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Original Research

The Effect of Seedling Planting Time on Macroelement and Microelement Concentrations in Basil (*Ocimum basilicum* L.) Leaves

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Abstract

A two-factorial field experiment was performed in a randomized block design with three replications in 2010-11 in the Experimental Garden of the University of Warmia and Mazury in Olsztyn, to determine the effect of seedling planting time on the concentrations of mineral compounds in basil leaves. Plot area was 1.2 m^2. The experimental factors were: (1) plants of sweet basil, purple (purpurascens) basil, and cinnamon basil, and (2) time of planting basil seedlings. The concentrations of macroelements (total nitrogen, phosphorus, potassium, magnesium, calcium, and sodium) and microelements (iron and copper) were determined in basil leaves. The content of total nitrogen, phosphorus, potassium, magnesium, calcium, and sodium in basil leaves depended on the cultivar. Cinnamon basil contained the highest concentrations of total nitrogen, phosphorus, magnesium, and calcium, whereas sweet basil had the highest content of potassium and sodium. The time of planting seedlings had a significant effect on the iron content of basil leaves, which was higher in plants that developed from seedlings planted on 19 May.

Keywords: basil, macroelements, microelements

Introduction

Basil is an annual plant of the family Lamiaceae (mints), native to the tropical regions of southeastern Asia and Africa [1]. Weather conditions in Poland, in particular in the Warmia region, are not conducive to basil growing by sowing seeds directly into the ground. However, Nurzyńska-Wierdak [2], Jadczak and Grzeszczuk [3], and Jadczak [4] demonstrated that plantations can be established by planting basil seedlings.

Basil is a culinary herb and a medicinal plant rich in biologically active substances that deliver health benefits. Due to their chemical composition, basil leaves are commonly used in Mediterranean cuisine. They are also a valuable source of macroelements and microelements [5-7]. The minerals contained in basil leaves, such as total nitrogen, phosphorus, potassium, magnesium, calcium, sodium, iron, and copper, have a beneficial influence on human health as they help to regulate water and electrolyte balance [8].

The aim of this study was to determine the effects of seedling planting time on the concentrations of mineral compounds in the leaves of select basil cultivars grown in the Olsztyn region.

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Table 1. Weather conditions in the years of the study vs. long-term averages.

Year	Ten days of a month	Temperature (ºC)				
		May	June	July	August	September
2010	I	10.8	18.2	20.0	20.7	11.8
	II	12.2	15.5	23.3	21.0	12.8
	III	12.9	15.6	20.1	16.6	11.5
	Average	12.0	16.4	21.1	19.4	12.0
2011	I	8.7	18.8	17.1	18.2	14.4
	II	14.2	15.4	19.2	16.9	14.6
	III	16.2	16.9	17.6	17.7	13.4
	Average	13.0	17.0	18.0	17.6	14.1
Long-term average 1961-2000		12.7	15.9	17.7	17.2	12.5
		Rainfall (mm)				
2010	I	25.4	25.3	31.3	26.6	15.2
	II	46.1	36.0	6.2	17.4	13.2
	III	60.4	23.5	42.9	51.3	12.1
	Total	131.9	84.8	80.4	95.3	40.5
2011	I	10.8	39.9	124.8	20.4	24.5
	II	32.5	30.7	36.4	44.9	43.0
	III	7.8	11.1	41.6	16.8	0.0
	Total	51.1	81.7	202.8	82.1	67.5
Long-term average 1961-2000		51.9	79.3	73.8	67.1	59.0

Materials and Methods

A two-factorial field experiment was performed in a randomized block design with three replications in 2010-11 in the Experimental Garden of the University of Warmia and Mazury in Olsztyn. Plot area was 1.2 m^2. The experiment was established on brown soil of quality class IVb and good rye complex.

The experimental factors were:

(1) plants of sweet basil, purple (purpurascens) basil, and cinnamon basil

(2) time of planting basil seedlings.

Seedlings were grown in a greenhouse, in pots filled with highmoor peat saturated with the following minerals: N-NO_3 – 100, P – 80, K – 215, Ca – 1,240, Mg – 121 g·dm^{-3}, at pH in H_2O 5.9 and salt concentration of 1.5 g·dm^{-3}. Each year, seeds were sown by hand in boxes for seedlings on 30 March and 14 April. Before the planned transplant date, seedlings were hardened by gradually reducing temperature and watering frequency. Seedlings were planted in the field at 30 cm×25 cm spacing on 19 May and 2 June in both years of the study. The mineral composition of soil was as follows: N-NO_3 – 11, N-NH_4 – 2, P – 207, K – 183, Ca – 1,070, Mg –77 mg·dm^{-3}, pH – 7.5, salt concentration – 0.2 g·dm^{-3}. Cultivation practices included weeding and watering according to needs. The plants were not fertilized during the growing season.

