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EFFECTS OF MAGNESIUM NUTRITION UNDER VARYING SOIL MOISTURE CONDITIONS ON SOME PHYSIOLOGICAL FEATURES OF FRAGRANT BASIL (*Ocimum basilicum* L.)

WPŁYW ŻYWIENIA MAGNEZEM W ZRÓŻNICOWANYCH WARUNKACH WILGOTNOŚCIOWYCH GLEBY NA NIEKTÓRE CECHY FIZJOLOGICZNE BAZYLII WONNEJ (*Ocimum basilicum* L.)

Summary: The first factor of the experiment was the level of nutrition with magnesium (0; 0.30 and 0.90 g Mg per Mitscherlich pot), whereas the other factor was the level of soil moisture (30 % and 60 % of the maximum water capacity). The following physiological features of fragrant basil were determined: assimilation surface of leaf laminas, fresh mass of the aboveground part, dry mass of leaves, stalks and roots, the structure of dry mass yield.

Keywords: *Ocimum basilicum L.*, magnesium, soil moisture, assimilation surface, yield

Fragrant basil (*Ocimum basilicum* L.) is a herb of which is used for therapeutic purposes or as a popular flavouring. Due to the intensification herbal plant production it is necessary to get thoroughly acquainted with the effect of mineral nutrition on their physiological features. Polish soils have been regarded for many years as containing very small amounts of magnesium. However this chemical element is indispensable and one of the most active biologically macrocomponents and its role in metabolism of plants is multidirectional. Magnesium is involved in 300 enzymatic reactions in living organisms [1].

The aim of the study was to assess the effect of soil nutrition with magnesium in diversified moisture conditions of soil on some physiological features of fragrant basil.

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Material and methods

Two-year pot (Mitscherlich type, 7 kg soil per pot) experiments were conducted in a cold greenhouse of the Szczecin University of Agriculture. The method of complete randomization in a two factor set in ten repetitions was used. The experimental factors were: I – level of nutrition with magnesium (Mg0, Mg1, Mg2), II – level of soil moisture (30 % and 60 % of maximum water capacity). The medium for the plants was soil material taken from the arable – humus level of postagricultural soil of the 6th soil quality class. Its mechanical composition was light silty clay sand.

The same doses of indispensable macro- and microelements except magnesium were used in the experiments. Magnesium doses in the form of $MgSO_4 \cdot 7H_2O$ were differentiated in the following way: Mg0 – 0 g Mg per pot, Mg1 – 0.30 g Mg per pot, Mg2 – 0.90 g Mg per pot. Doses of the remaining mineral components per pot were as follows: N – 1 g in the form of NH_4NO_3, K – 1.66 g in the form of K_2SO_4 and KCl (1:1), P – 0.44 g in the form of NaH_2PO_4, Ca – 0.36 g in the form of $CaCO_3$, a solution of microelements according to Hoagland – 5 cm^3, a solution of 1 % $FeCl_3$ – 5 cm^3. Nitrogen dose was divided into two equal parts and they were used in two periods: before planting and in the third ten – day period of June, two weeks after the plant thinning. The remaining mineral components were introduced into soil in the course of filling the pots with soil. In the experiments basil was cultivated from a seedling. At the very beginning of the experiment in each pot three most even plants were left. In the course of filling the pots, current moisture and maximum water capacity were determined every year. During the whole period of plant vegetation soil moisture was maintained by means of the gravimetric method at the level of 30 or 60 % of the maximum water capacity depending on the combination of the experiment [2].

The following physiological features of *O. basilicum* L. were determined: assimilation surface of leaf laminas, fresh mass of the aboveground part, dry mass of leaves, stalks and roots, the structure of dry mass yield.

Plants selected for the determination were harvested in two periods: the first one in the full phase of flower buds (the third ten-day period of June) and the other in the full phase of blossoming (in the middle of June). The gathered plants were divided into particular organs, *ie* stalks, leaves and roots. Total fresh mass of the aboveground part of basil was also determined. The summary assimilation surface of leaf laminas of individual plants were measured by means of a scanner co-working with the computer programme SCAN-25. The dry mass of stalks, leaves and the root system of basil was determined after drying the plant material at a temperature of 105 °C to the constant mass.

