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Effect of differential temperature and photoperiod on growth of *Ocimum basilicum*

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Abstract

The objective of our studies was to evaluate the growth of basil plants, cultivated under different conditions of photoperiod and temperature. Plants were cultivated under three different temperatures of day and night – DIF (DIF−5 – 20/25°C, DIF0 – 23°C, DIF+5 – 25/20°C) combined with two photoperiods (12 and 16 h). The 'Kasia' and 'Wala' cultivars of sweet basil were compared in the experiment. The fresh mass, height of plants, length of hypocotyl, the plant area and content of dry mass, as well as the relative chlorophyll content were measured. Significant differences between DIF+5 and DIF−5 were observed in plant heights. The growth of plant height was enhanced by positive DIF and was inhibited by negative DIF, although the strongest stem elongation inhibition was recorded at DIF0. Leaf area was greatly affected by the photoperiod and cultivars, but only inappreciably influenced by the temperature. The plants grown under 16 h light period were characterized by higher fresh mass, longer hypocotyl and plant height than those grown under 12 h light period. The 'Wala' cultivar was characterized by greater height, leaf area and fresh herbage biomass than 'Kasia'. The highest relative content of chlorophyll was observed for DIF−5.

Key words: DIF, photoperiod, *Ocimum basilicum*, growth rate.

Introduction

Cultivation of spice plants in containers is one of the youngest branches of the greenhouse vegetable growing. Currently, cultivation technology of herbs in containers is advanced and has changed from a marginal cultivation area in a separate glasshouse crops. This is connected with a growing demand for fresh spices all year round. Among problems facing spice cultivation in containers is excessive elongations of plants which is the result of disproportionate density of plants as well as shortage of light during the winter period (Frąszczak et al., 2008). Current temperature or photoperiod may affect elongation responses because both of these abiotic factors influence growth (Weinig, 2000).

Experiments on non-chemical methods of plant height control have been carried out for over twenty years. These methods include: DIF – differentiation of day and night temperatures, DROP – decline of temperature at the beginning of day or night, monitoring of light quality and quantity and mechanical stress (Garner et al., 1997; Xiong et al., 2002). The performed investigations revealed differences in plants' response to the applied methods depending on the examined plant species.

The DIF is determined by subtracting the night temperature from the day temperature. A positive DIF occurs when the day temperature is greater than the night temperature. A lower temperature in the day than in the night is called a negative DIF. A neutral DIF (DIF0) occurs when the temperatures are the same. It was observed that negative DIF exerted an inhibitory impact on the elongation growth of very many plant species. Its strategies have been successfully used as practical tools to control stem elongation in several horticultural crops. The abovementioned experiments involved, primarily, ornamental plants cultivated in containers and, in recent years, also vegetable seedlings. It is known that in some cases the response to negative DIF is not as good as expected, and some crops did not respond to negative DIF treatments at all (Mortensen, Moe, 1992; Shimizu, 2007).

The objective of the presented study was to ascertain the influence of varying temperatures (DIF positive, negative and constant) as well as the length of the lighting period on the growth rate of sweet basil plants, grown in containers, during the vegetation period.

Material and methods

Experiments were carried out in 2009 at the Experimental Station "Marcelin" of the Poznań University of Life Sciences, in Poland. Two cultivars of sweet basil (*Ocimum basilicum* L.) 'Kasia' and 'Wala' were compared in the experiment. Seeds came directly from growers – Institute of Natural Fibres and Medicinal Plants in

Poznań, Poland. Plants were grown in two growth chambers. A three-factor experiment was performed in eight repetitions, where one pot was treated as one repetition. The investigations were conducted in two series (replications). The first factor comprised two Polish cultivars of sweet basil: 'Kasia' and 'Wala', the second – the light period: 12 and 16 hours. The third factor was three different temperature regimes: positive DIF (DT/NT: 25/20°C), neutral (zero) DIF (DT/NT: 23/23°C) and negative DIF (DT/NT: 20/25°C) (Table 1). The temperature varied ± 0.5°C from the set point temperature. Photosynthetic photon flux density (PPFD) amounted to 150 μmol m^{-2} s^{-1} at plant height. Artificial light was provided using fluorescent lamps 36W/84 of "Philips" company (Poland). The experimental plants were grown in pots of 280 cm^3 volume, filled with peat substrate for vegetable transplanting production (white peat bedding substrate, "Klassmann-Deilmann", Germany). The number of plants grown in pots was identical and amounted to 50. Plants were watered every other day, by pouring capillary mats.

