Herb yield, essential oil content and its composition in two cultivars of sweet basil (*Ocimum basilicum* L.) grown in two different locations

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S u m m a r y

Content and composition of essential oil and yield of herb and seed of two Polish sweet basil cultivars ('Wala' and 'Kasia') were analyzed. In 2005 and 2006 the field experiments were conducted in order to investigate usefulness of basil cultivars in two different locations (Mikkeli, Finland and Poznań, Poland). The weather conditions were similar in both locations in the period from transplantation to full flowering. The biomasses developed similarly. In addition, the shorter growing season in Finland is not favorable for the seed development and seed production of basil. The chemical composition of basil oil was almost identical in both experimental sites. Two newly bred Polish basil cultivars performed stable growth and good quality characters. The morphological and chemical features were almost identical, even one plantation was conducted 1000 km up to the north.

Key words: sweet basil, cultivars, herb, essential oil, composition

INTRODUCTION

Sweet basil (*Ocimum basilicum* L.) is one of 30 species that belong to *Ocimum* genus performing a great variability of morphology and essential oil composition [4]. Basils are the species requiring warm, thus in general grown indoors in the Nordic countries [7]. Although, due to its popularity, the outdoor cultivation has become more and more popular. Basil herb (*Herba basilicae*) is widely used as a spice, in aromatherapy, cosmetics, as well as in phytotherapy [1, 4, 10]. It is cul-

tivated all over the world and the total growing area is ca. 5000 ha [7]. Basil herb shows significant differences in the essential oil content and composition, which depends on genotype, developmental stage or environmental conditions [3, 4]. Determination of ecological conditions affect basil herb and its quality could expand the possibilities of basil cultivation.

The main aim of this study was to investigate if two cultivars, suitable for cultivation in Poland, could be successfully grown in the southern part of Finland.

MATERIAL AND METHODS

Two field experiments were conducted in 2005–2006 at the Research Institute of Medicinal Plants of Poznań, Poland (52°25'N 16°58'E) and in Agrifood Research Finland in Mikkeli, Finland (61°44'N 27°18'E). Two Polish sweet basil cultivars 'Wala' and 'Kasia' were taken under investigation. The experimental design was completely random. In Poland, the soil was fertilized by using N-70 kg/ha, P-60 kg/ha, K-80 kg/ha and in Finland the organic chicken manure used contained N-70 kg/ha, P-18 kg/ha and K-105 kg/ha. In both experiments the basil plantlets, obtained from greenhouse, were transplanted to an open-air field. In Finland, basil was cultivated in pots (3 plantlets per pot). On the field, in both places the plant density was 10 pots/m^2. In Poland weeding was carried out mechanically and in Finland the soil was covered with black plastic mulch. Herb was collected in the beginning of flowering from an area of 1.0 m^2. Seeds were harvested in the phase of their black colorization.

In Poland basil herbs were dried in room temperature, in Finland in air-forced dryer at 40°C. The yield of fresh and dried herbs, leaves-stem ratio and dry matter contents were calculated.

Weather conditions

Average day temperature, sum of precipitation and heat sums were detected from the moment the plants were transplanted into the field till harvest. In Poland the weather data were obtained from the weather station (2 km apart) and in Finland from the weather station of Mikkeli airport (1 km apart).

The weather conditions were approximately similar in both places, slightly warmer in Poland. The heat sums in Finland were 652.1°C in 2005 and 858.7°C in 2006, while in Poland they were higher: 1060.6°C and 1016.1°C, respectively (tab. 1). In Finland the average monthly temperatures were lower by 1.4–1.8°C and the maximum temperatures were lower by 2.3–3.5°C. However, in both years of the experiment the weather conditions in Finland were unexpectedly favorable for basil growth. The experimental field was situated in a warm southern slope which compensated the air temperature differences. The average month temperatures in June were similar or higher than long term average (in 2006 higher by +0.9C°).