The obtained results of the studies were worked out statistically using the analysis of variance of individual experiments [3]. To determine differences between average experimental objectives Tukey confidence half-intervals at the level of significance of $\alpha = 0.05$ ($LSD_{0.05}$) were defined.

Results and discussion

In both years of experiments neither in the phase of flower buds nor in the phase of blossoming any significant influence of differentiated level of fertilizing with magnesium on the size of assimilation surface of leaf laminas was statistically confirmed. In both periods of harvesting during the first year of studies and in the phase of blossoming in the second year, basil plants growing in soil with moisture of 60 % of the maximum water capacity were characterized by a significantly larger summary surface of leaf laminas than those growing in soil moisture conditions of 30 % of the maximum water capacity (Table 1). According to Kimura et al [4] the size of assimilation surface of leaf laminas *O. basilicum* L. increases with the growth in the amount of water in soil easily available to plants.

No statistically significant influence of the level of nutrition with magnesium on the yield of fresh mass of the above-ground part of fragrant basil was shown. A positive effect of fertilizing with this macrocomponent on fresh mass of basil could be observed only in the second period of harvesting during the first year of the studies. In that period the largest fresh mass of the above-ground part (91.16 $g \cdot plant^{-1}$) was characteristic for the plants fertilized with the largest dose of magnesium applied in the experiment (Table 2). In the first year of the studies carried out on basil, both in the phase of flower buds and in that of blossoming significantly larger fresh mass of the above-ground part (respectively 57.06 and 102.15 $g \cdot plant^{-1}$) was determined in plants growing in soil with of 60 % of the full water volume than those cultivated at moisture level of 30 % of the full water volume – 43.53 and 63.43 $g \cdot plant^{-1}$ (Table 2). Similarly, in the second year of the studies, larger fresh mass of the above-ground part of basil was observed in plants growing in soil with of 60 % of the maximum water capacity. Similar results of the studies concerning the influence of differentiated moisture of soil on the yield of the basil herb were obtained by Rumińska (1980) [5]. According to this author an increase in moisture of soil to 80 % of the full water volume affects positively the growth of plants, resulting in an increase in fresh mass of the above-ground part. In the first year of the studies a significant influence of the interaction of experimental factors on the yield of fresh mass of the above-ground part of fragrant basil in the phase of flower buds was observed, as the largest fresh mass (62.63 $g \cdot plant^{-1}$) was produced by plants from the combination Mg0 60 % of the maximum water capacity. This mass was significantly different from the yield of fresh mass of the plants from the combinations Mg0 30 % of the maximum water capacity and Mg1 60 % of the maximum water capacity.

Statistical analysis of the results obtained in both years of the studies did not show any significant influence of differentiated level of magnesium nutrition on the amount of total dry mass yield of *O. basilicum* L. In the first year of the studies the total dry mass yield of basil growing in soil with 60 % moisture of the maximum water capacity amounted in successive periods of harvesting, respectively to 7.35 and 17.41 $g \cdot plant^{-1}$ and it was statistically significantly larger than the yield of plants grown in soil with 30 % moisture of the maximum water capacity (5.46 and 9.96 $g \cdot plant^{-1}$) (Table 3). In the second year of the studies a larger yield of dry mass was also produced by basil growing in soil with 60 % moisture of the maximum water capacity.The results of the studies can be confirmed by material in literature as, for example, according to Rumińska (1983) [6] the optimum level of water conditions for majority of herbal plants varies from 40 to 60 % of the maximum water capacity. In the first year of the studies the largest total dry mass yield of basil was obtained on the combination Mg3 60 % of

Table 1

The assimilation surface of fragrant basil [$dm^2 \cdot plant^{-1}$]

Level of Mg nutrition	I year						II year					
	1 harvest time			2 harvest time			1 harvest time			2 harvest time		
	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x
Mg0	6.12	7.94	7.03	5.62	9.17	7.39	4.13	4.16	4.14	7.02	12.64	9.83
Mg1	5.75	7.96	6.85	5.24	7.64	6.44	5.21	5.75	5.48	8.21	10.71	9.46
Mg2	4.26	10.11	7.18	5.95	5.27	5.61	4.10	4.34	4.22	9.34	9.78	9.56
x	5.38	8.67	7.02	5.60	7.36	6.48	4.48	4.75	4.61	8.19	11.04	9.61
$LSD_{0.05}$ for:	factor I		n.s.	factorI		n.s.	factor I		n.s.	factor I		n.s.
	factor II		1.959	factor II		1.515	factor II		n.s.	factor II		3.286
	interaction IxII		n.s.	interaction IxII		n.s.	interaction IxII		n.s.	interaction IxII		n.s.
	interaction IIxI		n.s.	interaction IIxI		n.s.	interaction IIxI		n.s.	interaction IIxI		n.s.

