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Effect of mycorrhization on growth and yield of basil

Wpływ mikoryzacji na wzrost i plonowanie bazylii

Summary. Eight-week-old potted transplants of green leaf type and 'Opal' basil were planted in the field on May 21st and harvested at the full blooming phase on August 3rd. Directly before planting, root blocks were inoculated with mycorrhizal fungi using "Vaxi-Root" vaccine. The inoculated plants grew more slowly and their height, stem diameter and fresh weight were lower during the harvest. Mycorrhization did not affect the air-dry weight of plants, the length and the width of leaves, the number of stem branches nor the content of dry matter, monosaccharides, total sugars, phenolic acids, essential oil and the DPPH scavenging ability in fresh basil leaves. The effect of mycorrhization on the content of anthocyans, chlorophyll and L-ascorbic was dependent of basil type.

Key words: plants growth, dry matter, sugars, anthocyans, chlorophyll, essential oil

INTRODUCTION

Mycorrhiza are symbiotic associations between plant roots and certain soil fungi which play a key role in nutrient cycling in the ecosystem and also protect plants against environmental and cultural stress. Most of the major plant families are able to form mycorrhiza and its applying is feasible for crops using a transplant stage, as it is the case with horticultural systems [Azcón-Aguilar and Barea 1997]. Mycorrhiza can improve plant growth, nutrition and resistance decreasing the need for chemical fertilizers and pesticides and this is essential for sustainable plant production [Kubiak 2005, Głuszek *et al.,* 2008]. The effect of mycorrhiza on the growth and development of horticultural plants have been studied in many research papers and in general fruit crops have received more attention than vegetable and ornamental crops [Azcón-Aguilar and Barea 1997]. Only few information are related to basil. In the experiment curried out by Copetta *et al.* [2006], the basil plants (*Ocimum basilicum* L., var. *genovese*) inoculated with three mycorrhizal fungi had longer and more branched roots and their leaves developed more glandular hairs producing more essential oil. Hemavathi *et al.* [2006] found that inoculation of soil with fungus *Glomus fasciculatum* and with growth promoting rhizobacteria *Bacillus* and *Pseudomonas* made a favourable effect on growth of basil plants, their fresh and dry weight, number of stem branches and content of phosphorus in the plant. In the experiment conducted by Rashmi *et al*. [2008], basil (*Ocimum gratissimum* L.) plants cultivated on soil inoculated with *Glomus*, *Aspergillus* and *Azotobacter* grew better and contained more dry matter, essential oil and microelements. In the studies curried out by Toussaint *et al.* [2007, 2008], the basil plants inoculated with mycorrhizal fungi contained more antioxidants, however the content of essential oil remained unchanged and the content of eugenol methyl in essential oil decreased. According to Górka [2004], sometimes the effect of mycorrhization can be unfavourable, especially when cultivated plants have very good growth conditions. In the experiment conducted by Nowak [2009], mycorrhization did not affect the content of phosphorus in the leaves of China aster (*Callistephus chinensis* (L.) Ness) plants fertilized with high level of this element and slightly increased P content was detected in the leaves of mycorrhizal plants grown under low P level. Inoculated plants were significantly lower and their shoot biomass was also significantly lower in comparison to control plants. Golcz and Bosiacki [2008] found that thyme (*Thymus vulgaris* L.) plants inoculated with mycorrhizal fungi had lower fresh and dry weight and contained considerably less essential oil. Similarly Nowak [2007] observed unfavourable effect of mycorrhization on growth of sage (*Salvia splenders* Sello) plants. Effectiveness of mycorrhiza can be modified by soil pH, fertilization, temperature, light, availability of water and it is visible especially well in stress conditions [Księżniak 2001]. The aim of this experiment was to study the effect of mycorrhization of basil transplants on growth and yield of plants and on content of several components in basil leaves.

