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YIELD AND CHEMICAL COMPOSITION OF BASIL HERB DEPENDING ON CULTIVAR AND FOLIAR FEEDING WITH NITROGEN

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Abstract. Foliar feeding is an effective method of supplying plants with nutrients, much faster than soil fertilization. The effectiveness of this procedure may result from quick penetration and transfer of the applied nutrients inside the plant. The aim of foregoing studies was to assess the effect of foliar nitrogen application upon the yield of fresh and air-dry basil herb of the cultivars: 'Kasia', 'Wala', 'Genua Star' and 'Opal', grown in an unheated foil tunnel. Foliar feeding was performed dosing 0.5% urea solution until complete wetting of leaf blade surface. The influence of cultivar and urea application upon the yield and chemical composition of basil herb was demonstrated. The highest concentrations of total nitrogen, potassium, calcium and protein, but also nitrates, were characteristic of 'Opal' plants. Among green-leaved cultivars, the highest fresh herb weight was that of 'Genua Star'. The foliar application of nitrogen increased the weight and yield of fresh herb. It also caused increased concentrations of $N\text{-}NO_3$ and $N\text{-}NH_4$, K, Ca, compared to control plants.

Key words: *Ocimum basilicum,* urea, herb yield, protein, nitrates, macronutrients

INTRODUCTION

Foliar fertilization is at present one of the basic elements of plant agrotechny in intensive and ecological agriculture. It allows to provide plants with indispensable micro- and macronutrients. The best effects are obtained at full root fertilization and in the period of intense plant growth and development. Nitrogen, indispensable to plants for producing protein substances and non-protein compounds of primary importance, is, simultaneously the fastest taken up element. It participates in almost all biochemical reactions taking place in living organisms. The deficiency of this element is a frequent

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factor that limits the formation of new tissues. In practice urea is often used for foliar fertilization with nitrogen. Urea is a nitrogen fertilizer significant for plant growth, fruit yield and accumulation of proteins, nucleic acids, as well as other compounds and, consequently, it significantly contributes to the course of photosynthesis. This fertilizer, in the form of intra-foliar solution, is strongly absorbed by leaf cuticle and equally fast used by the plant. An advantageous effect of foliar application of urea upon yield quantity and quality was revealed in various vegetable species, such as broccoli, cabbage, onions, peppers or cucumber [Kołota and Osińska 2001, Yildrim et al. 2007, del Amor et al. 2009, Charbaji et al. 2008, Abd and Faten 2009]. Borowski and Michałek [2009] found an advantageous effect of urea on potassium absorption through spinach leaves. In further studies [Borowski and Michałek 2010] the authors proved that adding urea to the applied solutions of magnesium salts increased the course of gas exchange processes in spinach plants, as well as the contents of protein, chlorophyll, carotenoids, nitrates and proline in leaves, at the same time decreasing the concentrations of vitamin C, potassium and magnesium.

Nitrogen plant nutrition is closely connected to the quantity and quality of the obtained yield, as this element, besides its yield-creating role, also affects the biological value: in. a. the contents of sugars, L-ascorbic acid, protein, plant dyes, but also nitrates and heavy metals. Sweet basil, grown as a seasoning, aromatic and medicinal plant, has high nutritional requirements and the ability to use mineral components intensely. High level of nitrogen fertilization positively affects the basil yield, as well as its quality [Golcz et al. 2002, 2006, Golcz and Markiewicz et al. 2002, Arabaci and Bayram 2004, Sifola and Barbieri 2006, Nguyen and Niemeyer 2008, Biesiada and Kuś 2010]. Refaat and Saleh [1998] demonstrated that foliar application of NPK and microcomponents in the concentration of 3000 ppm in monthly time intervals, advantageously affected basil yield quantity and the quality of essential oil. Smoleń and Sady [2007] indicate that nitrogen fertilization, except yield-creating effect of nitrogen, also influences the biological value of yield. The authors demonstrated the decrease of soluble sugars contents and unchanged concentrations of carotenoid and phenolic compounds in carrots with the application of foliar feeding with nitrogen. Szura et al. [2009], in turn, found that applying foliar nitrogen feeding in red beet growing, irrespectively of soil fertilization manner with this component affected the decrease of nitrate contents in plant roots and leaves. Wojciechowska et al. [2005] report that foliar feeding with urea significantly decreased nitrate contents in broccoli heads, as compared to non-feeding plants. Besides, Wojciechowska et al. [2006] proved the stimulating effect of reduced nitrogen forms applied in soil and foliar fertilization upon the activity of nitrate reductase activity in carrot leaves. Foliar feeding, combined with soil fertilization with NH_4NO_3 increased the share of nitrate reduction in leaves up to above 80%.