Each year, basil leaves were harvested toward the end of July. Leaves were harvested during flowering. Basil plants were cut 10 cm above the ground, and the plants that developed from seedlings planted at the same time were harvested. Bulk samples of basil leaves were collected from each treatment to determine the content of mineral nutrients. Crumpled samples were dried at 35ºC and ground in an electric mill. The prepared material was forwarded to the laboratory at the Chemical and Agricultural Station in Olsztyn, where it was mineralized with concentrated sulfuric acid and analyzed to determine the content of: total nitrogen – by potentiometry, phosphorus – by the vanadium-molybdate method, potassium – by flame photometry, magnesium – by atomic absorption spectrometry (AAS), calcium and sodium – by flame photometry, iron and copper – and by atomic absorption spectrometry (AAS). The study was carried out under Accreditation Certificate No. AB 277 issued by the Polish Center for Accreditation in Warsaw.

The results were processed statistically by analysis of variance (ANOVA). The significance of differences between means was estimated by Tukey's range test at α = 0.05. All calculations were performed using STATISTICA 10 software.

Table 2. Concentrations of macroelements and microelements in basil leaves as dependent on the time of planting seedlings (means of 2010-11).

Type basil	Time of planting out seedlings	Dry matter	Macroelements (% DM.)						Microelements (mg·kg^{-1} DM)	
			N	P	K	Mg	Ca	Na	Fe	Cu
Sweet basil	I	8.59	1.38	0.36	2.37	0.20	1.80	0.05	690.14	6.69
	II	13.72	1.30	0.24	1.98	0.11	0.83	0.04	345.19	2.78
Mean		11.15	1.34	0.30	2.18	0.15	1.32	0.05	517.67	4.74
Cinnamon basil	I	8.22	1.74	0.44	1.68	0.20	1.33	0.02	432.65	14.55
	II	7.39	1.68	0.40	2.05	0.19	2.04	0.04	510.88	22.17
Mean		7.81	1.71	0.42	1.87	0.20	1.69	0.03	471.76	18.36
Purple basil	I	7.77	1.19	0.28	1.19	0.16	0.81	0.01	549.77	11.37
	II	5.98	1.19	0.29	1.15	0.15	0.82	0.01	564.00	16.63
Mean		6.88	1,19	0.29	1.17	0.16	0.81	0.01	556.88	14.00
Mean for the time of planting out seedlings	I	8.19	1.44	0.36	1.75	0.19	1.31	0.03	557.52	10.87
	II	9.03	1.39	0.31	1.73	0.15	1.23	0.03	473.36	13.86
NIRα=0.05 - LSDα=0.05										
Type of basil		2.57	0.09	0.06	0.20	0.05	0.40	0.01	n.s.	3.32
Time of planting out seedlings		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	58.04	n.s.
Interaction		2.43	0.14	0.06	0.15	n.s.	0.11	0.01	6.12	0.62

I –time of planting seedlings – 19 May
II- time of planting seedlings – 2 June

Results and Discussion

The quality of basil leaves and tops is largely determined by the cultivar, but also by environmental conditions, in particular ambient temperature, which should range from 20 and 25ºC during the growing season [9]. Chang et al. [10] demonstrated that basil plants grown at 25ºC accumulated more essential oils than those grown at 15ºC. In the present study, air temperatures in both years of study were higher than the long-term average, except in May 2010 (Table 1). Monthly rainfall totals during the growing season were similar to or slightly higher than the respective means over a 40-year period. Basil is a warm-season crop that requires high temperatures for growth and development. Temperature regulates microbial and chemical processes in soil and affects nutrient availability. Warm-season crop species wilt quickly in temperatures below 12ºC (physiological drought), and they may die due to insufficient supply of water and nutrients.

A statistical analysis of mean values for both years of the study revealed a significant effect of cultivar on the concentrations of the following macroelements in basil leaves: total nitrogen, phosphorus, potassium magnesium, calcium, and sodium. Cinnamon basil plants contained the highest average concentrations of total nitrogen (1.71% DM), phosphorus (0.42% DM), magnesium (0.20% DM), and calcium (1.69% DM), whereas sweet basil had the highest content of potassium (2.18% DM) and sodium (0.05% DM) (Table 2). The noted values are similar to those reported by Dzida [11]. The time of planting seedlings had no significant effect on the levels of the analyzed macroelements in basil leaves. The interaction between the experimental factors shows that cinnamon basil plants grown from seedlings transplanted into the ground on 19 May accumulated the largest amounts of total nitrogen, phosphorus, and calcium, whereas sweet basil plants transplanted on the same day had the highest concentrations of potassium and sodium. Purple basil leaves harvested from plants transplanted on 19 May and 2 June had a lower content of total nitrogen, potassium, calcium, and sodium. The concentrations of macronutrients (except for phosphorus) in basil leaves noted in the current study were lower than those reported by Jadczak et al. [12] for basil grown in the Szczecin region. In a similar experiment conducted in the Lublin area by Kwiatkowski and Juszczak [13], the levels of macroelements in dried basil leaves from the control treatment (without growth promoters) were higher than those noted in the present study, and reached: total nitrogen – 3.15% DM, phosphorus – 0.49% DM, potassium – 4.69% DM, magnesium – 2.18% DM, and calcium – 2.19% DM. A higher total nitrogen content of sweet marjoram was reported by Nurzyńska-Wierdak and Dzida [6], while the concentrations of the other analyzed nutrients were similar to those observed in our experiment.

