdak and Borowski 2011, Nurzyńska-Wierdak et al. 2011a], which is the proof of yield-creating role of this component. The results of this paper do not confirm the above relationship, which can be explained by cultivar differences between the examined plants, which is indicated by the significance of coeffect of the cultivar and nitrogen dose upon the weight of fresh basil herb.

Lack of significant influence of potassium was demonstrated, as well as the coeffect of nitrogen and potassium upon the fresh and air-dry basil herb yield. Similarly, the increasing level of potassium did not cause significant differences in fresh basil herb weight [Sharafzadeh et al. 2011]. The application of K_2O did not also affect the main and the first ratoon basil crops in field growing. Also the interaction effect of N and K on the yield of basil was not significant in any of the three harvests [Rao et al. 2007]. The response of plants to the increasing potassium dose, as well as to the interaction between N and K was demonstrated as late as at the third herb harvest, growing back after the main harvest, which the authors explain by the decreased potassium amount in the soil, as the vegetation went on. In the light of this, lack of response from the examined basil plants upon the increased amount of potassium, as well as lack of cooperation between N and K in the formation of herb yield weight, could result from the fact that harvest was performed only once.

After the studies have been finished, the substratum analyses were performed, where it was demonstrated that the increased nitrogen and potassium doses contributed to the decreased substratum pH value, however, the differences were not significant (tab. 4). In all the examined objects the substrate reaction remained on the optimal level for correct growth and development of plants [Nurzyński 2003]. The EC value was significantly the highest (2.0 $mS \cdot cm^{-1}$) in the substrate after harvesting the plants of Wala cultivar, compared to the remaining ones, which was also demonstrated in previous studies [Nurzyńska-Wierdak et al. 2011b]. This dependence may result from less intense uptake of nutrients from the medium by the examined plants. The concentration of ions in the peat substrate increased with the increase of nitrogen and potassium doses, which is confirmed in previous papers [Nurzyńska-Wierdak 2009, Nurzyńska-Wierdak et al. 2011b]. The significance of the coeffect of examined factors upon ion concentration in the substrate after plant harvest was also demonstrated.

The remains of mineral nitrogen and potassium after basil harvest were on different levels and depended upon the examined factors (tab. 4). The plants of examined basil cultivars were taking up nutrients from the peat substrate with different intensity, in the case of Wala cultivar the most of them was found, and as to the green-leaved form – the least of mineral nitrogen and potassium after harvest. These data remain consistent with the characterization of basil biomass; the green-leaved form was the tallest, its leaves were the biggest and the air-dry herb weight was the highest, as compared to the other

Table 4. EC ($mS \cdot cm^{-1}$) and chemical composition ($mg \cdot dm^{-3}$) of substratum from basil cultivation (mean for 2009–2010)
Tabela 4. EC ($mS \cdot cm^{-1}$) oraz skład chemiczny podłoża ($mg \cdot dm^{-3}$) z uprawy bazylii (średnio z 2009–2010)

Cultivar Odmiana	Dose – dawka ($g \cdot dm^{-3}$) N	Dose – dawka ($g \cdot dm^{-3}$) K	pH	EC	$N\text{-}NH_4 + N\text{-}NO_3$	K
Kasia	0.2	0.4	5.5–6.1	1.0	52.8	165.7
		0.8	5.4–5.8	1.3	42.7	464.5
	0.4	0.4	5.4–5.6	1.4	95.2	171.5
		0.8	5.1–5.6	1.5	120.1	488.2
	0.6	0.4	5.0–5.4	1.6	168.6	154.0
		0.8	4.9–5.4	1.7	179.7	391.2
	0.9	0.4	4.9–5.4	2.1	270.9	182.7
		0.8	4.9–5.3	2.2	272.6	516.7
Wala	0.2	0.4	5.6–5.9	1.4	33.6	164.5
		0.8	5.5–5.7	1.6	38.7	771.5
	0.4	0.4	5.3–5.5	1.7	82.4	117.5
		0.8	5.1–5.5	2.0	120.4	393.0
	0.6	0.4	5.0–5.2	2.1	168.8	223.0
		0.8	4.9–5.2	2.3	222.9	615.7
	0.9	0.4	4.9–5.1	2.5	277.0	203.7
		0.8	4.8–5.0	2.6	332.9	318.7
Green leaved form Forma zielonolistna	0.2	0.4	6.0–6.1	0.8	55.1	79.2
		0.8	5.9–6.1	1.3	48.7	547.2
	0.4	0.4	5.7–5.8	1.6	73.6	67.5
		0.8	5.6–5.7	1.7	88.0	258.7
	0.6	0.4	5.3–5.6	1.7	157.4	136.0
		0.8	5.2–5.5	1.9	171.8	332.0
	0.9	0.4	5.0–5.5	1.9	247.9	73.7
		0.8	4.6–5.4	2.3	292.0	326.3
Mean – Średnio	Kasia		4.9–5.5	1.6	150.3	316.8
	Wala		4.8–5.9	2.0	159.6	350.9
	Green leaved form		4.6–6.1	1.7	141.7	227.6
Mean N dose Średnio dawka N	0.2		5.5–6.1	1.2	42.3	365.4
	0.4		5.1–5.8	1.6	96.6	249.4
	0.6		4.9–5.6	1.9	178.2	308.6
	0.9		4.9–5.5	2.2	282.2	170.3
Mean K dose – Średnio dawka K		0.4	4.9–6.1	1.6	140.2	144.9
		0.8	4.6–6.1	1.9	157.2	452.0
Mean – Średnio			4.6–6.1	1.7	148.7	298.4
$LSD_{0.05}$ $NIR_{0,05}$	A – cultivar – odmiana			0.11	2.45	2.49
	B – N dose – dawka			0.14	3.13	3.18
	C – K dose – dawka			0.07	1.66	1.68
	A × B			0.32	7.09	7.21
	A × C			0.20	4.30	4.37
	B × C			0.17	5.31	5.40
	A × B × C			n. s.	n. s.	n. s.