MATERIAL AND METHODS

The experiment was carried out in the Felin Experimental Farm (215 m above see level, 51°14´ N latitude, 22º38´ W longitude) in 2009. It was established on podzolic soil developed from dusty medium loam containing 1.6% of organic matter and with pH (in H_2O) of 6,7. The parsnip was the forecrop. On May 20th, the experimental field was fertilized with ammonium nitrate 80 kg N · ha^{-1}, superphosphate 30.5 kg P · ha^{-1} and potassium sulphate 75 kg K · ha^{-1}. Additional nitrogen fertilization was applied as a top dressing using ammonium nitrate 80 kg N · ha^{-1} on June 19th. The seeds of basil (*Ocimum basilicum* L.) 'Opal' with purple leaves and of type with green leaves produced by PNOS Ożarów Mazowiecki were seeded in glasshouse to the seedling flats filled with the mixture of soil and peat on March 20th and than the seedlings were transplanted to 5 cm diameter pots filled with the same mixture on April 8th. 17 cm high potted transplants of basil cv. Opal and 29 cm high transplants of green leaves type were planted in the field on May 21st. Directly before planting, the transplants were taken out from pots and the root blocks were dipped for 15 minutes in "Vaxi-Root" arbuscular micorrhizal vaccine produced by "Zielony Dom" firm. Then 10 plants of each basil type were planted by hand on one plot in four rows with the 0,4 m distance between rows and 0.2 cm distance between plants in the row. The area of one plot was 1.6 m^2. The experiment was established in completely randomized designe with four replications. On June 17th the soil samples were taken and then the content of macroelements and the soil salinity were determined in the Regional Chemical-Agricultural Station in Lublin ($N\text{-}NO_3$ – 96 mg · dm^{-3} – ion measuring method, P – 231 mg · dm^{-3} – colorimetric method, K – 250 mg · dm^{-3} – flame photometry, Ca – 1010 mg · dm^{-3} – flame photometry, Mg – 114 mg · dm^{-3} – atomic absorption spectrometry, and the soil salinity was 0.63 g NaCl · dm^{-3}). After planting, the plant height and the stem diameter of all plants were measured every week till harvest. The weeds were controlled by hand as soon as they germinated. On July 2nd and August 3rd three soil samples from the 0–20 and 20–40 cm layers were taken using 100 cm^{-3} cylinders. Then the samples were weighed, dried in 105°C during 24 hours and weighed again. Obtained results were used for calculation of soil moisture. On July 27th the samples of leaves were taken from basil plants and then the content of dry matter (oven dry method), anthocyanins [acc. to Miłkowska and Strzelecka 1995], chlorophyll (Mac Kinney`s method), L-ascorbic acid (J. H. Roe`s method modified by Ewelin), sugars (Schoorl-Luff`s method) and the sum of phenolic acids (Arnov`s method) as well as the activity of removal of DPPH radicals (measured at the concentration of 20 μg · ml and expressed as percentage of DPPH inhibition [acc. to Chen and Ho`s 1997] in the leaves were determined. The plants were harvested in full blooming phase on August 3rd. The fresh weight, the height and the number of stem branches of each plant were measured immediately after harvest. Moreover the length of 10 fully developed leaves with petiole as well as the length and the width of leaf blades were measured on each plant. Then the air-dry weight of all harvested plants was determined. In November the content of essential oils in air-dry shoots was measured and then the oil constituents were determined using gas chromatography method in connection with mass detector (Varian 4000 GC/MS/MS).

During period of basil cultivation the air temperatures and the sums of rainfalls were noted in a meteorological station situated in the Felin Experimental Farm. In May the average monthly air temperature was 13.6°C and the sum of rainfall was 71.1 mm, in June these values were 16.4°C and 125.5 mm, in July – 19.9°C and 57.1 mm and in August – 19.0°C and 54.7 mm, respectively. The moisture of the 0–20–cm and 20–40 cm soil layer measured on July 2nd was 19.5% and 20.9% and measured on August 3rd it was 12.7% and 13.9%, respectively.

The results were studied by analysis of variance and the significance of differences were determined using Tukey`s test at 0.05 probability level.

RESULTS

The basil types studied in the experiment differed considerably in the character of growth and their reaction to inoculation with mycorrhizal fungi was sometimes also differentiated. The mycorrhization had an unfavourable effect on plant growth of both basil forms. At harvest time, the height of 'Opal' control and inoculated plants was 42.3 cm and 37.6 cm and the height of green leaves control and inoculated basil plants was 66.9 cm and 64.1 cm, respectively with the differences being significant. In the case of green leaves basil type, this effect appeared in the second half of July only (tab. 1).