Table 1. Experimental scheme for one cultivar

DIF	Temperature °C		Light period h	
	day	night		
+5	25	20	16	12
−5	20	25	16	12
0	23	23	16	12

The plants were measured every 7 days during the vegetation period, first time – 7 days after emergence and later on the 14th, 21st and 28th day (harvest time) of cultivation. In every pot, 10 plants were measured. The harvesting involved hand cutting of plants close to the surface of the substrate. After harvesting, the weight of the fresh mass of plants from the pot was determined. In addition, measurements of plant heights, hypocotyl length and the area of leaves were measured. A scanner ("Mustek 1200 UB") and the *Skwer* program ("IksmodaR", Poland) were used to calculate the surface of leaves. Also the relative chlorophyll content was measured. Measurements were performed using the SPAD – "Minolta Camera Co" Ltd. (USA) as SPAD value.

The significance of the impact of DIF, light periods and cultivars on the height, hypocotyl length, yields of fresh mass, area of basil leaves and values of indices was determined employing the *F* test. Differences between means were estimated with the aid of the Newman-Keuls test at a significance level of $\alpha = 0.05$. All statistical analyses were carried out employing the *Stat* program.

Relative growth rate (RGR), leaf area index (LAI), net assimilation rate (NAR) and leaf area ratio (LAR) were calculated as described by Hunt (1982). Values of indices refer to individual pots.

The index of the relative growth rate (RGR) was calculated on the basis of the following formula:

$$\mathrm{RGR} = \frac{dW}{W \cdot dt},$$

where: W – weight of fresh plant material at the moment harvesting (g), dW – fresh mass increment (g), dt – time of cultivation (day).

The leaf area index (LAI) refers to the area of the leaf surface in relation to the pot area taken up by all plants. It was calculated on the basis of the following formula:

$$\mathrm{LAI} = A/P,$$

where: A – plant assimilation area (dm^2), P – pot area (dm^2).

The net assimilation rate (NAR) is the increment of the biomass per unit of time and per unit of any measure of magnitude of the assimilation organs:

$$\mathrm{NAR} = \frac{dW}{A \cdot dt},$$

where: A – area of assimilation organs (dm^2), dW – fresh mass increment (g), dt – time of cultivation (day).

Leaf area ratio (LAR) is defined as the ratio of assimilation organs to the mass of the entire plant:

$$\mathrm{LAR} = A/W,$$

where: A – area of assimilation organs (dm^2), W – weight of fresh plant material at the moment of harves-ting (g).

Results

During the initial plant vegetation period, the quantity of fresh mass did not differ significantly between the experimental cultivars, while the leaf area was greater in the 'Kasia' cultivar in comparison with the 'Wala' cultivar (Table 2). During the consecutive periods of growth, 'Wala' was characterised both by a greater herbage biomass (about 15% on 21st day of cultivation) as well as leaf area (41%) than 'Kasia'. Throughout the growing period, 'Wala' was also characterised by a greater height of plants (15%), length of hypocotyl (12%) and dry matter content (33%) in comparison with 'Kasia'. On the other hand, herbage of 'Kasia' was found to contain higher chlorophyll levels in comparison with 'Wala'. At harvesting there were no differences between cultivars in the fresh mass and plant height.

Light period was found to exert a significant impact on fresh herbage mass. During the entire period of growth, plants cultivated in the 16 h light period regime were characterised by a greater mass of herbage in comparison with those grown in the 12 h light period regime. On the 21st day of cultivation fresh mass of plants grown under 16 h light period was about 11% higher, on the 21st day of cultivation and 15% higher, on the 28th day of cultivation compared to 12 h light period. The impact of the light period on the length of hypocotyl was the greatest during the initial period of vegetation during which the 16 h light period exerted a stronger influence on the elongation of the hypocotyl length (6%) than the 12 h light period. During the consecutive weeks of cultivation, no significant differences in the length of hypocotyl were observed depending on the light period. A reverse situation occurred for plant height. No significant differences were recorded in plant heights between light periods after 14 days of cultivation. During the following growth stage, both greater plant height as well as higher relative chlorophyll content was recorded for plants growing under the 16 h light period, despite the fact that at harvesting the plant height was the same for both light periods.

Plants treated with DIF+5 were characterised by the highest fresh mass of herbage and dry matter content.