The purpose of the foregoing studies was to assess the effect of foliar urea application upon the yield of fresh and air-dry basil herb of ‘Kasia’, ‘Wala’, ‘Genua Star’ and ‘Opal’ cultivars, grown in an unheated foil tunnel. In the experiment the total nitrogen, protein and nitrate contents in basil herb were also determined.

MATERIAL AND METHODS

The study subject were plants of the two first Polish sweet basil cultivars: ‘Kasia’and ‘Wala’, as well as of ‘Genua Star’ and ‘Opal’. The sowing material came from the Institute of Natural Fibers and Herbal Plants in Poznań (Polish cultivars), as well as from PNOS – Ożarów Mazowiecki (the remaining cultivars). The experiment was established on the premises of the Experimental Farm of the University of Life Sciences in Lublin, using the complete randomization method, in four repetitions, as a two-factor one. Factor A was basil cultivar (‘Kasia’ – medium-sized plants, rounded habit with large, dropping, rolling green leaves and light-violet flowers; ‘Wala’– tall plants of uplifted habit with large, slightly rolling green leaves and light-violet flowers; ‘Genua Star’ – green-leaved, tall plants of uplifted habit, with white or purplish white flowers ‘Opal’ – purple-leaved, short-plants with purple flowers), factor B: foliar feeding of plants with nitrogen (plants feeding with urea and non-feeding). The studied basil cultivars represented typical essential oil composition and biomass productivity of basil chemotypes grown in the middle-east Europe.

Basil seeds were sown in a heated glasshouse in the third decade of March 2008 and 2009, into sowing boxes filled with peat substrate. Before sowing the seeds were treated with Dithane Neo Tec 75WG. When the seedlings reached the height of 6–7cm, they were thinned into multiplates filled with substrate. At the end of April the hardened seedlings of 15–16 cm were planted into an unheated foil tunnel. The temperature in 2008 was recorded from 9.3°C (April) and 12.8°C (May) to 17.7°C (June) and from 11.4°C (April) and 13.6°C (May) to 16.4°C (June) in 2009. Long-term average (1951–2000) of monthly temperature was 7.4°C, 13.0°C and 16.2°C, respectively at that time.

Soil in the tunnel was lessive, derived from medium silty loam with 1.9% organic matter, pH_{H2O} 7.4, EC 0.31 mS cm^{-1}, 8.0 mg $N\text{-}NH_4$+$N\text{-}NO_3$, 60 mg P, 20 mg K and 60 mg Mg in 1 dm^3. Cultivator tillage was performed, having first spread the compound fertilizer Azofoska (13.6% N, 2.8% P, 15.9% K, 2.7% Mg, 0.18% Cu, 0.17% Fe, 0.045% Zn, 0.27% Mn, 0.045% B, 0.09% Mo), in the dose of 45 kg · 100 m^{-2}, introducing into the soil: 306 mg $N\text{-}NH_4$ + $N\text{-}NO_3$, 65 mg P, 360 mg K and 60 mg Mg · dm^{-3}. The plants were grown in the spacing of 30 × 30 cm, there were 36 plants on one plot. The area of one plot was 4.2 m^2, and of the whole experiment – 90 m^2.