The effect of mycorrhization on stem diameter was significantly differentiated in dependence of basil form. The mycorrhization did not affect the stem growth of green leaves basil plants and it had an unfavourable effect on stem growth of 'Opal' plants in the second half of vegetation period (tab. 2). The fresh and the air dry weight of inoculated plants of both basil types was lower in comparison to control plants, however this effect was significant only in the case of fresh weight. The mycorrhization did not affect the number of branches developed by stem of basil plant (tab. 3). It did not also affect the length of leaf with petiole, nor the length and the width of leaf blade (tab. 4).

Table 1. Height of basil plants in dependence of type, mycorrhizal inoculation and date of measurement
Tabela 1. Wysokość roślin bazylii w zależności od jej formy, inokulacji szczepionką mikoryzową i terminu pomiaru (cm)

Date of measurement Termin pomiaru	Inoculated Rozsada inokulowana		Mean Średnio	Not inoculated Rozsada nieinokulowana		Mean Średnio
	Green Zielona	'Opal'		Green Zielona	'Opal'	
May 28th 28 maja	31,6	17,6		30,6	20,4	
June 4th 4 czerwca	33,1	18,6		32,1	21,1	
June 12th 12 czerwca	36,4	18,9		36,0	22,4	
June 19th 19 czerwca	38,1	19,9		38,4	23,6	
June 25th 25 czerwca	40,5	21,0		41,4	24,8	
July 3rd 3 lipca	46,3	21,2		46,9	25,7	
July 10th 10 lipca	50,5	23,7		50,8	26,9	
July 16th 16 lipca	54,1	25,7		53,5	29,9	
July 23th 23 lipca	57,0	30,5		60,8	35,3	
July 30th 30 lipca	60,8	35,6		64,4	38,7	
August 3rd 3 sierpnia	64,1	37,6	50,9	66,9	42,3	55,2

$LSD_{0.05}$ (for last measurement)
$NIR_{0,05}$ (dla ostatniego pomiaru) A (form of basil, forma bazylii) = 3,07
B (mycorrhization, mikoryzacja) = 3,07
A × B = n.s., n.i.

Table 2. Diameter of basil stem in dependence of type, mycorrhizal inoculation and date of measurement (mm)
Tabela 2. Średnica łodygi bazylii w zależności od jej formy, inokulacji szczepionką mikoryzową i terminu pomiaru (mm)

Date of measurement Termin pomiaru	Inoculated Rozsada inokulowana		Mean Średnio	Not inoculated Rozsada nieinokulowana		Mean Średnio
	Green Zielona	'Opal'		Green Zielona	'Opal'	
May 28th 28 maja	4,47	3,23		4,43	3,82	
June 4th 4 czerwca	4,81	3,59		4,78	4,20	
June 12th 12 czerwca	5,14	3,82		5,22	4,42	
June 19th 19 czerwca	5,53	3,97		5,69	4,72	
June 25th 25 czerwca	6,16	4,38		6,54	5,11	
July 3rd 3 lipca	7,79	4,79		7,68	5,46	
July 10th 10 lipca	8,64	5,40		8,36	6,94	
July 16th 16 lipca	9,84	6,20		9,79	8,92	
July 23th 23 lipca	10,78	7,21		10,83	10,71	
July 30th 30 lipca	11,40	8,54	9,97	11,58	11,29	11,43
$LSD_{0.05}$ (for last measurement) $NIR_{0,05}$ (dla ostatniego pomiaru) A (form of basil, forma bazylii) = 0,943 B (mycorrhization, mikoryzacja) = 0,943 A × B = 1,818						

Table 3. Effect of basil type and mycorrhizal inoculation on fresh and air-dry weight of plant herb (g) and on number of stem branches
Tabela 3. Wpływ formy bazylii i zastosowania szczepionki mikoryzowej na świeżą i powietrznie suchą masę ziela (g) oraz na liczbę rozgałęzień pędu