During the initial period of plant vegetation, there were no significant differences in the herbage biomass between cultivations at DIF0 and DIF−5, while during the consecutive vegetation period greater herbage mass was observed for plants growing in DIF−5 conditions than in DIF0. DIF0 was found to exert the strongest impact on the inhibition of hypocotyl growth and plant height during the initial period of vegetation as well as during the harvest time, whereas during the middle period of plant growth, no differences between DIF0 and DIF−5 were recorded. Cultivation at DIF+5 exerted the most stimulating effect on the length of hypocotyl and plant height. On the seventh day of cultivation DIF0 conditions decreased hypocotyl length by 30%, while negative DIF decreased about 20% compared to positive DIF. Moreover, also chlorophyll content in leaves (for the 21st day of cultivation) was the highest for DIF+5 lower – for DIF−5 and the lowest – for DIF0. But at harvesting the highest chlorophyll content was obtained for DIF0.

During the initial period of growth, greater leaf areas were observed in plants cultivated under DIF+5; however, later on greater leaf areas were recorded for DIF0 and at harvesting for DIF+5 (Table 2).

Table 2. The effect of cultivar, light period and temperature on the biometric characteristics of plants during the vegetation period

Factor	Days	Cultivar		Light period h		DIF		
		‘Kasia’	‘Wala’	12	16	+5	−5	0
Fresh mass g pot^{-1}	7	2.03 a	1.89 a	1.72 b	2.19 a	5.67 a	1.66 b	1.54 b
	14	5.19 b	6.21 a	5.05 b	6.34 a	7.92 a	4.79 b	4.37 b
	21	10.99 b	12.74 a	11.24 b	12.48 a	14.97 a	11.56 b	9.06 c
	28	16.36 a	17.76 a	15.82 b	18.29 a	18.63 a	17.26 a	15.29 b
Hypocotyl length cm	7	2.18 b	2.32 a	2.18 b	2.33a	2.60 a	2.15 b	2.01 c
	14	4.32 b	5.02 a	4.64a	4.69 a	5.50 a	4.45 b	4.05 c
	21	5.53 b	6.22a	5.83 a	5.93 a	6.45 a	5.63 b	5.56 b
	28	5.85 b	6.64 a	6.20 a	6.29 a	6.76 a	6.14 b	5.83 c
Plant height cm	14	4.81 b	5.46 a	5.19 a	5.08 a	6.05 a	4.85 b	4.50 c
	21	7.51 b	8.67 a	7.86 b	8.32 a	8.97 a	7.78 b	7.52 b
	28	9.56 a	9.87 a	9.61 a	9.81 a	10.29 a	9.78 b	9.07 c
Leaf area dm^2 pot^{-1}	7	0.74 a	0.69 b	0.69 b	0.74 a	0.92 a	0.61 b	0.63 b
	14	1.87 b	2.45 a	2.04 b	2.28 a	2.36 a	2.30 a	1.82 b
	21	4.69 b	6.62 a	5.49 a	5.82 a	5.48 b	5.48 b	6.00 a
	28	6.38 b	6.82 a	6.82 a	6.70 a	6.27 b	7.25 a	6.28 b
Dry mass g pot^{-1}	7	0.19	0.20	0.18	0.21	0.19	0.19	0.20
	14	0.15	0.18	0.16	0.16	0.18	0.17	0.14
	21	0.18	0.24	0.18	0.24	0.25	0.20	0.19
Chlorophyll (SPAD)	21	23.46	22.28	21.98	23.76	25.29	22.49	20.84
	28	23.39	22.90	22.75	23.62	22.73	24.18	22.5

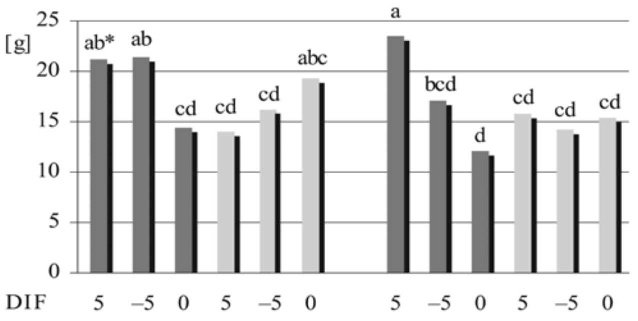
* – values followed by the same letters for individual factor do not differ significantly at $\alpha = 0.05$

A significant influence of the cultivars, day length and DIF combination on the examined traits was observed. Plants cultivated at 16-hour lighting period and DIF+5 were characterized by the greatest herbage mass and plant height as well as hypocotyl length (Figs 1–3). On the other hand, the largest leaf area was recorded for the plants cultivated at 16-hour light regime but for DIF−5 (Fig. 4). For all the examined characteristics (yield, plant height, length of hypocotyl, leaf area) the most significant was the interaction between DIF and light period. The interaction between DIF and cultivar had a significant impact only on the leaf area, and the interaction between cultivar and the light period was statistically significant for plant height and yield. Cultivar had the greatest impact on the hypocotyl length. DIF significantly differentiated leaf area, plant height and yield (with the light period).