ones. In the case of Wala cultivar, in turn, the lowest plant height and fresh herb weight were the lowest, compared to the 'Kasia' and green leaved form. The remains of mineral nitrogen and potassium were also under the influence of the dose of applied fertilizers. The decrease of potassium remains under the influence of increased nitrogen dose should be noticed, which confirms the stimulating effect of nitrogen upon potassium uptake by plants, also demonstrated in previous works [Nurzyńska-Wierdak 2009, Nurzyńska-Wierdak et al. 2011b].

CONCLUSIONS

1. The plants of examined cultivars differed in mean height, number of branchings, size of leaves, as well as weight of fresh and air-dry herb. The highest plants, with the largest leaves and weight of air-dry herb were created by the green-leaved form, which was the most popular in Poland on the fresh herb market. The highest fresh herb weight, in turn, was that of Kasia cultivar, which can be typified as especially valuable for obtaining fresh seasoning raw material.
2. The application of nitrogen fertilization significantly differentiated the mean height, as well as length and width of basil plant leaf blades, which decreased with the increase of the dose of that nutrient.
3. The highest number of branchings was reported at the medium and highest nitrogen dose. Plants fed with the medium and highest doses of nitrogen had significantly higher weight of fresh and air-dry herb, compared to the plants obtaining the highest dose.
4. The fresh herb weight of the examined plants remained under the significant influence of co-operating cultivar and nitrogen dose, which should be considered at establishing the level of nitrogen fertilization in growing particular basil cultivars.
5. Lack of significant effect of nitrogen and potassium doses upon biometrical features of basil plants was demonstrated. The interaction between nitrogen and potassium in the formation of basil growth and development was demonstrated only with reference to the height of plants and leaf blade width. In spite of that, on the basis of substratum analysis after harvesting, a stimulating effect of nitrogen upon potassium uptake by the examined basil plants was found.

REFERENCES

Abduelrahman A.H.N., Elhussein S.A., Osman N.Al., Nour A.H., 2009. Morphological variability and chemical composition of essential oils from nineteen varieties of basil (*Ocimum basilicum* L.) growing in Sudan. Int. J. Chem. Technol., 1 (1), 1–10.

Ali M. A., Hossain M.A., Mondal M.F., Farooque A.M., 2003. Effect of nitrogen and potassium on yield and quality of carrot. Pak. J. Biol. Sci., 6 (18), 1574–1577.

Anwar M., Patra D.D., Chand S., Alpesh K., Naqvi A.A., Khanuja S.P.S., 2005. Effect of organic manures and inorganic fertilizer on growth, herb and yield, nutrient accumulation, and oil quality French basil. Comm. Soil Sci. Plan., 36 (13/14), 1737–1746.

Arabaci O., Bayram E., 2004. The effect of nitrogen fertilization and different plant densities on some agronomic and technologic characteristic of *Ocimum basilicum* L. (Basil). J. Agron., 3 (4), 255–262.

Biesiada A., Kuś A., 2010. The effect of nitrogen fertilization and irrigation on yielding and nutritional status of sweet basil (*Ocimum basilicum* L.). Acta Sci. Pol. Hortorum Cultus, 9 (2), 3–12.

Chang X., Alderson P.G., Wright Ch.J., 2008. Solar irradiance level alters the growth of basil (*Ocimum basilicum* L.) and its content of volatile oils. Environ. Exp. Bot., 63, 216–223.