Plant weight Masa rośliny	Inoculated Rozsada inokulowana		Mean Średnio	Not inoculated Rozsada nieinokulowana		Mean Średnio	$LSD_{0.05}$ $NIR_{0,05}$
	Green Zielona	'Opal'		Greek Zielona	'Opal'		
Fresh Świeża	305,9	136,8	221,4	414,7	159,3	287,0	A* = 51,13 B* = 51,13 A × B = n.s., n.i.
Air-dry Powietrznie sucha	65,0	19,9	42,5	80,0	24,3	52,6	A = 10,40 B = n.s., n.i. A × B = n.s., n.i.
Number of stem branches Liczba rozgałęzień pędu	10,0	7,0	8,5	9,0	9,0	9,0	A = 1,4 B = n.s., n.i. A × B = n.s., n.i.

A – form of basil, forma bazylii
B – mycorrhization, mikoryzacja

Table 4. Effect of basil type and mycorrhizal inoculation on length and width of leaf (cm)
Tabela 4. Wpływ formy bazylii i zastosowania szczepionki mikoryzowej na długość i szerokość liścia (cm)

Measured trait Cecha mierzona	Inoculated Rozsada inokulowana		Mean Średnio	Not inoculated Rozsada nieinokulowana		Mean Średnio	$LSD_{0.05}$ $NIR_{0,05}$
	Green Zielona	'Opal'		Green Zielona	'Opal'		
Length of leaf with petiole Długość z ogonkiem	10,0	8,0	9,0	9,9	8,4	9,2	A* = 0,80 B* = n.s., n.i. A × B = n.s., n.i.
Length of leaf blade Długość blaszki liściowej	7,8	5,8	6,8	7,6	5,9	6,8	A = 0,64 B = n.s., n.i. A × B = n.s., n.i.
Width of leaf blade Szerokość blaszki liściowej	4,0	3,5	3,8	3,9	3,6	3,8	A = 0,29 B = n.s., n.i. A × B = n.s., n.i.

*notations the same as in tab. 3
oznaczenia takie same jak w tab. 3

Table 5. Effect of basil type and mycorrhizal inoculation on content of some compounds and DPPH scavenging ability
Tabela 5. Wpływ formy bazylii i zastosowania szczepionki mikoryzowej na zawartość wybranych związków i aktywność antyoksydacyjną DPPH

Measured trait Cecha mierzona	Inoculated Rozsada inokulowana		Mean Średnio	Not inoculated Rozsada nieinokulowana		Mean Średnio	$LSD_{0.05}$ $NIR_{0,05}$
	Green Zielona	'Opal'		Green Zielona	'Opal'		
Dry matter Sucha masa (% f.w.)	17,69	12,08	14,89	16,34	13,18	14,76	A* = 1,143 B* = n.s., n.i. A × B = 2,246
Monosaccharides Cukry proste (% f.w.)	0,114	0,296	0,205	0,106	0,235	0,171	A = 0,0619 B = n.s., n.i. A × B = n.s., n.i.
Total sugars Cukry ogółem (% f.w.)	0,636	0,303	0,469	0,485	0,303	0,394	A = 0,1220 B = n.s., n.i. A × B = n.s., n.i.
L-ascorbic acid Kwas L-askorbinowy ($mg \cdot 100\ g\ f.w.^{-1}$)	44,9	73,3	59,1	55,9	75,8	65,9	A = 2,67 B = 2,67 A × B = 5,25
Anthocyanins Antocyjany (% f.w.)	0,0067	0,0328	0,0197	0,0072	0,0324	0,0198	A = 0,00007 B = 0,00007 A × B = 0,00013
Chlorophyll Chlorofil ($mg \cdot g\ f.w.^{-1}$)	1,832	1,716	1,774	1,679	1,853	1,766	A = 0,0071 B = 0,0071 A × B = 0,0140
Phenolic acids Fenolokwasy (% f.w.)	0,4539	0,5161	0,4850	0,4554	0,5220	0,4887	A = 0,00820 B = n.s., n.i. A × B = n.s., n.i.
DPPH scavenging ability (%)	73,468	75,494	74,481	67,124	76,560	71,842	A = 5,1288 B = n.s., n.i. A × B = n.s., n.i