The iron content of basil leaves was significantly affected by the time of planting seedlings and by interaction between the experimental factors. Basil leaves harvested from plants transplanted on 19 May had a significantly higher iron content, and the highest iron concentrations were noted in sweet basil (690.14 mg·kg^{-1} DM). Sweet basil grown from seedlings planted on 2 June accumulated the lowest amount of iron (345.19 mg·kg^{-1} DM). Similar iron levels in herbaceous plants were reported by Kołodziej [1], while Golcz, Seidler-Łożykowska [14], and Golcz et al. [15] observed lower concentrations of iron. In terms of iron content, basil is third only to common thyme and sweet marjoram [8].

The copper content of basil leaves ranged from 2.78 mg·kg^{-1} DM in sweet basil transplanted on 2 June to 22.17 mg·kg^{-1} DM in cinnamon basil planted out on the same day. Copper concentrations in cinnamon and purple basil noted in our study were similar to those reported by Golcz, Seidler-Łożykowska [14], Golcz et al. [15], and Dzida [11].

The availability of dietary minerals is determined not only by their amounts but also by their relative proportions [16]. In basil leaves, the values of the Ca:P ratio ranged from 2.8 in purple basil to 4.8 in sweet basil, and they were higher than recommended for garden plants (1.2-2.2) (Figs. 1, 2). Wider Ca:P ratios were observed in basil leaves harvested from plants transplanted on 2 June. The Ca:Mg ratio indicated a magnesium deficiency. According to Barczak et al. [17], the Ca:Mg ratio should remain around 3, because higher values suggest excess calcium uptake at the expense of magnesium. In the current experiment, the lowest and highest Ca:Mg ratios were noted in purple basil and sweet basil, respectively.

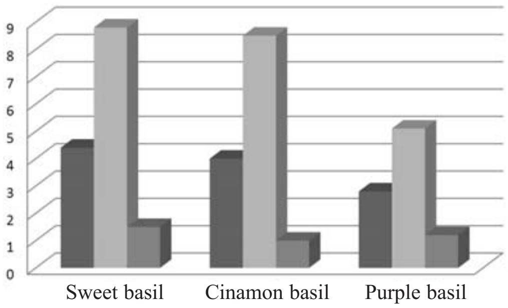

Fig. 1. Ca:P, Ca:Mg, and K: (Mg+Ca) ratios in basil leaves irrespective of the time of planting seedlings (means of 2010-11).

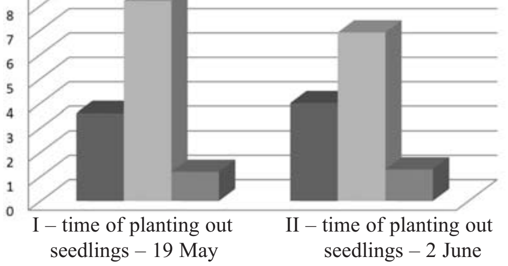

Fig. 2. Ca:P, Ca:Mg, and K: (Mg+Ca) ratios in basil leaves as dependent on the time of planting seedlings (means of 2010-11).

The K:(Ca+Mg) ratio, considered an important indicator of the nutritional value of plants, should not be higher than 2.2 [16]. Such a value was achieved in basil leaves harvested from plants transplanted on 2 June. In the other treatments, K:(Ca+Mg) ratios in basil leaves ranged from 0.9 to 1.5 depending on the cultivar and the time of planting seedlings.

Conclusions

1. The content of macroelements (total nitrogen, phosphorus, potassium, magnesium, calcium, and sodium) in basil leaves depended on basil type. Cinnamon basil contained the highest concentrations of total nitrogen, phosphorus, magnesium, and calcium, whereas sweet basil had the highest content of potassium and sodium.
2. The time of planting seedlings had a significant effect on the iron content of basil leaves, which was significantly higher in plants that developed from seedlings planted on 19 May.
3. Cinnamon basil leaves were characterized by the highest copper content, as compared with sweet and purple basil.

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