During vegetation the necessary managing procedures were performed, such as weeding and constant watering with the use of dropping lines. Foliar fertilization of basil was performed with the use of a hand spray, dosing 0.5% urea solution until the surface of leaf blade was totally wet. The plants not fertilized with nitrogen were watered in the same way at that time. Nitrogen fertilization and plant watering was performed four times in 10-day intervals, starting from the third decade of May, when the plants were at the initial stage of exuberant vegetation growth, and finishing two weeks before herb harvest – about the middle of June. The herb was collected manually, by shearing the whole overground part of the plant, above the lignified fragments of sprout. During harvest the plants were in the initial period of full bloom. For ‘Kasia’ and ‘Wala’ harvest fell at the end of June and for the remaining ones – about one week later, which was connected with plant development of the examined cultivars.

After harvest the average plant weight and fresh herb yield were determined. Then the herb was dried in thermal drying room in the temperature of 35°C. After drying the air-dry herb yield was determined. A part of the material was dried in the temperature of 70°C, in order to perform the analysis of N-total, protein, $N-NH_4$ and $N-NO_3$ contents. After milling the dry plant material and burning it in H_2SO_4, N-total was determined with the use of Kjeldahl's method on the automatic Kjel-Foss apparatus. In the 2% extract of acetic acid $N-NH_4$ and $N-NO_3$ were determined by means of Bremner's distillation method modified by Starck. Also the protein content (% d.m.) was calculated. After dry-burning in the temperature of 550°C there were determined: phosphorus – colorimetrically with ammonium vanadomolybdate, potassium, calcium and magnesium – using atomic absorption method (Perkin-Elmer, Analyst 300). The obtained results were statistically elaborated with the use of variance analysis method for double classification at significance level $\alpha = 0.05$.

RESULTS

The conducted studies proved the significant effect of cultivar and foliar nitrogen feeding of basil plants upon the fresh weight quantity of the obtained herb (tab. 1). The plants of 'Genua Star' cultivar had significantly the highest mean fresh herb weight (305.7 g per plant), as compared to the remaining ones. The cultivars 'Kasia' and 'Opal' formed plants of comparable fresh weight, while 'Wala' cultivar had the lowest fresh weight of the formed plants. Foliar application of urea caused a significant increase of fresh weight of basil plants.

Similar interdependencies were demonstrated in the case of yield of fresh basil herb (tab. 1). The cultivar and feeding plants with nitrogen significantly differentiated the herb yield. The highest yield of fresh herb was found for 'Wala' cultivar, whereas the plants of 'Genua Star' reached the yield on the level of 3.3 kg $\cdot$ m^2, which did not significantly differ from that of plants of 'Wala'. The lowest yield was found in 'Opal' cultivar. The plants, which were foliar feeding with urea, had significantly higher yield of fresh herb than non-feeding ones. No significant interaction was demonstrated between the above listed features and both the fresh plant weight and fresh herb yield.

In the case of air dry basil herb yield, a significant differentiation was found within the scope of examined cultivars. 'Opal' cultivar had significantly the lowest air dry herb yield, compared to the plants of remaining cultivars. The yields of remaining cultivars did not significantly differ between each other. Lack of significant effect was demonstrated, upon the air dry herb yield, as well as lack of significant interaction of the examined factors on the feature under discussion.

Total nitrogen content in basil herb equaled on average 2.4% d.m. and significantly depended on cultivar (tab. 2). The most nitrogen (3.0% d.m.) was accumulated by 'Opal' cultivar plants, whereas the lowest quantity of this component was found in the herb of 'Genua Star' cultivar plants (1.9% d.m.). Foliar nitrogen feeding of plants did not significantly differentiate the total nitrogen contents.