*notations the same as in tab. 3
oznaczenia takie same jak w tab. 3

Table 6. Effect of mycorrhization on content of identified compounds in essential oil from green leaves basil type
Tabela 6. Wpływ mikoryzacji na skład olejku eterycznego roślin formy zielonej bazylii pospolitej (%)

No Nr	Compound Nazwa związku	Inoculated Rozsada inokulowana	Not inoculated Rozsada nieinokulowana	No Nr	Compound Nazwa związku	Inoculated Rozsada inokulowana	Not inoculated Rozsada nieinokulowana
1	α-pinene	0,60	0,20	36	α-cis-bergamotene	0,93	0,13
2	Camphene	tr.	tr.	37	(E)-caryophyllene	1,82	0,31
3	Sabinene	0,44	0,24	38	β-cedrene	tr.	0,17
4	β-pinene	1,28	0,66	39	α-trans-bergamotene	0,68	5,82
5	Myrcene	1,20	0,72	40	α-guaiene	1,25	0,69
6	2-δ-carene	0,07	tr.	41	(Z)-β-farnezene	tr.	0,17
7	α-terpinene	tr.	tr.	42	Muurolene-3,5-dien-cis	tr.	0,17
8	Limonene	0,21	0,16	43	(E)-β-farnegene	1,09	0,61
9	1,8-cyneol	11,18	8,96	44	α-humulene	0,66	0,68
10	γ-terpinene	0,07	tr.	45	Muurolene-4(14),5-dien-cis	0,52	0,67
11	Cis- sabinene	0,22	0,26	46	β-acoradiene	tr.	0,16
12	Terpineol	tr.	tr.	47	α-amorphene	0,10	0,17
13	Cis-linalol-oxide	tr.	tr.	48	Germacrene D	1,80	2,25
14	Phenchene	0,52	-	49	Viridiflorene	0,22	tr.
15	Linalol	54,54	53,92	50	Bicyclogermacrene	1,50	0,64
16	Endo-phenchol	0,23	-	51	α-bulnesene	2,21	1,02
17	Camphor	tr.	0,20	52	Germacrene A	0,58	0,31
18	Borneol	0,12	0,22	53	γ-cadinene	2,16	3,29
19	Terpinen-4-ol	tr.	0,06	54	δ-amorphene	0,11	0,06
20	α-terpineol	0,32	0,68	55	Trans-calamenene	0,19	0,29
21	Phenchyl acetate	1,99	-	56	α-murol-5-en-4-ol-cis	tr.	0,07
22	Linalol acetate	tr.	0,06	57	α-cadinene	tr.	0,07
23	Bornyl acetate	0,06	1,47	58	Spathulenol	0,64	0,67
24	Trans-pinocarveol acetate	tr.	tr.	59	Caryophyllene oxide	0,23	tr.
25	δ-elemene	tr.	tr.	60	Globulol	0,10	0,11
26	??	0,10	0,09	61	Viridiflorol	0,07	0,14
27	α-cubebene	0,09	0,06	62	Epi-di-1,10-cubenol	0,69	1,01
28	α-terpinyl acetate	tr.	0,06	63	α-epi-cadinol	0,12	0,08
29	??	tr.	0,07	64	α-muurolol	4,76	6,93
30	Eugenol	0,21	1,59	65	α-cadinol	0,37	0,41
31	α-copaene	0,40	0,57	66	Intermedeol	0,31	0,12
32	??	0,19	0,12	67	Khusinol	0,07	0,08
33	β-bourbonene	0,20	0,36	68	β-(E)-ocimene	-	tr.
34	β-elemene	2,15	1,05	69	Octanol	-	0,28
35	β-cubebene	tr.	0,20	70	Sesquiphellandrene	-	0,18

tr. – content lower than 0.05%
zawartość nie mniejsza niż 0,05%

Table 7. Effect of mycorrhization on content of compounds determined in essential oil from basil plants cv. Opal
Tabela 7. Wpływ mikoryzacji na skład olejku eterycznego roślin bazylii pospolitej odmiany 'Opal' (%)