Daneshian A., Gurbuz B., Cosge B., Ipek A., 2009. Chemical components of essential oils from basil (*Ocimum basilicum* L.) grown at different nitrogen levels. Internat. J. Nat. Eng. Sci., 3 (3), 8–12.

Dzida K., 2010a. Nutrients contents in sweet basil (*Ocimum basilicum* L.) herb depending on calcium carbonate dose and cultivar. Acta Sci. Pol. Hortorum Cultus, 9 (4), 143–151.

Dzida K., 2010b. Biological value and essential oil content in sweet basil (*Ocimum basilicum* L.) depending on calcium fertilization and cultivar. Acta Sci. Pol. Hortorum Cultus, 9 (4), 153–161.

Dzida K., Jarosz Z., 2006. Plonowanie i skład chemiczny majeranku ogrodowego (*Origanum majorana* L.) w zależności od zróżnicowanego nawożenia azotowo-potasowego. Acta Agrophys., 7 (3), 561–566.

Geetha A., Rao P.V., Reddy D.V., Shaik M., 2009. Effect of organic and inorganic fertilizers on macro and micro nutrient uptake, oil content, quality and herbage yield in sweet basil (*Ocimum basilicum* L.). res. Crops, 10 (3), 740–742.

Golcz A., Politycka B., Seidler-Łożykowska K., 2006. The effect of nitrogen fertilization and stage of plant development on the mass and quality of sweet basil leaves (*Ocimum basilicum* L.). Herba Pol., 52 (1/2), 22–29.

Kandil M.A., Khatab M.E., Ahmed S.S., Schnug E., 2009. Herbal and essential oil yield of Genovese basil (*Ocimum basilicum* L.) grown with mineral and organic fertilizer sources in Egypt. J. Kulturpflanzen, 61 (12), 443–449.

Kaya C., Higgs D., 2003. Supplementary potassium nitrate improves salt tolerance in bell pepper plants. J. Plant Nutr., 26 (7), 1367–1382.

Luz J. M. Q., Morais T. P. S., Blank A. F., Sodre A. C. B., Oliveira G. S., 2009. Content, yield and chemical composition of the essential basil oil under chicken manure levels. Hort. Bras., 27 (3), 349–353.

Ma L., Shi Y., 2011. Effects of potassium fertilizer on physiological and biochemical index of *Stevia rebaudiana* Bertoni. Energy Procedia, 5, 581–586.

Ma L., Ren G., Shi Y,. 2012. Effects of potassium fertilizer on diurnal change of photosynthesis in *Stevia rebaudiana* Bertoni. Adv. Mater. Res.Vols, 343–344, 1087–1091.

Megda M.M., Monteiro F.A., 2010. Nitrogen and potassium supply and the morphogenic and productive characteristics of marandu palisadegrass. Rev. Bras. Zootec., 39 (8), 1666–1675.

Nguyen P.M., Kwee E.M., Niemeyer E.D., 2010. Potassium rate alters the antioxidant capacity and phenolic concentration of basil (*Ocimum basilicum* L.) leaves. Food Chem., 123, 1235–1241.

Nour A.H., Elhussein S.A., Osman N.A., Ahmed N.E., Abduelrahman A.A., Yusoff M.M., Nour A.H., 2009. Antibacterial activity of the essential oils of Sudanese accessions of basil (*Ocimum basilicum* L.). J. Applied Sci., 9 (23), 4161–4167.

Nurzyńska-Wierdak R., 2009. Growth and yield of garden rocket (*Eruca sativa* Mill.) affected by nitrogen and potassium fertilization. Acta Sci. Pol. Hortorum Cultus, 8 (4), 23–33.

Nurzyńska-Wierdak R., Borowski B., 2011. Dynamics of sweet basil (*Ocimum basilicum* L.) growth affected by cultivar and foliar feeding with nitrogen. Acta Sci. Pol. Hortorum Cultus, 10 (3), 307–317.

Nurzyńska-Wierdak R., Borowski B., Dzida K., 2011a. Yield and chemical composition of basil herb depending on cultivar and foliar feeding with nitrogen. Acta Sci. Pol. Hortorum Cultus, 10 (1), 207–219.

Nurzyńska-Wierdak R., Rożek E., Borowski B., 2011b. Response of different basil cultivars to nitrogen and potassium fertilization: total and mineral nitrogen content in herb. Acta Sci. Pol. Hortorum Cultus, 10 (4), 217–232.

Nurzyński J., 2003. Nawożenie roślin ogrodniczych. WAR, Lublin.

Oxenham S.K., Svoboda K.P., Walters D.K., 2005. Antifungal activity of the essential oil of basil (*Ocimum basilicum*). J. Phytopathol., 153 (3), 174–180.

Rao E.V.S.P., Puttana K., Ganesha R.S., Ramesh S., 2007. Nitrogen and potassium nutrition of French basil (*Ocimum basilicum* Linn.). J. Spices Aromat. Plants, 16 (2), 99–105.