Accumulation of nitrates by examined basil plants was under significant influence of cultivar and the procedure of foliar nitrogen feeding. The plants of 'Opal', containing

Table 1. Effect of cultivar and foliar feeding with nitrogen on mean plant weight and yield of basil herb
Tabela 1. Wpływ odmiany i dokarmiania dolistnego azotem na średnią masę rośliny oraz plon ziela bazylii

Cultivar Odmiana	Supplemental fertilization with nitrogen Uzupełniające nawożenie azotem	Mean weight of one plant Masa jednostkowa rośliny g			Yield of fresh herb Plon świeżego ziela kg m^{-2}			Yield of air-dry basil herb Plon powietrznie suchego ziela bazylii ($g \cdot m^{-2}$)		
		2008	2009	mean	2008	2009	mean	2008	2009	mean
Kasia	foliar feeding with nitrogen dokarmianie dolistne azotem	230.2	310.4	270.3	2.9	4.0	3.4	0.02	0.03	0.03
Wala		192.2	295.7	244.0	3.1	4.4	3.8	0.02	0.02	0.02
Genua Star		182.8	460.5	321.7	2.9	4.3	3.6	0.03	0.03	0.03
Opal		224.2	287.4	255.8	2.5	3.3	2.9	0.01	0.01	0.01
Mean – Średnio		207.4	338.5	273.0	2.9	4.0	3.4	0.02	0.02	0.02
Kasia	without foliar feeding with nitrogen bez dokarmiania dolistnego azotem	199.2	263.8	231.5	2.2	3.5	2.9	0.02	0.03	0.02
Wala		138.8	253.8	196.3	2.5	4.1	3.3	0.02	0.03	0.03
Genua Star		119.1	460.1	289.6	1.9	4.3	3.1	0.02	0.02	0.02
Opal		218.5	302.8	260.7	2.1	3.0	2.5	0.01	0.02	0.01
Mean – Średnio		168.9	320.1	244.5	2.2	3.7	3.0	0.02	0.03	0.02
Kasia		214.6	287.1	250.9	2.6	3.8	3.2	0.02	0.03	0.03
Wala		165.4	274.7	220.2	2.8	4.3	3.6	0.02	0.03	0.02
Genua Star		150.9	460.1	305.7	2.4	4.3	3.3	0.03	0.03	0.03
Opal		221.3	295.1	258.3	2.3	3.1	2.7	0.01	0.01	0.01
$LSD_{0.05}$ – $NIR_{0,05}$ cultivar – odmiana		36.3	74.2		0.3	0.5		0.01	0.01	
foliar feeding – dokarmianie dolistne		19.5	15.6		0.2	0.3		n. s.	n. s.	
cultivar × foliar feeding odmiana × dokarmianie dolistne		n. s.	n. s.		n. s.	n. s.		n. s.	n. s.	

Table 2. Nitrogen and protein content (% d.m.) in basil herb
Tabela 2. Zawartość azotu oraz białka (% s.m.) w zielu bazylii