Especially July was much warmer (+1.9°C in 2005 and +0.2°C in 2006). The precipitation was similar to the long term average. Therefore, the plant growth was intensive.

Table 1.

Weather conditions in 2005 and 2006

weather condition	location/years			
	Mikkeli		Poznań	
	2005 13.06.-25.07.	2006 12.06.-03.08.	2005 24.05.-20.07.	2006 15.05.-10.07.
average day temperature [°C]	17.1	17.2	18.9	18.6
temperature range [°C]	3.0-29.4	2.7-28.1	1.5 – 33.6	2.0 – 33.9
sum of precipitation [mm]	88.1	78.8	29.1	81.1
heat sums [°C]	652.1	858.7	1 060.6	1 016.1

Oil isolation

The content of essential oil and its composition in all samples was estimated in the Research Institute of Medicinal Plants of Poznań, Poland. Essential oil content was measured in herb samples without stems, after hydrodistillation in Deryng's apparatus, following the rules of Polish Pharmacopoeia VI [2].

GC Data

The hexane solution of the oil was analyzed by gas chromatography using Perkin Elmer Clarus 500 system. Chromatographic column (Elite – FFAP 30m x) was used in starting temperature of 60°C (2 min.). Subsequently, the temperature increased by 5°C/min. to 200°C, then was kept constant for 15 min. The flow rate of carrier gas (helium) was set to 0.35 mL/min. Split-splitless injector was used with a split ratio of 1:20 mode at 240°C. The volume of injected sample was 1 μL. FID detector was operated at 250°C. The components of tested solution were: linalool (Fluka), geraniol (Dragoco), 1,8-cineole (Fluka), eugenol (Fluka), methylchavicol (Fluka) were located using retentions times from the reference chromatogram solutions. Quantification was made using the normalization procedure.

RESULTS AND DISCUSSION

All phenological measures, except seed harvesting, were previously done in Poznań and compared with Mikkeli: sowing – 21 (2006) and 14 (2005) days earlier; prickling – 12 (2005) and 10 (2006) days earlier; transplanting into the field – 20 (2005)

and 28 (2006) days earlier. However, full blooming occurred only 3 (2005) and 7 (2006) days earlier and herb harvesting 5 (2005) and 7 (2006) days earlier than in Mikkeli. On the other hand, the seed yields were collected earlier in Mikkeli – in 2005 the seed harvest took place 15 days earlier and in 2006 11 days earlier than in Poznań (tab. 2). Thus, in Mikkeli the length of period from transplantation to the first harvest was shorter by 15 and 4 days and to seed harvest by 35 and 39 days in 2005 and 2006 respectively.

Table 2.

Phenological data of sweet basil grown in Poznań and Mikkeli in 2005–2006

phase	location/years			
	Mikkeli		Poznań	
	2005	2006	2005	2006
sowing	4 May	2 May	13 April	18 April
pricking	16 May	12 May	4 May	2 May
transplanting on the field (a)	13 June	12 June	24 May	15 May
full blooming	25 July	17 July	22 July	10 July
herb harvest (b)	25 July	3 August	20 July	10 July
seed harvest (c)	15 September	18 September	30 September	29 September
growing season in days (a-b)	42	52	57	56
(a-c)	94	98	129	137

The plant height of 'Wala' cultivar ranged from 33 cm to 53 cm, while plants of 'Kasia' cultivar were little shorter (32.4–49.0 cm). In 2005 and in 2006 both cultivar basil plants grew higher in Mikkeli (tab. 3). Similar results were reported by Marotti et al. [4], where basil plants of 10 investigated cultivars were 31.3 - 51.1cm high. Lower plant heights were reported by Galambosi et al. [9] in 1984–85–86, when plants were 30.6, 32.0 and 30.4 cm high, respectively.