Said-Al Ahl H.A.H., Mahmoud A.A., 2010. Effect of zinc and/or iron foliar application on growth and essential oil of sweet basil (*Ocimum basilicum* L.) under salt stress. Ozean J. Appl. Sci., 3 (1), 97–111.

Sekar K., Thangaraj S., Saravana Babu S., Harisaranraj R., Suresh K., 2009. Phytochemical constituent and antioxidant activity of extract from the leaves of *Ocimum basilicum*. J. Phytol., 1 (6), 408–413.

Sharafzadeh S., Esmaeili M., Mohammadi A.H., 2011. Interaction effects of nitrogen, phosphorus and potassium on growth, essentials oil and total phenolic content of sweet basil. Adv. Environ. Biol., 5 (6), 1285–1289.

Sifola M.I., Barbieri G., 2006. Growth, yield and essential oil content of three cultivars of basil grown under different levels of nitrogen in the field. Sci. Hort, 108, 408–413.

Singh K., Singh P.P., Beg S. U., Kumar D., Patra D.D., 2004. Effect of NPK fertilizers on growth, oil yield and quality of French basil (*Ocimum basilicum* L.). J. Spices Aromat. Crops, 13, 52–54.

Suh E.-J., Park K.-W., Park K.-W., 1999. Effect of different concentrations of nutrient solutions on the growth, yield, and quality of basil. Acta Hortic., 483, 193–198.

Svecova E., Neugebauerova J., 2010. A study of 34 cultivars of basil (*Ocimum* L.) and their morphological, economic and biochemical characteristics, using standardized descriptors. Acta Univ. Sapientiae, Alimentaria, 3, 118–135.

Taie H.A.A., Salama Z.A.E.R., Radwan S., 2010. Potential activity of basil plants as a source of antioxidants and anticancer agents as affected by organic and bio-organic fertilization, Not. Bot. Hort. Agrobot. Cluj 38, 119–127.

Wójcik P., 2004. Uptake of mineral nutrients from foliar fertilization. J. Fruit Orn. Plant Res. Spec. ed., 12, 201–218.

Zheljazkov V.D., Cantrell Ch.L., Ebelhar M.W., Rowe D.E., Coker Ch., 2008. Productivity, oil content, and oil composition of sweet basil as a function of nitrogen and sulphur fertilization. Hort. Sci., 43 (5), 1415–1422.

REAKCJA ROŚLIN BAZYLII POSPOLITEJ (*Ocimum basilicum* L.) NA NAWOŻENIE AZOTEM I POTASEM

Streszczenie. Właściwości lecznicze i aromatyczne ziela bazylii sprawiają, że gatunek ten coraz częściej pojawia się w uprawach polowych i szklarniowych. Wzrost i plonowanie roślin bazylii uzależnione jest m.in. od odmiany oraz nawożenia. Doświadczenie przeprowadzono w szklarni w okresie od lutego do maja 2009–2010. Rośliny uprawiano w doniczkach o pojemności 4 dm^3, wypełnionych substratem torfowym. Różnicowano koncentrację w podłożu azotu: 0,2; 0,4; 0,6; 0,9 g N · dm^3, podanego w formie saletry amonowej oraz potasu: 0,4; 0,8 g K · dm^3, danego w postaci siarczanu. Rośliny badanych odmian bazylii (Kasia, Wala, forma zielonolistna) różniły się średnią wysokością, liczbą rozgałęzień, wielkości liści oraz masy świeżego i powietrznie suchego ziela. Zastosowanie nawożenia azotem w istotny sposób różnicowało średnią wysokość oraz długość i szerokość blaszki liściowej roślin bazylii, które zmniejszały się wraz ze wzrostem dawki tego składnika. Rośliny żywione najmniejszą i średnią dawką azotu charakteryzowały się istotnie większą masą świeżego i powietrznie suchego ziela, w porównaniu z roślinami otrzymującymi dawkę najwyższą. Wielkość masy świeżego ziela badanych roślin pozostawała pod istotnym wpływem współdziałania odmiany i dawki azotu. Stwierdzono brak istotnego wpływu dawki potasu na badane cechy biometryczne roślin bazylii. Interakcję azotu i potasu w kształtowaniu wzrost i rozwoju bazylii wykazano jedynie w odniesieniu do wysokości roślin oraz szerokości blaszki liściowej.

Słowa kluczowe: *Lamiaceae*, morfologia rośliny, odmiany, świeża masa ziela, makroskładniki

ACKNOWLEDGMENT

Research financed by Ministry of Science and Higher Education within the frames of project No N N310 450738

Accepted for print – Zaakceptowano do druku: 13.01.2012