Cultivar Odmiana	Supplemental N fertilization Uzupełniające nawożenie azotem	N-total N-og.			$N-NO_3$			$N-NH_4$			Protein Białko		
		2008	2009	mean	2008	2009	mean	2008	2009	mean	2008	2009	mean
Kasia	foliar feeding with nitrogen dokarmianie dolistne azotem	2.6	2.2	2.4	0.06	0.10	0.08	0.07	0.03	0.05	16.3	13.7	15.0
Wala		2.5	1.9	2.2	0.07	0.17	0.12	0.08	0.09	0.09	15.6	11.9	13.8
Genua Star		2.5	1.4	2.0	0.06	0.20	0.13	0.03	0.06	0.05	15.6	8.5	12.1
Opal		2.7	3.1	2.9	0.03	1.43	0.73	0.13	1.00	0.57	16.9	19.5	18.2
Mean – Średnio		2.6	2.2	2.4	0.06	0.48	0.27	0.08	0.30	0.19	16.1	13.4	14.8
Kasia	without foliar feeding with nitrogen bez dokarmiania dolistnego azotem	2.6	2.1	2.4	0.07	0.03	0.05	0.06	0.01	0.04	16.3	13.0	14.7
Wala		2.6	1.6	2.1	0.08	0.09	0.09	0.08	0.01	0.05	16.3	10.2	13.3
Genua Star		2.3	1.3	1.8	0.03	0.06	0.05	0.04	0.01	0.03	14.4	8.2	11.3
Opal		3.2	2.7	3.0	0.13	1.00	0.57	0.05	0.02	0.04	20.0	16.7	18.4
Mean – Średnio		2.7	1.9	2.3	0.08	0.30	0.19	0.06	0.01	0.04	16.8	12.0	14.4
Kasia		2.6	2.1	2.4	0.07	0.07	0.07	0.07	0.01	0.05	16.3	13.3	14.9
Wala		2.6	1.8	2.2	0.08	0.13	0.11	0.08	0.03	0.07	16.0	11.0	13.6
Genua Star		2.4	1.3	1.9	0.05	0.13	0.09	0.04	0.03	0.02	15.0	8.4	11.7
Opal		3.0	2.9	3.0	0.08	1.21	0.65	0.09	0.04	0.03	18.5	18.1	18.2
$LSD_{0.05}$ – $NIR_{0,05}$													
cultivar – odmiana		0.5	0.5		0.02	0.06		0.01	0.02		1.0	2.5	
foliar feeding – dokarmianie dolistne		n. s.	n. s.		0.02	0.11		0.02	0.01		n. s.	n. s.	
cultivar × foliar feeding odmiana × dokarmianie dolistne		n. s.	n. s.		0.04	1.44		n. s.	n.s.		n. s.	n. s.	

Table 3. Phosphorus, potassium, calcium and magnesium content (% d.m.) in examined basil herb
Tabela 3. Zawartość fosforu, potasu, wapnia i magnezu (% s.m.) w badanym zielu bazylii

Cultivar Odmiana	Supplemental fertilization with nitrogen Uzupełniające nawożenie azotem	P			K			Ca			Mg		
		2008	2009	mean	2008	2009	mean	2008	2009	mean	2008	2009	mean
Kasia	foliar feeding with nitrogen dokarmianie dolistne azotem	0.58	0.70	0.64	2.69	2.72	2.71	2.73	2.58	2.66	0.37	0.35	0.36
Wala		0.53	0.47	0.50	2.80	2.68	2.74	2.52	2.55	2.54	0.24	0.24	0.24
Genua Star		0.40	0.41	0.41	2.07	2.27	2.17	3.14	3.04	3.09	0.29	0.32	0.31
Opal		0.56	0.47	0.52	2.97	3.03	3.00	2.92	2.99	2.96	0.26	0.27	0.27
Mean – Średnio		0.52	0.51	0.52	2.63	2.68	2.66	2.83	2.79	2.81	0.29	0.30	0.30
Kasia	without foliar feeding with nitrogen bez dokarmiania dolistnego azotem	0.52	0.57	0.55	2.18	2.07	2.13	2.84	3.12	2.98	0.31	0.23	0.27
Wala		0.50	0.40	0.45	2.33	2.22	2.28	2.46	2.41	2.44	0.24	0.15	0.20
Genua Star		0.39	0.41	0.40	2.08	2.04	2.06	2.18	2.13	2.16	0.28	0.25	0.27
Opal		0.54	0.60	0.57	2.73	2.70	2.72	2.90	2.77	2.84	0.23	0.21	0.22
Mean – Średnio		0.49	0.50	0.49	2.33	2.26	2.30	2.60	2.61	2.61	0.27	0.21	0.24
Kasia		0.56	0.64	0.60	2.44	2.43	2.42	2.79	2.85	2.82	0.34	0.29	0.32
Wala		0.52	0.44	0.48	2.57	2.45	2.51	2.49	2.48	2.49	0.24	0.20	0.22
Genua Star		0.40	0.41	0.41	2.08	2.16	2.12	2.66	2.59	2.63	0.29	0.29	0.29
Opal		0.55	0.54	0.55	2.85	2.87	2.86	2.91	2.88	2.90	0.25	0.24	0.25
$LSD_{0.05}$ – $NIR_{0,05}$ cultivar – odmiana		0.11	0.13		0.18	0.23		0.16	0.28		0.11	0.07	
foliar feeding – dokarmianie dolistne		n. s.	n. s.		0.09	0.11		0.11	0.16		n. s.	n. s.	
cultivar × foliar feeding odmiana × dokarmianie dolistne		n. s.	n.s.		n. s.	n. s.		n. s.	n. s.		n. s.	n. s.	