n.s. – not significant

Table 2

Fresh mass of the above – ground part of fragrant basil [$g \cdot plant^{-1}$]

Level of Mg nutrition	I year						II year					
	1 harvest time			2 harvest time			1 harvest time			2 harvest time		
	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x
Mg0	52.02	62.32	57.17	68.58	95.85	82.21	24.98	32.19	28.58	75.77	97.12	86.44
Mg1	43.87	47.11	45.49	60.40	89.57	74.98	33.83	38.10	35.96	77.74	64.83	71.28
Mg2	40.69	61.76	51.22	61.30	121.03	91.16	24.40	34.23	29.31	75.66	81.19	78.42
x	45.53	57.06	51.29	63.43	102.15	82.78	27.74	34.84	31.28	76.39	81.05	78.71
$LSD_{0.05}$ for:	factor I		7.931	factorI		n.s.	factor I		n.s.	factor I		n.s.
	factor II		5.357	factor II		12.586	factor II		6.077	factor II		n.s.
	interaction IxII		11.216	interaction IxII		n.s.	interaction IxII		n.s.	interaction IxII		n.s.
	interaction IIxI		9.278	interaction IIxI		n.s.	interaction IIxI		n.s.	interaction IIxI		n.s.

n.s. – not significant

the maximum water capacity and it amounted in successive periods of harvesting, respectively, to 8.34 and 21.52 g · plant^{-1} (Table 3).

In the first year of the studies no significant effect of in-soil nutrition with magnesium on the yield of dry mass of leaves of *O. basilicum* L. was observed. Only in the second experimental year in the phase of flower buds the largest yield of leaf dry mass (2.49 g · plant^{-1}) was obtained after the application of magnesium in the dose of Mg1 in the phase of blossoming, whereas the largest yield of leaves (3.25 g · plant^{-1}) was registered for plants fertilized with magnesium at the level of Mg2 (Table 4). A clearly negative influence of small moisture of soil (30 % of the maximum water capacity) on the yield of leaf dry mass was observed. In both years of the studies a larger dry mass of leaves was characteristic for plants cultivated in soil with 60 % of the maximum water capacity.

In the first year of the studies the yield of dry mass of basil stalks harvested in the phase of flower buds did not depend on the level of nutrition with magnesium, whereas in the second period of harvesting plants fertilized with magnesium at the level of Mg2 – 11.52 gave significantly the largest yield of stalks. A larger dry mass of *O. basilicum* L. stalks, both in the phase of flower buds and in the phase of blossoming was observed in plants growing in soil with moisture of 60 % of the maximum water capacity. In the first year of the studies significance of the interaction of experimental factors was proved. Significantly the largest yield of dry mass of basil stalks was obtained in the combination Mg2 60 % of the maximum water capacity and it amounted to 16.29 g · plant^{-1} (Table 5).

In the first year of studies a larger mass of roots (in the first and in the second period, respectively 0.62 and 0.97 g · plant^{-1}) was characteristic for basil cultivated on soil with moisture of 60 % of the maximum water capacity than for the plant growing on soil of moisture of 30 % (of the maximum water capacity) (Table 6). A similar yield of dry mass of the root system of *O. basilicum* L. in the phase of full blossoming was obtained by Gregorczyk (1996) [7] as this yield varied from 0.33 to 0.56 g · plant^{-1}.