Only slight LAI differentiation between experimental treatments was observed during the initial period of plant growth but in the course of the successive period, the differences in LAI values were found greater in ‘Wala’ than in ‘Kasia’ (Fig. 1). The highest LAI value at harvest was determined in plants cultivated at DIF−5 and 16 h light period, whereas its lowest value was found in plants cultivated at DIF0 and 16 h light period.

The tested cultivars differed in leaf area ratio (LAR). It exhibited a sinusoidal character for both cultivars but for ‘Kasia’ the differences, both between experimental treatments as well as consecutive dates of measurements were greater. Moreover, a higher LAR value was recorded for this cultivar.

The net assimilation rate (NAR) was similar for both experimental cultivars during the initial period of vegetation. The highest value was obtained for cultivations at DIF+5 for ‘Wala’ and for both light periods, while for ‘Kasia’ – only for the 16 h light period. For the latter cultivar, equally high NAR values were obtained in the initial period of vegetation for DIF0 and 16 h light period. On the other hand, for the ‘Wala’ cultivar, this combination reached a high value during the final period of growth.



* – values followed by the same letters do not differ significantly at α = 0.05

The analysis of the significance of the impact of individual factors

F for:

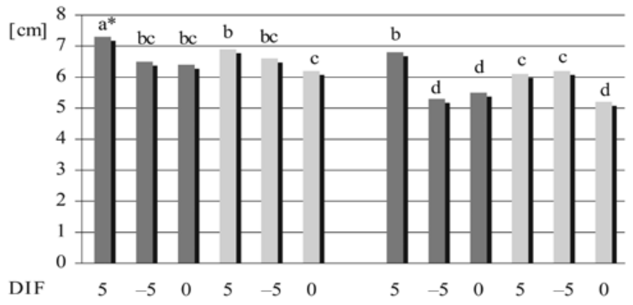
DIF (A)	6.68**
light period (B)	10.72**
cultivar (C)	3.50

interaction:

A x B	20.73**
A x C	5.46**
B x C	0.00
A x B x C	0.59

* significant differences in α = 0.05;
** significant differences in α = 0.01.

Figure 1. The cultivar, light period and DIF interaction effects on fresh mass yield at harvesting



* Values followed by the same letters do not differ significantly at α = 0.05.

The analysis of the significance of the impact of individual factors

F for:

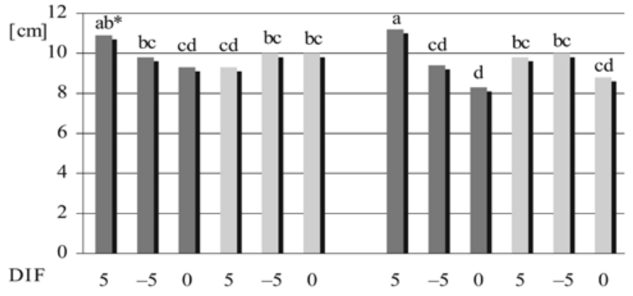
DIF (A)	45.42**
light period (B)	1.15
cultivar (C)	94.47**

interaction:

A x B	14.81**
A x C	1.44
B x C	1.17
A x B x C	4.36*

* significant differences in α = 0.05;
** significant differences in α = 0.01.

Figure 2. The cultivar, light period and DIF interaction effects on hypocotyl length at harvesting



* Values followed by the same letters do not differ significantly at α = 0.05.

The analysis of the significance of the impact of individual factors

F for:

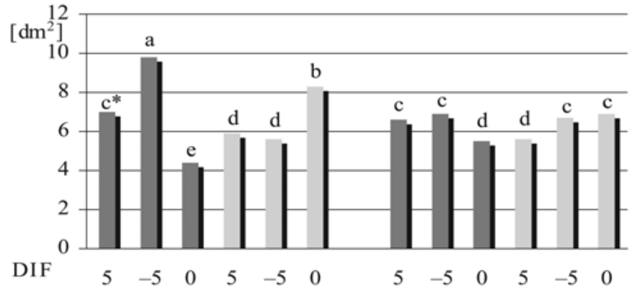
DIF (A)	14.44**
light period (B)	1.21
cultivar (C)	2.87

interaction:

A x B	13.24**
A x C	6.38**
B x C	0.04
A x B x C	0.32

* significant differences in α = 0.05;
** significant differences in α = 0.01.