the most total nitrogen, nitrate nitrogen and protein (tab. 2). The plants of 'Kasia' in turn, were distinguished by the lowest (0.07% d.m.) accumulation of nitrates. Besides, plants feeding with urea contained significantly more nitrates than non-feeding plants. A strong differentiation should be noticed in the amount of accumulated nitrates by basil plants feeding with nitrogen in both study years. In the year 2009 the examined plants accumulated even a few times more nitrates than in the year 2008. This relationship occurred also in the case of non-feeding plants of 'Opal'cultivar. Besides, significance was found of interaction of the examined factors upon the examined feature.

The examined basil plants accumulated small amounts of ammonium nitrogen, which was 0.04% d.m. (tab. 2) on average. Both the cultivar and urea application significantly modified the concentration of $N\text{-}NH_4$. The lowest ammonium nitrogen content in herb was in the plants of 'Genua Star', and the highest – in these of 'Wala'. 'Opal' cultivar, in which the most nitrate nitrogen was found, was characterized by a small amount of ammonium nitrogen. The basil plants that were foliar feeding with nitrogen, accumulated more ammonium nitrogen than non-feeding ones. Lack of significant interaction was demonstrated between the examined factors within the feature under discussion.

It was found that the plants of examined cultivars significantly differed as to the intensity of protein accumulation. The highest quantities of this component were found in plants of 'Opal', whereas the least – in the case of 'Genua Star' (tab. 2). Mean total protein content in the basil herb of examined cultivars was 14.6% d.m. The application of urea did not significantly affect protein concentration.

The examined basil plants were characterized by the following mean contents of mineral components in the herb: P 0.51%, K 2.48%, Ca 2.71%, and Mg 0.27% d.m (tab. 3). The concentrations of the above-mentioned components remained under the influence of the examined factors. A significant effect of the cultivar was revealed, upon the contents of phosphorus, potassium, calcium and magnesium. The highest quantities of phosphorus and magnesium were found in the herb of 'Kasia' plants, whereas those of 'Opal' accumulated the most potassium and calcium. Besides, it was found that the concentrations of potassium, calcium and magnesium in basil herb increased under the influenced of urea application. Although the contents of phosphorus in the examined herb did not remain under a significant effect of the procedure of foliar plant feeding with nitrogen, more of that component was found in feeding than in non-feeding plants.

DISCUSSION

The *Ocimum* genus, belonging to *Lamiaceae* family, is very differentiated in its morphological features and chemical composition. The most important plant within this genus, as far as economy is concerned, is sweet basil (*Ocimum basilicum* L.), grown and used in various countries all over the world. There are many well-known basil cultivars, differing in height, habit of the plant, color and size of leaves and flowers, as well as in the chemical composition [Grayer et al. 1996, Nurzyńska-Wierdak 2007a, b, Klimánkova et al. 2008, Seidler-Łożykowska and Król 2008]. The presented studies confirm high morphological and chemical variability of *Ocimum basilicum* L., and indicate the effect of environmental, as well as agrotechinical factors on the biometric features, yield and chemical composition of basil herb. Noguchi and Ichimura [2004] proved a significant influence of environmental factors, such as length of the day, growth temperature and light upon growth, flowering, oil concentration and chemical composition of basil. The authors report that the optimal conditions for fresh basil herb production are: the temperature of 25–30°C and a 12-hour day. The examined basil cultivars responded differently to growth conditions during vegetation period, which was visible in the obtained herb yield. Herb weight and yield were stimulated by genetic variability of the examined cultivars, differing in growth strength, leaf and sprout weight, plant habit. The highest fresh herb weight was characteristic of 'Genua Star', marked with strong growth and forming thick sprouts, as well as large leaves. The fresh herb weight was the highest in 'Wala', and the lowest – in the case of 'Opal' – with low height, well-stocked habit and average thickness of sprouts and leaves. Irrespective of urea application the basil plants of the examined cultivars, except 'Opal', were characterized by higher herb weight in the year 2008 than in 2009, which shows that basil growth and development depends on climatic conditions. Basil, as a tropical climate plants, has strict thermal requirements and distinctly responds with increased yield and improvement of its quality to increased air temperature. The air temperature during basil vegetation in the year 2008 was on average higher than in the year 2009, which probably affected the growth of examined plants.