No Nr	Compound Nazwa związku	Inoculated Rozsada inokulowana	Not inoculated Rozsada nieinokulowana	No Nr	Compound Nazwa związku	Inoculated Rozsada inokulowana	Not inoculated Rozsada nieinokulowana
1	α-thujene	tr.	tr.	34	β-elemene	1,80	0,75
2	α-piene	0,97	0,69	35	(E)-caryophyllene	2,08	0,15
3	Camphene	0,07	0,09	36	α-trans-bergamotene	0,75	7,03
4	Sabinene	0,66	0,62	37	α-guaiene	1,29	0,15
5	β-pinene	1,62	1,33	38	Aromadendrene	tr.	0,08
6	Myrcene	1,62	1,33	39	(Z) - β- farnesene	1,54	0,51
7	2-δ-carene	tr.	tr.	40	α-humulene	0,74	0,44
8	α-phellandrene	0,06	tr.	41	Muurolene-4(14),5-dien-cis	0,59	0,50
9	α-terpinene	tr.	tr.	42	β-acoradiene	0,13	0,08
10	Limonene	0,58	0,30	43	α-himachalene	0,16	0,06
11	1,8-cyneol	11,69	10,46	44	Germacrene D	1,97	1,87
12	γ-terpinene	0,08	0,05	45	β-selinene	0,30	tr.
13	Cis-sabinene	0,32	0,34	46	Bicyclogermacrene	1,63	0,49
14	Terpineol	tr.	tr.	47	α-bulnesene	1,83	0,81
15	Cis-linalol oxide	tr.	tr.	48	Germacrene A	0,56	0,29
16	Phenchene	0,75	tr.	49	γ-cadinene	2,28	2,79
17	Linalol	49,65	50,32	50	δ-amorphene	0,10	0,06
18	Endo-phenchol	0,31	tr.	51	Cis-calamenene	0,33	0,59
19	Trans-pinene	tr.	-	52	10-epi-cubebol	0,05	0,10
20	Camphor	0,12	0,34	53	α-cadinene	0,06	0,07
21	δ-terpineol	0,23	0,17	54	??	tr.	0,10
22	Terpinen-4-ol	0,16	0,21	55	Spathulenol	0,92	0,65
23	α-terpineol	1,15	1,14	56	Caryophyllene oxide	0,26	0,08
24	Endo-phenchyl acetale	2,21	-	57	Globulol	0,07	tr.
25	Bornyl acetate	0,13	1,49	58	Viridiflorol	0,07	0,12
26	Trans pinocarveol acetate	tr.	tr.	59	Humulene epioxide	0,06	0,05
27	δ-elemene	tr.	tr.	60	Epi-di-1,10-cubenol	0,77	1,06
28	??	0,16	0,14	61	α-epi-cadinol	0,20	0,10
29	α-cubebene	0,10	tr.	62	α-muurolol	4,83	7,11
30	α-terpinyl acetate	tr.	0,06	63	α-cadinol	0,45	0,46
31	Eugenol	0,57	3,03	64	(E)-14-hydroxy-9-epi-caryophyllene	0,10	0,06
32	α-copaene	0,34	0,29	65	β-(E)-ocimene	-	tr.
33	(E)β-damasceon	0,20	0,16	66	Borneol	-	0,16

tr. – content lower than 0.05%
zawartość nie mniejsza niż 0,05%

The mycorrhization did not affect the content of dry matter, monosaccharides and total sugars, phenolic acids as well the DPPH scavenging ability in the leaves of both basil types. The effect of mycorrhization on content of other leaf components measured at the end of vegetation period was differentiated (tab. 5). The content of L-ascorbic acid was significantly dependent on mycorrhization, on basil type and on interaction between them. Leaves of green basil plants contained significantly less L-ascorbic acid than the leaves of 'Opal' plants and mycorrhization lowered this content significantly. Mycorrhization did not affect the high content of L-ascorbic acid in the leaves of 'Opal' plants. Similarly the low content of anthocyans in the leaves of green basil plants significantly decreased and the much higher content of anthocyans in the leaves of 'Opal' plants significantly increased under influence of mycorrhization. However, a different effect on chlorophyll content was observed in the experiment. The mycorrhizal fungi decreased significantly the content of this component in the leaves of 'Opal' plants and increased significantly its content in the leaves of green basil plants.