Figure 3. The cultivar, light period and DIF interaction effects on plant height at harvesting



* Values followed by the same letters do not differ significantly at α = 0.05.

The analysis of the significance of the impact of individual factors

F for:

DIF (A)	17.08**
light period (B)	1.75
cultivar (C)	8.07**

interaction:

A x B	86.04**
A x C	2.31
B x C	2.18**
A x B x C	34.50**

* significant differences in α = 0.05;
** significant differences in α = 0.01.

Figure 4. The cultivar, light period and DIF interaction effects on leaf area in pot at harvesting

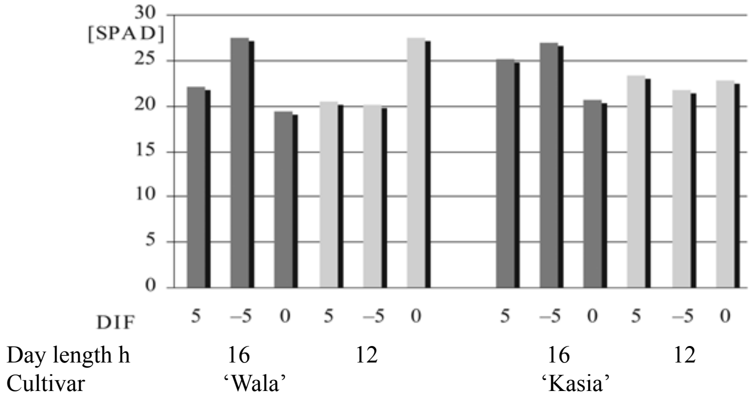


Figure 5. The cultivar, light period and DIF interaction effects on relative chlorophyll content at harvesting

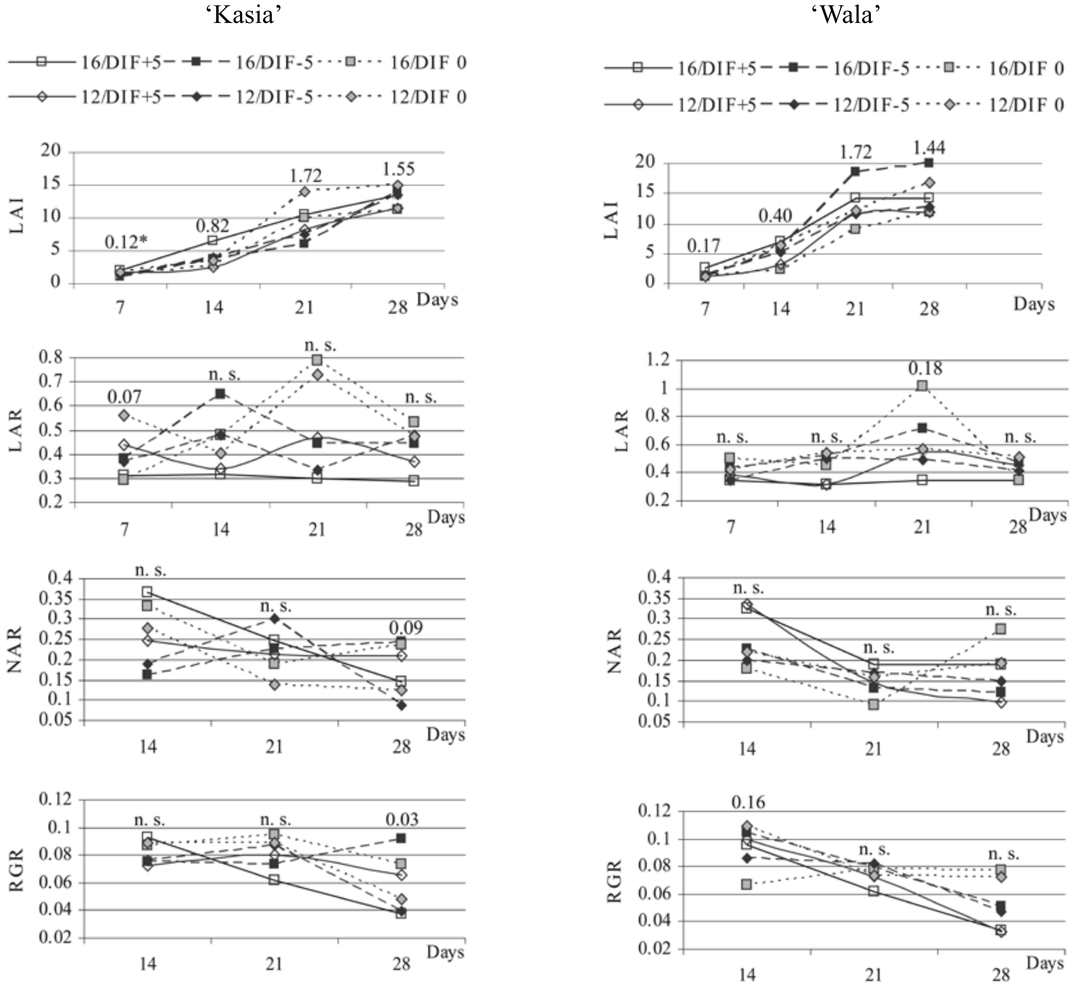
Relative growth rate (RGR) values for both cultivars were similar for the entire growth period. For 'Wala', high RGR value was recorded for DIF0 and 12 h light period and during the final vegetation period – also for DIF0 and 16 h light period which was characterised by the least variable RGR value during the entire growth period. The RGR value for this combination was high for the entire growth period also for 'Kasia'. During the final stage of growth, the highest RGR value was found for DIF−5 and 16 h light period.