Genetic variability of basil was also reflected in the different chemical composition of the examined cultivars. They accumulated nitrogen and protein in various degrees and the material differences from the two study years were less noticeable compared to the yield features discussed before. Only the accumulation of nitrate nitrogen was higher in the year 2009 than 2008, whereas it was mostly the other way round in the case of ammonium nitrate accumulation. From the cultivated plants of green-leaved cultivars ('Kasia', 'Wala', 'Genua Star') the highest total nitrogen, phosphorus, magnesium and protein was found in 'Kasia'. Similarly, Dzida [2010] found higher contents of nitrogen total, potassium, calcium, magnesium and sulfur in plants of 'Kasia' compared to these of 'Wala'. However, comparing all basil cultivars, it was found that the plants of 'Opal' accumulated significantly more nitrogen total, potassium, calcium and protein, as well as nitrates than the remaining ones. Similar relationships were demonstrated by Golcz and Markiewicz [2002], who found out that the herb of 'Dark Opal' plants was distinguished by higher nitrogen total content compared to the herb of 'Wala' plants. This can be explained by significant morphologically-developmental diversity of these cultivar groups to which also chemical and physiological differences are also related. This is indicated, for instance, by differences in the essential oil quantity and composition in the basil cultivars with green and purple leaves [Grayer et al. 1996, Nurzyńska-Wierdak 2001, 2007a, b, Silva et al. 2003, Koba et al. 2009], as well as in phenolic compound concentrations [Phuong et al. 2010], carotenoid and chlorophylic dyes [Kopsell et al. 2005]. Golcz and Markiewicz [2002] as well as Golcz and Politycka [2005] also proved a significant correlation between nitrogen contents in basil leaves and the level of dyes, depending on fertilization dose and term.

Nitrogen fertilization is significant for growth, yield and chemical composition of basil herb [Golcz et al. 2002, Arabaci and Bayram 2004, Sifola and Barbieri 2006, Omer et al. 2008, Daneshian et al. 2009, Biesiada and Kuś 2010]. Zheljazkov et al. [2008] demonstrated that nitrogen application significantly increased the herb yield of basil grown in different climatic conditions. Applying nitrogen in the amounts up to 60 kg ha^{-1} increased the yield of basil, irrespectively of the location of growing. Besides, Anwar et al. [2005] obtained basil herb yield increase, adding mineral fertilizers to Wermikompost in the amounts: NPK 50:25:25 kg ha^{-1}. Golcz et al. [2006] found that nitrogen fertilization significantly increase basil leaf weight, which was the highest in 'Mittelgross' cultivar. At the same time the leaf weight in plants of 'Mittelgross' and 'Wala' did not differ significantly. In the presented studies the fresh basil herb weight and yield significantly increased under the influence of foliar nitrogen application. At the same time the applied plant feeding increased the contents of nitrogen total, nitrate and ammonium nitrogen, potassium, calcium, magnesium and protein in the examined herb. Abd and Faten [2009] report that the manner of urea application affected the chemical composition of peppers fruit and soil dressing turned out to be more advantageous than spraying. Del Amor et al. [2009], applying foliar feeding of peppers with urea found the increased nitrogen total contents in fruit. Similarly, Yildirim et al. [2007] demonstrated the increased contents of nitrogen and other mineral components in broccoli leaves and heads caused by foliar application of urea. Otherwise, Wojciechowska et al. [2005] found a significant decrease of nitrate contents in broccoli heads caused by foliar feeding with urea. Besides, Wojciechowska et al. [2006] demonstrated the stimulating effect of reduced nitrogen forms applied in soil dressing and foliar feeding upon the activity of nitrate reductase in carrot leaves. In addition, the participation of leaves in nitrate reduction in relation to roots distinctly increased, affected by reduced fertilizing nitrogen forms, especially combined with foliar application of urea.