In the yield of dry mass of fragrant basil, stalks were dominant in the first year of the studies. Their average contribution in successive periods of harvesting amounted, respectively, to 50.7 and 70.7 % (Fig. 1A, B). A similar structure of the yield was obtained in the second year of the studies in basil in the phase of blossoming (contribution of stalks – 60.7 %) (Fig. 2B). Only in the phase of flower buds in the second year of studies leaves had the largest contribution in the yield of basil (46.8 %) whereas stalks had slightly smaller (43.8 %) (Fig. 2A). Considerably larger contribution of dry mass of leaves in the yield of *O. basilicum* L. was observed in both years in plants in the phase of flower buds. In the first year in the phase of flower buds it amounted to 40.5 %, while in the phase of blossoming, to only 24 %. The contribution of roots in the yield varied from 5.3 % (1st year, 2nd period) to 11.2 % (2nd year, 2nd period). Contribution of leaves in the basil yield obtained in the first year in the phase of flower buds in different experimental combinations was similar and varied from 39 % (Mg0 30 % of the maximum water capacity and Mg2 60 % of the maximum water capacity) to 43 % (Mg1 30 % of the maximum water capacity). In the same year the largest contribution of leaf dry mass in the basil yield in the phase of blossoming was characteristic for the combination Mg0 60 % of the maximum water capacity (27 %), whereas it was the lowest

Table 3

Total dry mass of plants of fragrant basil [g · plant^{-1}]

Level of Mg nutrition	I year						II year					
	1 harvest time			2 harvest time			1 harvest time			2 harvest time		
	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x
Mg0	6.24	7.94	7.09	10.46	15.60	13.03	4.40	4.77	4.59	9.86	14.27	12.06
Mg1	4.94	5.78	5.36	9.60	15.09	12.34	5.44	5.43	5.44	12.70	9.41	11.05
Mg2	5.19	8.34	6.76	9.81	21.52	15.67	4.12	5.34	4.73	8.53	13.06	10.79
x	5.46	7.35	6.40	9.96	17.41	13.68	4.65	5.18	4.92	10.36	12.25	11.30
$LSD_{0.05}$ for:	factor I		1.37	factorI		n.s.	factor I		n.s.	factor I		n.s.
	factor II		0.93	factor II		2.29	factor II		n.s.	factor II		n.s.
	interaction IxII		n.s.	interaction IxII		4.79	interaction IxII		n.s.	interaction IxII		5.10
	interaction IIxI		n.s.	interaction IIxI		3.97	interaction IIxI		n.s.	interaction IIxI		4.22

n.s. – not significant

Table 4

Dry mass of fragrant basil leaves [g · plant^{-1}]

Level of Mg nutrition	I year						II year					
	1 harvest time			2 harvest time			1 harvest time			2 harvest time		
	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x
Mg0	2.43	3.15	2.79	2.62	4.28	3.45	1.92	2.22	2.07	2.40	3.73	3.06
Mg1	2.12	2.41	2.26	2.50	3.38	2.94	2.44	2.55	2.50	3.30	2.98	3.14
Mg2	2.07	3.24	2.65	2.42	3.99	3.20	2.05	2.56	2.30	2.57	3.93	3.25
x	2.21	2.93	2.57	2.51	3.88	3.20	2.14	2.44	2.29	2.76	3.55	3.15
$LSD_{0.05}$ for:	factor I		n.s.	factorI		n.s.	factor I		n.s.	factor I		n.s.
	factor II		0.430	factor II		0.715	factor II		n.s.	factor II		0.721
	interaction IxII		n.s.	interaction IxII		n.s.	interaction IxII		n.s.	interaction IxII		n.s.
	interaction IIxI		n.s.	interaction IIxI		n.s.	interaction IIxI		n.s.	interaction IIxI		n.s.

n.s. – not significant

Table 5

Dry mass of stalks of fragrant basil [g · plant^{-1}]

Level of Mg nutrition	I year						II year					
	1 harvest time			2 harvest time			1 harvest time			2 harvest time		
	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x
Mg0	3.23	4.09	3.66	7.38	10.45	8.91	2.14	2.11	2.12	6.54	9.12	7.83
Mg1	2.36	2.93	2.64	6.61	10.90	8.75	2.60	2.32	2.46	7.43	5.12	6.27
Mg2	2.61	4.38	3.49	6.76	16.29	11.52	1.49	2.37	1.93	5.14	8.15	6.64
x	2.73	3.80	3.26	6.92	12.55	9.73	2.08	2.27	2.17	6.37	7.46	6.91
$LSD_{0.05}$ for:	factor I		n.s.	factorI		2.315	factor I		n.s.	factor I		n.s.
	factor II		0.629	factor II		1.564	factor II		n.s.	factor II		n.s.
	interaction IxII		n.s.	interaction IxII		3.274	interaction IxII		n.s.	interaction IxII		3.400
	interaction IIxI		n.s.	interaction IIxI		2.708	interaction IIxI		n.s.	interaction IIxI		2.812

n.s. – not significant

Table 6

Dry mass of roots of fragrant basil [g · plant^{-1}]