Discussion

The main purpose of the differentiation in day and night temperatures is to reduce the elongation growth of plants. The response of some plants to the application of a definite thermoperiodism is well recognised. In the majority of experiments conducted both on pot plants as well as vegetable seedlings, negative DIF exerted the strongest inhibitory impact on plant elongation (Carvalho et al., 2002). In general, plants from the negative DIF treatment are usually smaller than those from positive DIF (Bielenin, Joustra, 2000). A similar plant response was observed in our own studies. It should be noted, however, that during the later stages of plant growth, the strongest impact on the inhibition of elongation was exerted by DIF0. In the experiments carried out on apple mint (*Mentha rotundifolia* L.), plants cultivated at negative DIF were characterised by the lowest height, although also cultivation at DIF0 led to a considerable inhibition of plant elongation growth in comparison with positive DIF (Jeong et al., 1996). In the studies conducted by Ito et al. (1995), transpiration rate in the grafted tomato plants, during the light period decreased considerably under negative DIF treatments. Transpiration rate during the dark period increased markedly in the negative DIF plants. However, there were no differences in total respiration as compared with the positive DIF. In our investigations, transpiration was not assessed; nevertheless, it can be presumed that the applied relatively high temperatures both during the day and at night resulted in high diurnal transpiration levels which exerted a negative impact on plant growth rate at DIF0 at a later stage the vegetation.

Investigations carried out by other researchers (Pollet et al., 2009) revealed that DIF0, especially accompanied by high temperature, inhibits plant elongation growth very strongly. It is true that in experiments by Patil and Moe (2009), the length of hypocotyl and shoots in cucumber plants was higher for DIF+5 than for DIF0 but values obtained under DIF0 were close to those under positive DIF. However, in the experiments carried out by Orbovic´ and Poff (2007), seedlings of *Arabidopsis thaliana* were the longest at constant temperature (25°C) and any temperature change in the course of vegetation (to higher or to lower) during the initial period inhibited plant elongation growth. According to Sysoyeva et al. (2003), when the mean 24-hour temperature is below the optimal for the given species, plants growing at varying day and night temperatures require smaller sum of effective temperatures (>5°C) in order to attain a specific developmental phase than plants growing at constant temperature. Plants treated with DIF−5 were characterised by a shorter hypocotyl length and plant height in comparison with plants treated with DIF+5 but greater than at DIF0. According to the above researchers, the reduction in the elongation rate in etiolated seedlings transferred from 25°C to different temperatures, suggests that 25°C may be an optimum or near the optimum temperature for sweet basil growth.

