ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 17, No. 12 2010

Grzegorz MIKICIUK[1] and Małgorzata MIKICIUK[2]

INFLUENCE OF THREE TYPES OF SOIL AND MINERAL FERTILIZATION ON THE CONTENT OF ASSIMILATION PIGMENTS IN THE LEAVES OF CELERY (*Apium graveolens* L. var. *rapaceum* (Mill.) Gaud.)

WPŁYW TRZECH TYPÓW GLEB I ZRÓŻNICOWANEGO NAWOŻENIA MINERALNEGO NA ZAWARTOŚĆ BARWNIKÓW ASYMILACYJNYCH W LIŚCIACH SELERA KORZENIOWEGO (*Apium graveolens* L. var. *rapaceum* (Mill.) Gaud.)

Abstract: In a town of Doluje near Szczecin, at the Experimental Station of the Market Gardening Chair, University of Agriculture in Szczecin, a two-factor vegetation experiment (microfield) in the system of complete randomization was carried out in three replications. It was a two year experiment. The first experimental factor was the type of soil: proper black earth, muck soil and proper pseudogley soil. The second factor was the level of NPK fertilization (0 – 0, 0, 0 kg · ha^{-1}; I – 75, 33, 100 kg · ha^{-1}; II – 150, 66, 200 kg · ha^{-1}). Celery, var. *rapaceum* (Mill) Gaud., cultivar Diamant was the biological material for the studies. At five dates of the harvesting, the content of assimilation pigments (chlorophyll *a*, chlorophyll *b*, total chlorophyll and carotenoids), in the celery leaves was determined. A significant effect of both experimental factors on the concentration of chlorophyll as well as on carotenoids in the leaves of the examined plant was observed.

Keywords: *Apium graveolens* L. var. *rapaceum*, NPK fertilization, assimilation pigments, proper black earth, muckous soil, proper pseudogley soil

One of the ways of adaptation of a plant to environment is a change in the composition of its tissues. According to Chroboczek and Skapski [1] such compounds as vitamins, proteins, carbohydrates, organic acids, oils, phytoncides and mineral salts determine the biological value of vegetables. A physiological feature of plants that contains information about, among other things, the state of their supply with some

[1] Department of Horticulture, West Pomeranian University of Technology in Szczecin, ul. J. Słowackiego 17, 71–434 Szczecin, Poland, email: grzegorz.mikiciuk@zut.edu.pl

[2] Chair of Plant Physiology, West Pomeranian University of Technology in Szczecin, ul. J. Słowackiego 17, 71–424 Szczecin, Poland, email: malgorzata.mikiciuk@zut.edu.pl

macro- and microelements such as: nitrogen. magnesium, iron, manganese, copper or zinc, is the content of assimilation pigments in photosynthetic organs of the indicator plant. In the conducted studies, celery (*Apium graveolens* L. var. *rapaceum* (Mill.) Gaud.) was selected to be an indicator plant. Celery is a very popular vegetable plant, a rich source of mineral salts of potassium, sodium, calcium, magnesium, phosphorus and iron, and also vitamins, particulary vitaminum C [2]. This plant needs a lot of nitrogen, phosphorous and potassium. It is also characterized by quite large soil demands. It the case of celery it is essential to apply optium mineral fertilization for the soil conditions in which it is grown.

The studies were aimed to assess the content of assimilation pigments in the leaves of the indicator plant cultivated on three types of soil of different physicochemical properties, at differentiated mineral fertilizing with NPK.

Material and methods

A two-factor vegetation experiment (microplot) in the system of complete randomization was carried out in three replications in Doluje near Szczecin, at the Experimental Station of the Market Gardening Chair, University of Agriculture in Szczecin. It was a two year experiment. The first experimental factor was the type of soil: typical black earth (A), muck soil (B) and typical pseudogley soil (C). The main features differentiating the soils were as follows: the mechanical composition, the sorptive properties, pH value, and the content of macro- and microelements (Table 1) [3]. In each year of the studies experiments were carried out on three types of soil on three research sites.