The content of essential oil in the dry leaves of control as well as of inoculated green basil plants was 0.42 % and in the leaves of control and of inoculated 'Opal' plants it was 0.45% and 0.48%, respectively. 70 compounds were determined in the essential oil obtained from control and from inoculated green basil plants in comparison to 66 compounds determined in the essential oil obtained from control and from inoculated 'Opal' plants (tab. 6 and 7). The essential oil obtained from control green basil plants did not contain phenchene, endo-phenchol and phenchyl acetate and the essential oil obtained from inoculated green basil plants did not contain β-(E)-ocimene, octanol and sesquiphellandrene. The essential oil obtained from control 'Opal' plants did not contain trans-pinene and endo-phenchyl acetate and the essential oil obtained from inoculated 'Opal' plants did not contain borneol and (E)-ß-ocimene. Linalol made about 50% of the essential oil obtained from 'Opal' plants and about 54% of the essential oil obtained from green basil plants and its content was not affected by mycorrhizal fungi.

DISCUSSION

In the experiment the effect of mycorrhization on green leaves type and 'Opal' basil plants was generally negative and this not agree with the results obtained in different environmental conditions by Copetta *et al.* [2006], Hemavathi *et al*. [2006] and Rashmi *et al*. [2008]. In this study the basil was cultivated in good growing conditions (temperature, rainfall, soil moisture, nutrition) and according to Górka [2004] sometimes in such situations the effect of mycorrhization can be unfavourable. The favourable effect of mycorrhization is visible especially good in stress conditions [Księżak 2001]. In Poland, the negative effect of mycorrhization on growth of China aster and sage was observed by Nowak [2007, 2009] and on growth of thyme by Golcz and Bosiacki [2008]. The effect of mycorrhization on several traits related to plant growth was dependent on type of basil. It was less visible on vigorously growing plants with green leaves in comparison to 'Opal' plants with violet leaves. Similarly the mycorrhization had a negative effect on content of anthocyans and L-ascorbic acid only in the leaves of green type plants witch contained much less these components than the leaves of 'Opal' plants. In the experiment the mycorrhization did not influence the content of essential oil in basil leaves what confirms the results obtained by Toussaint *et al.* [2008].

CONCLUSIONS

1. Green leaf type and 'Opal' basil plants inoculated with mycorrhizal fungi grew slower and at harvest their height, stem diameter and fresh weight were lower in comparison to control plants.

2. Mycorrhization did not affect air-dry weight of basil plants, length and width of basil leaves, number of stem branches, content of dry matter, monosaccharides, total sugars, phenolic acids, essential oil and activity of removal of DPPH radicals.

3. Effect of mycorrhization on content of anthocyans, chlorophyll and L-ascorbic acid in the leaves was dependent of basil type.

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Streszczenie. Ośmiotygodniową doniczkowaną rozsadę bazylii typu zielonolistnego oraz odm. Opal posadzono w polu 21 maja, a będące w pełni kwitnienia rośliny zebrano 3 sierpnia. Bezpośrednio przed sadzeniem system korzeniowy roślin był szczepiony grzybami mikoryzowymi za pomocą szczepionki „Vaxi-Root". Rośliny szczepione rosły wolniej i podczas zbioru ich wysokość, średnica łodygi oraz świeża masa były mniejsze. Mikoryzacja nie miała wpływu na powietrznie suchą masę roślin, długość i szerokość liści, liczbę rozgałęzień pędu ani na zawartość suchej masy, cukrów ogółem, cukrów prostych, kwasów fenolowych, olejku eterycznego oraz aktywność antyoksydacyjną DPPH w świeżych liściach bazylii. Wpływ mikoryzacji na zawartość antocyjanów, chlorofilu i kwasu L-askorbinowego był zależny od typu bazylii.

Słowa kluczowe: wzrost roślin, sucha masa, cukry, antocyjany, chlorofil, olejek eteryczny