According to Ito et al. (1997), the elongation after DIF alternation was greater in seedlings that were smaller at the time of DIF treatment. Like in our experiments, in the studies carried out by Mortensen and Moe (1992), plants were characterized by a compact habit not only when cultivated at negative DIF but also at a constant temperature. It is worth adding here that not all plants investigated so far responded to the treatment with DIF. This can be associated with the fact that plants are characterized by different times of elongation growth during the 24-hour period (Shimizu et al., 2008). In their studies on *Brassica oleracea* var. *acephala*, the highest elongation growth occurred during the period of darkness, at low temperature. This explains additionally the observed growth inhibition of sweet basil plants in our own experiments at a constant temperature of 23°C. There are nine combinations between the stem elongation (SE) growth and the temperature during the periods of day and night. The combinations that strongly respond to DIF among these nine patterns are: 1) the pattern that SE increases as the temperature in the light period increases by lowering the temperature in the dark period and SE is not affected by the temperature in the dark period, 2) the pattern that SE increases by lowering the temperature in the dark period and SE is not affected by the temperature in the dark period, 3) the pattern that SE increases with the rise of the temperature in the light period and the descent of the temperature in the dark period (Shimizu, 2007). On the basis of the performed investigations, the authors believe that



Notes. LAI – leaf area index, LAR – leaf area ratio, NAR – Net assimilation rate, RGR – relative growth rate; * LSD – least significant differences, n.s. – not significant for $P < 0.05$, separately for each cultivar.

Figure 6. The values of the basil plant growth indices during the vegetation period

sweet basil belongs to the third of the above-mentioned groups. However, the growth inhibition of this plant was affected more strongly by DIF0 than by negative DIF.

Stem extension growth is a product of both cell elongation and cell division and stems developed under positive DIF have more cells and longer cells compared to negative DIF (Thingness et al., 2003). Moreover plants growing under positive DIF have a higher content of the plant hormone gibberellin (GA) (Stavang et al., 2005).

The results on fresh and dry mass obtained in this study are similar to those of Jeong et al. (1996). Longer light period and positive DIF led to an increase in fresh and dry mass of herbage. In the last two weeks of vegetation lower herbage mass was determined only for of the plants treated with DIF0 when compared with the remaining two combinations. In investigations on rose cultivation (Dieleman et al., 2005), plants growing at constant temperature were characterized by a considerably more intensive root growth and later date of harvest in comparison with plants cultivated at negative DIF. According to Karlsen and Bertram (1995), constant temperature may lead to intensive root growth and inhibition of stem elongation. Sweet basil is a plant of high thermal requirements. It is evident from the performed experiments that a daytime temperature of 23°C was sufficient for the plant biomass growth, especially at a given light level. In the studies conducted by Bakken and Flones (1995), brussels sprouts and cabbage transplants (plants of moderate thermal requirements) propagated under negative DIF yielded better than transplants under positive DIF. However, in the experiments on cucumber (tropical plant), it was demonstrated that a day temperature of 19°C may lead to a lower photosynthetic rate than the temperature of 25°C which is close to the optimal day temperature (Wien, 1996). It should, however, be emphasized that in our own experiments, a considerably higher yield of fresh herbage mass was obtained for a 16-hour lighting period in comparison with a 12-hour period. Studies have shown that thermoperiodic responses can be modified by light climate, like photoperiod (Moe et al., 2002) and light intensity (Catley et al., 2002). Interaction between DIF and light period was found in each of the studied factors.

Myster and Moe (1995) suggested that there is a higher sensitivity of stem elongation to temperature fluctuations during the short day period rather than the long day period for several pot plants. In our own experiments, we failed to observe significant differences in plant height depending on the length of the light period.

The experimental cultivar 'Wala' was characterized by greater height, leaf area and fresh herbage biomass than 'Kasia'. This was connected with its cultivar characteristics since this cultivar is characterized by elevated, high structure and a greater growth rate. On the other hand, 'Kasia' is characterized by a more compact, dense structure (Seidler-Lozykowska, 2004). Nevertheless, the authors believe that 'Wala' is better suited for intensive cultivation in containers. One of the major parameters which is decisive with respect to the date of harvest and sale of these plants is their height. 'Wala', due to its greater growth rate, requires a shorter period of vegetation in order to achieve the required parameters. In addition, both cultivars did not differ with regard to the percentage proportion of hypocotyl in the length of stems, i.e. the degree of plant elongation was similar. The interaction between the light period and the cultivar as well as between the cultivar and DIF combinations was considerably smaller and frequently negligible.