Level of Mg nutrition	I year						II year					
	1 harvest time			2 harvest time			1 harvest time			2 harvest time		
	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x	30 %	60 %	x
Mg0	0.59	0.70	0.64	0.46	0.88	0.67	0.34	0.44	0.39	0.91	1.42	1.16
Mg1	0.45	0.44	0.44	0.49	0.81	0.65	0.40	0.56	0.48	1.97	1.31	1.64
Mg2	0.51	0.72	0.62	0.63	1.23	0.93	0.57	0.41	0.49	0.82	0.99	0.90
x	0.52	0.62	0.57	0.53	0.97	0.75	0.90	0.47	0.45	1.23	1.24	1.27
$LSD_{0.05}$ for:	factor I		n.s.	factorI		n.s.	factor I		n.s.	factor I		n.s.
	factor II		n.s.	factor II		0.212	factor II		n.s.	factor II		n.s.
	interaction IxII		n.s.	interaction IxII		n.s.	interaction IxII		n.s.	interaction IxII		n.s.
	interaction IIxI		n.s.	interaction IIxI		n.s.	interaction IIxI		n.s.	interaction IIxI		n.s.

n.s. – not significant

in the combination Mg2 60 % of the maximum water capacity – 19 %. In the second year of the studies in the first period of harvesting the largest contribution of leaves in the basil yield (50 %) was observed in combination Mg0 30 % of the maximum water capacity. In the second period of harvesting the largest contribution of leaves (32 %) was characteristic for combination Mg1 60 % of the maximum water capacity and the smallest (25 %) for combination Mg1 60 % of the full water volume. In the studies by Golcz et al. (2002) [8] contribution of leaf dry mass in the yield of herb of this kind was at the beginning of blossoming on average 55.7 %, while in the full blossoming – 56.5 %.

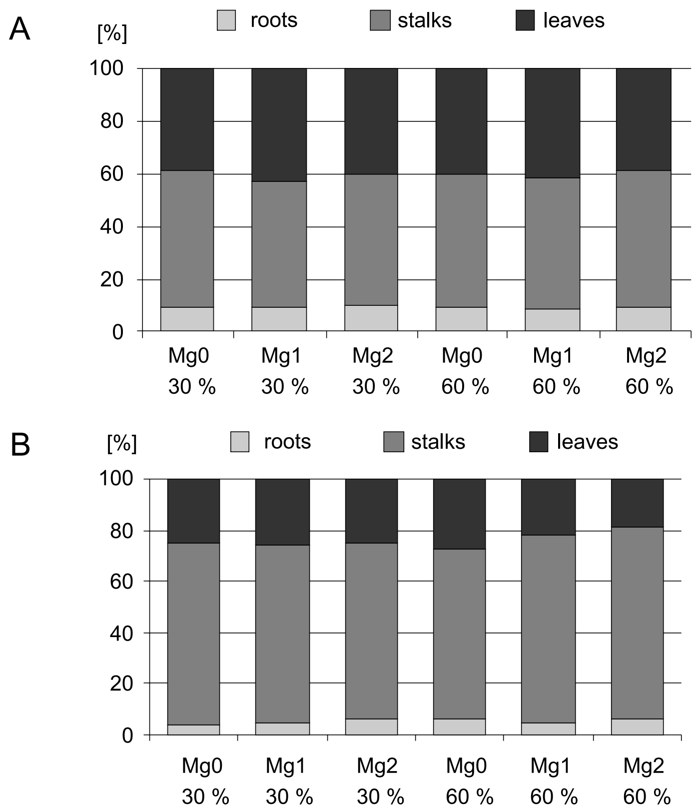
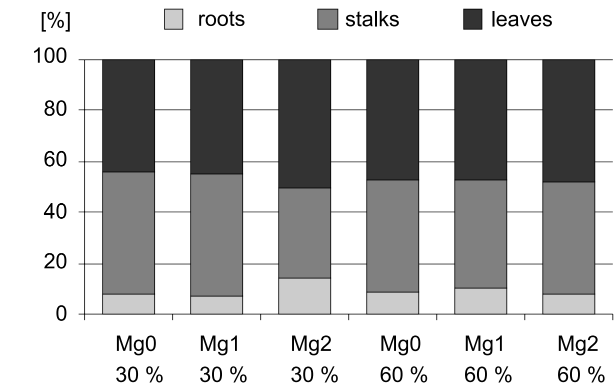


Fig. 1. The structure of dry mass yield of fragment basil in first (A) and second (B) harvest time [%] – I year

Conclusions

1. Optimum moisture of the medium (60 % of the maximum water capacity) had a significant positive effect on the production of the above-ground part of *O. basilicum* L., both fresh and dry mass.