The total fresh and the dried leaves-flower herb yields of both cultivars ranged between 1150–2833 g/m², and 126–295 g/m², respectively. In both years the total fresh herb yield of 'Wala' cultivar was 60% and 87% higher in Mikkeli than in Poznań. The total fresh herb yield of cultivar 'Kasia' in 2005 was nearly same in both sites, but in 2006 it was 52% higher in Mikkeli (tab. 3). The yield differences can be explained by the plant density of basil plants. In Finland – due to the expected cooler weather conditions – in general 3 plants are prickled into each pot, while in Poland only one plant were transplanted into the open field.

In the earliest studies Galambosi et al. [9] reported that in unfavorable weather conditions the dry herb yields in Finland (Puumala) were 41-53 g/m², higher yields were obtained in black plastic mulched beds (174–275 g/m²).

Table 3.

Plant height, yields of herb and seeds of 'Wala' and 'Kasia' basil cultivars cultivated in two locations in 2005–2006

Traits	'Wala'				'Kasia'			
	Mikkeli		Poznań		Mikkeli		Poznań	
	2005	2006	2005	2006	2005	2006	2005	2006
plant height[cm]	51.0	53.0	43.7	33.0	49.0	48.3	41.2	32.4
total fresh yield [g/m^2]	1845.0	2833.0	1150.0	1517.0	1469.0	2256.0	1350.0	1483.0
total dried yield [g/m^2]	239.9	476.0	206.9	248.0	191.0	424.0	242.0	225.7
dry matter content [%]	13.0	16.8	18.0	16.3	13.0	18.8	17.9	15.2
dried herb yield without stems [g/m^2]	131.9	295.0	134.3	151.4	126.0	267.0	157.8	141.3
leaves : stems ratio	55:45	62:38	65:35	61:39	66:34	63:37	67:33	63:37
yield of seeds [g/m^2]	50.0		24.8	29.6	38.8		3.7	20.4

The similar scheme was performed for total dried herb yield, dried herb without stem yield and dry matter content (tab. 3). The leaves and stem ratio of 'Kasia' cultivar was identical in the test years in both locations. Cultivars characterization done by Seidler-Łożykowska [1] showed lower content of stems in total dried herb yield (34–35%) when compared with those obtained in Mikkeli in 2005.

Nordic weather conditions are not favorable for basil seed formation. For both cultivars in 2005 the seed yields were higher in Mikkeli, but seed germination values were low ('Wala'13% and 'Kasia' 24%). In 2006 only a few seeds were mature, therefore the germination capacity was 0% for 'Kasia' and 4% for 'Wala'. Seeds harvested in Poznań germinated in 94%('Wala') and 86% ('Kasia').

Content of essential oil in both cultivars was higher in herbs obtained in Poznań than that obtained in Mikkeli (tab. 4). The content of essential oil ranged from 1.25% (2006, 'Wala', Mikkeli) to 2.20% (2005, 'Kasia', Poznań). In both locations and years 'Kasia' cultivar had higher content of oil as compared to 'Wala' cultivar. Data presented by Marotti et al. [4] showed low content of essential oil (0.3-0.8%) in dried herb of 10 tested cultivars. Hälvä [10] measured 0.46–0.89 % of essential oil in basil herb from south Finland. Galambosi & Szebeni [8] reported essential oil contents in basil herb from 0.38 to 1.29% and in greenhouse between 0.68 and1.44%. Content of oil obtained from herb in both years and locations was higher than in cultivars characterization performed by Seidler-Łożykowska [1].

The main component of the oil was linalool, obtained from 59.82% (2006, 'Kasia', Poznań) to 75.24% (2005, 'Wala', Mikkeli) (tab. 4). In both years and locations the oil of 'Wala' cultivar contained more linalool. Other components of considerable amounts were geraniol, 1,8-cineol and eugenol. Content of geraniol varied from 9.25% (2005, 'Wala', Mikkeli) to 12.79% (2005, 'Kasia', Poznań). Content of 1,8-cineol oscillated between 3.35% (2006 'Wala', Mikkeli) and 7.08% (2005, 'Kasia', Mikkeli). Eugenol content ranged from 2.45% (2005 'Wala', Poznań) to 4.13%

(2006, 'Wala', Mikkeli). Oil of 'Kasia' cultivar contained more geraniol, 1,8-cineol and eugenol than the oil of 'Wala' cultivar.