One of the most important aspects of foliar plant feeding is the increased nutrient uptake from the soil. This phenomenon is explained by the fact that foliar feeding causes releasing more sugars and other secretions by plants from their roots to the rhisosphere. In this situation the microorganisms settling the rhisosphere are stimulated to increase the accessibility of these substances. Intensification of biological activity increases the accessibility of nutrients, vitamins and other components which are necessary for the plants, thus stimulating their metabolism. In addition, urea absorption through leaves of most cultivable plants is higher and quicker than in the case of inorganic nitrogen forms. This can be explained by the fact that the cuticle membrane is 10 to 20 times more permeable for urea than for inorganic ions [Wójcik 2004].

CONCLUSIONS

1. The examined basil cultivars differed significantly between themselves as to average fresh weight of the plant and yield of herb, as well as the contents of nitrogen total, nitrate and ammonium nitrogen, as well as protein.

2. The highest concentrations of protein, nitrogen total, potassium, calcium, but also nitrates, were characteristic of 'Opal' plants.

3. Among green-leafed cultivars, the highest fresh herb yield was that of 'Genua Star'. At the same time, the yield of fresh and air-dry herb matter of that cultivar herb, as well as of 'Kasia' and 'Wala' did not significantly differ between themselves.

4. Foliar application of nitrogen increased the weight and yield of fresh herb. It also caused the increase concentrations of $N\text{-}NO_3$ and $N\text{-}NH_4$, K, Ca, as compared to control plants.

5. The application of urea did not significantly affect total nitrogen, protein, phosphorus and magnesium content.

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PLON ORAZ SKŁAD CHEMICZNY ZIELA BAZYLII W ZALEŻNOŚCI OD ODMIANY I DOLISTNEGO DOKARMIANIA ROŚLIN AZOTEM

Streszczenie. Dokarmianie dolistne jest skutecznym sposobem dostarczenia roślinom składników pokarmowych, znacznie szybszym od doglebowego. Efektywność tego zabiegu może wynikać z szybkości wnikania i przemieszczania w roślinie zastosowanych składników pokarmowych. Celem niniejszych badań była ocena wpływu dolistnego stosowania azotu na plon świeżego i powietrznie suchego ziela bazylii odmian: 'Kasia', 'Wala', 'Genua Star' oraz 'Opal' uprawianej w nieogrzewanym tunelu foliowym. Dokarmianie dolistne bazylii wykonano, dozując 0,5% roztwór mocznika do całkowitego zwilżenia powierzchni blaszki liściowej. Wykazano wpływ odmiany oraz dokarmiania dolistnego mocznikiem na plon i skład chemiczny ziela bazylii. Największą koncentracją azotu ogółem, potasu, wapnia i białka, ale również azotanów charakteryzowały się rośliny odmiany 'Opal'. Spośród odmian zielonolistnych największą świeżą masą ziela odznaczała się odmiana 'Genua Star'. Aplikacja azotu zwiększała masę i plon świeżego ziela oraz powodowała zwiększenie koncentracji $N\text{-}NO_3$ i $N\text{-}NH_4$, K, Ca w porównaniu z kontrolą.

Słowa kluczowe: *Ocimum basilicum*, mocznik, plon ziela, białko, azotany, makroskładniki

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