A


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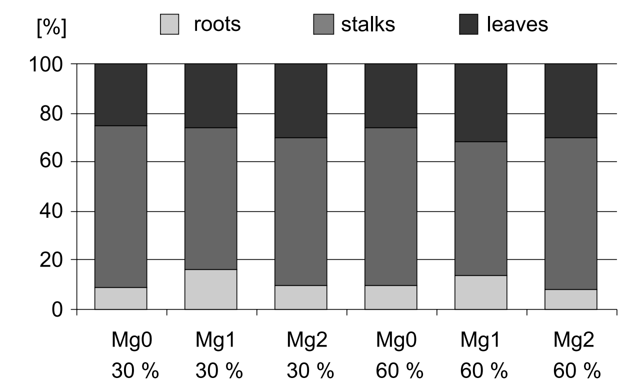

Fig. 2. The structure of dry mass yield of fragment basil in first (A) and second (B) harvest time [%] – II year

2. The application of dry conditions (30 % of the maximum water capacity) resulted in a smaller total surface of leaf laminas of fragrant basil.

3. The yield of dry mass of *O. basilicum* L. depended on moisture of the medium, *ie* larger moisture (60 % of the maximum water capacity) caused a larger yield of dry mass and its better structure.

4. In the yield of dry mass of fragrant basil in both years of studies and all the periods of harvesting stalks were dominant.

References

[1] Panak H.: *Znaczenie magnezu w żywieniu roślin*. Biul. Magnezol., 1997, **2**(4), 232.
[2] Żurbicki Z.: Metodyka doświadczeń wazonowych. PWRiL, Warszawa 1974.
[3] Wójcik A. R. and Laudański Z.: Planowanie i wnioskowanie statystyczne w doświadczalnictwie. PWN, Warszawa 1989.

[4] Kimura M, Ichimura M. and Tomitaka Y.: *Effects of catering on growth, yield, essentials oil concentration and evapotranspiration of sweet basil (Ocimum basilicum* L.*)*. Jap. J. Trop. Agricult. 1994, **38**(1), 65–72.

[5] Rumińska A.: *Wstępne badania nad wpływem nawożenia mineralnego i wody na plon ziela oraz produkcję nasion bazylii wonnej*. Wiad. Ziel., 1980, (5), 2–3.

[6] Rumińska A.: Rośliny lecznicze. PWN, Warszawa 1983.

[7] Gregorczyk A.: *Wpływ dokarmiania dolistnego magnezem na plon i zawartość olejku eterycznego w bazylii, cząbrze i majeranku*. Biul. Magnezol., 1996, **1**(2), 25–29.

[8] Golcz A., Seidler-Łożykowska K. and Markiewicz B.: *Effect of increasing nitrogen doses and harvest terms on the growth and development of sweet basil (O. basilicum* L.*)*. Part I. Herba Pol. 2002, **48**(2), 55–60.

WPŁYW ŻYWIENIA MAGNEZEM W ZRÓŻNICOWANYCH WARUNKACH WILGOTNOŚCIOWYCH GLEBY NA NIEKTÓRE CECHY FIZJOLOGICZNE BAZYLII WONNEJ (*Ocimum basilicum* L.)

S t r e s z c z e n i e

Pierwszym czynnikiem doświadczalnym był poziom żywienia magnezem (0; 0,30 i 0,90 g Mg na wazon typu Mitscherlicha), drugim natomiast poziom uwilgotnienia gleby (30 i 60 % pełnej pojemności wodnej). Oznaczono następujące cechy fizjologiczne bazylii wonnej: powierzchnia asymilacyjna blaszek liściowych, świeża masa części nadziemnej, sucha masa liści, łodyg i korzeni, struktura plonu suchej masy

Słowa kluczowe: *Ocimum basilicum* L., magnez, wilgotność gleby, powierzchnia asymilacyjna, plon