Table 4.

Essential oil content and its main components of two basil cultivars from two different locations in 2005–2006

content of essential oil and its components [%]	Mikkeli				Poznań			
	2005		2006		2005		2006	
	'Wala'	'Kasia'	'Wala'	'Kasia'	'Wala'	'Kasia'	'Wala'	'Kasia'
essential oil	1.50	1.90	1.25	1.75	1.80	2.20	1.55	2.05
linalool	**75.24**	**61.70**	**65.95**	**60.04**	**69.39**	**61.35**	**61.23**	**59.82**
geraniol	9.25	10.14	9.84	12.74	9.83	12.79	9.44	11.08
1,8-cineole	3.78	7.08	3.35	4.75	5.80	5.12	4.87	5.12
eugenol	2.78	3.78	4.13	3.93	2.45	3.43	3.25	3.78
metylchawicol	0.20	0.28	0.30	0.31	0.28	0.37	0.38	0.42

Pessala et al. [5] reported that the composition of essential oil was very variable and the highest content of linalool (78.5%) was in the oil of Hungarian cultivar 'Keskenylevelu'. Marotti et al. [4] reported that 10 cultivars were characterized by high content of linalool (41.2–76.2%), 1,8-cineol (0.9–12.3%) and cadinol (2-8%). Eugenol content ranged from traces to 2.2%. Content of geraniol was not analyzed. Galambosi & Szebeni [8] cultivated sweet basil accessions obtained from Hungary and they found the main compounds linalool (73–78%) and eugenol (3.3–4.2 %). According to Özcan and Chalchat [6] the main compounds of oil from basil herb collected in Turkey were methyl eugenol (78.02%), α-cubebene (6.17%) and nerol (0.83%).

CONCLUSIONS

1. The growing period of basils in Finland was shorter, especially in the early phases of the ontogeny. In both locations the weather conditions were similar from transplantation to full flowering, and the biomasses developed similarly. In addition, the shorter growing season in Finland is not favorable for basil seed development and their production.
2. The chemical composition of oil was nearly identical at both experimental sites. From the data obtained from the experiment we may conclude that two newly bred Polish basil cultivars had stable growth and good quality characters. The morphological and chemical features were nearly identical even when grown 1000 km up to the north, and they can be cultivated successfully in warm, protected outdoor places in southern Finland.

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PLON SUROWCA, ZAWARTOŚĆ OLEJKU ETERYCZNEGO ORAZ JEGO SKŁAD W DWÓCH ODMIANACH BAZYLII POSPOLITEJ (*OCIMUM BASILICUM* L.) ROSNĄCYCH W POLSCE I W FINLANDII

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Streszczenie

W latach 2005–2006 analizowano zawartość olejku i jego skład oraz plon surowca i nasion dwóch polskich odmian bazylii pospolitej 'Wala' i 'Kasia'. Doświadczenia polowe prowadzono w dwóch lokalizacjach (Mikkeli, Finlandia i Poznań, Polska) w celu sprawdzenia

przydatności polskich odmian. Warunki pogodowe w obu latach były podobne, a rośliny rozwijały się tak samo. Krótki okres wegetacji w Finlandii nie sprzyjał zawiązywaniu nasion bazylii. Surowiec pochodzący z Poznania zawierał więcej olejku niż surowiec fiński. Skład chemiczny obu olejków był niemal identyczny. Obie polskie odmiany wykazały stabilność genetyczną i dobrą jakość w dwóch różnych lokalizacjach.

Słowa kluczowe: *bazylia, odmiany, ziele, olejek eteryczny, skład olejku*