In experiments conducted by Jeong et al. (1996), the area of round-leaved mint was greater at 16 h photoperiod and DIF+9 and 0 in comparison with the 8 h photoperiod and DIF−9. Similar results were also obtained by Pollet et al. (2009). Similar results during the initial phase of investigations were also obtained by the authors, although during the final period of growth, plants cultivated at DIF−5 were characterized by the strongest increment of the leaf blade area (Fig. 6, LAI). Also the highest relative chlorophyll contents were observed at DIF−5 (Table 2). The effect of DIF on leaf chlorophyll content was in agreement with other results (Vogelezang, 2000). Different results were reported by Vagen et al. (2003). In the investigations conducted by the above-mentioned researchers, negative DIF was found to reduce chlorophyll content in leaves of sweet basil, dropsy plant and fuchsia.

Such parameter as NAR can describe physiological adaptation of plants to the environment (De Groot et al., 2001). NAR of both cultivars was quite high under DIF+5 and 16 h light period. Moreover, also RGR for these cultivation conditions was high, especially during the initial period of cultivation indicating that these conditions (closest to natural) were the most optimal for photosynthesis. Similar results were obtained by Xiong et al. (2011). Negative DIF was characterized by the smallest NAR value. Stavang et al. (2010) indicated that the reduction in plant biomass production of pea grown under negative DIF was a result of the net effect of reduced photosynthesis during daytime and increased respiration during the night. During the final phase of growth of sweet basil, plants growing under DIF0 and 16 h light period, physiologically adapted very well to constant temperature. Plants growing in this combination were also characterized by a high RGR value during the final period of growth. In their studies, Gratani et al. (2008) reported a close correlation between RGR and NAR. A similarly significant correlation was found in the case of our own experiments; the determined correlation significance increased with consecutive measurements and for the last measurement r (correlation coefficient) for 'Kasia' amounted to 0.91 and for 'Wala' to 0.71 at $p < 0.01$ degree of significance. On the other hand, in contrast to the above-mentioned researchers, no significant correlation was determined between RGR and LAR in our own studies. The value of the correlation decreased together with consecutive measurements. The obtained results indicate that the level of RGR depended, primarily, on the changing NAR and not on the changes in LAR. Heuvelink (1989) reported correlations opposite to those found by the authors.

Conclusion

Negative DIF is a method which can be useful to inhibit excessive elongation of sweet basil plants in container cultivation. Its application is most justifiable during the initial period of cultivation in order to inhibit the excessive growth of hypocotyl. Despite the fact that DIF0 was found to inhibit plant growth most, its application is not economically justified, especially during winter period. However, plant cultivation under DIF+5 is more favourable in the course of later stages of plant production (when rapid growth of plants is wanted). The 16 h light period turned out to be more advantageous to produce desirable plant characters (height, hypocotyl length, fresh biomass) than the 12 h light period (for this temperature range).

It was also concluded that, due to its greater growth rate, 'Wala' cultivar is more suitable for container cultivation than 'Kasia'. After four weeks of vegetation, the differences between cultivars were minimal compared to the earlier period of cultivation.

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Skirtingų dienos bei nakties temperatūrų ir fotoperiodo įtaka kvapiojo baziliko (*Ocimum basilicum* L.) augimui

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Santrauka

Tyrimų tikslas – įvertinti baziliko augalų augimą įvairiomis temperatūros ir fotoperiodo sąlygomis. Augalai auginti esant trims DIF lygiams (DIF−5 – 20/25°C, DIF0 – 23°C bei DIF+5 – 25/20°C) ir taikant 12 bei 16 h fotoperiodą. Tyrimų metu lygintos dvi kvapiojo baziliko veislės 'Kasia' ir 'Wala'. Nustatyta augalų žalia masė, jų aukštis, hipokotilio ilgis, lapų plotas bei sausųjų medžiagų kiekis, taip pat santykinis chlorofilo kiekis. Dideli aukščio skirtumai nustatyti esant DIF+5 ir DIF−5. Augalų aukštį teigiamas DIF didino, o neigiamas mažino, nors stiebo ilgėjimą stipriausiai slopino DIF0. Lapų plotui didžiausią įtaką turėjo fotoperiodas ir veislė, o temperatūros įtaka buvo nežymi. Augalams, augintiems esant 16 h šviesos periodui, buvo būdingas didesnis žalios masės kiekis, ilgesnis hipokotilis ir augalų aukštis, palyginti su augusiais esant 12 h šviesos periodui. Veislės 'Wala' augalai pasižymėjo didesniu aukščiu, lapų plotu ir biomase nei veislės 'Kasia'. Didžiausias santykinis chlorofilo kiekis nustatytas esant DIF−5.

Reikšminiai žodžiai: DIF, fotoperiodas, *Ocimum basilicum*, augimo greitis.