Table 1

Physico-chemical properties of soils

Soil	Genetic horizon	Depth [cm]	Percent of clay fraction [%]	pH		C-organic	N-total	P-available	K-available
				H_2O	KCl	[%]		[mg · 100 g^{-1}]	
A*	A1p	0–10	16	6.7	6.1	1.17	0.11	11.79	15.89
	A2p	10–20	15	7.0	6.4	0.91	0.11	11.62	16.68
	Aa	20–60	15	7.1	6.5	0.61	0.07	2.64	12.49
B	A(M)1	0–10	16	7.6	6.9	1.80	0.20	23.32	16.71
	A(M)2	10–20	15	7.7	7.0	1.88	0.20	22.88	20.98
	A(M)3	20–40	15	7.7	7.1	1.78	0.27	17.16	15.58
C	A1p	0–10	32	7.7	6.8	1.18	0.13	10.56	15.08
	A2p	10–20	32	7.8	7.0	0.94	0.13	12.67	12.29
	A3h	20–40	39	6.9	6.3	0.84	0.10	3.60	7.59

* A – proper black earth, B – muck soil, C – proper pseudogley soil.

The second factor was the level of NPK fertilization (0 – 0, 0, 0 kg · ha^{-1}; I – 75, 33, 100 kg · ha^{-1}; II – 150, 66, 200 kg · ha^{-1}). Nitrogen, phosphorus and potassium fertilization was applied in the forms of ammonium nitrate, triple superphosphate and potassium sulphate. Fertilization was performed on 15 May, before planting the seedlings on the experimental plots. The area of one microplot was 3 m^2. Celery, var. *rapaceum*, cultivar Diamant was the biological material for the studies. The seedlings of this plant taken from the Assessment of Potato Cultivars Station in Szczecin were planted with a spacing of 30 × 30 cm.

Using Lichtenthaler and Wellburn's method [4], at five dates of harvesting (4 and 29 July, 23 August, 15 September, 18 October), the content of assimilation pigments in the leaves in three replications was determined. The content of chlorophyll *a*, *b*, total and carotenoids was computed following Arnon et al [5]. The data in the tables show averages of the five dates of harvesting.

The results and discussion

Assimilation pigments play a role of photoreceptors in the process of CO_2 assimilation in plants. Thus, their content is a reflection of photosynthetic activity. In higher plants, two kinds of chlorophyll, ie *a* and *b*, take part in the process of photosynthesis. The ratio of chlorophyll *a* to *b* in plants of the moderate climate varies from 2.3 to 5.5 [6, 7].

In the first year of the studies the significantly smallest amount of chlorophyll was characteristic of the leaves of celery non-fertilized with NPK (level 0). A significant difference was also recorded between the content of this dye in the leaves of celery cultivated in typical black earth and in a muck soil, whereas in the second year of the studies no significant influence of experimental factors on the amount of chlorophyll *a* in the leaves of the indicator plant was observed (Table 2).

The content of chlorophyll *b* in the leaves of celery in both years of the studies depended significantly on the level of NPK fertilization, the type of soil and the interaction of these factors, for the significantly smallest concentration of this dye was noticed in plants growing in a muck soil, non-fertilized with NPK. It amounted, in the first and in the second year, to 0.303 and 0.290 $mg \cdot g^{-1}$ fm, respectively (Table 2).

In both years of the studies, the level of mineral fertilization had, a significant impact on the content of total chlorophyll in the leaves of *Apium graveolens*. In the first year, the smallest content of this photosynthetic pigment was observed in plants non-fertilized with NPK (1.161 $mg \cdot g^{-1}$ fm), in the second year a significant difference was recorded between the concentration of total chlorophyll in the leaves of plants from the combination of non-fertilized and fertilized plants at level II (Table 2)

Carotenoids are pigments which, according to Devlin and Baker [8], protect chlorophyll from photooxidation, convey light energy to chlorophyll and partly participate in the assimilation of CO_2. Non significant effect of soil type on the content of these pigments in the leaves of the indicator plant was observed. However in both years a significantly larger concentration of carotenoids in the leaves of plants fertilized with the largest doses of NPK (level II) than in the leaves of non-fertilized plants (level 0) was recorded.

Table 2

Content of chlorophyll *a*, *b*, *a*+*b* and carotenoids in leaves of *Apium graveolens* [mg · g^{-1} f.m.]

Soil	I year				II year			
	Level of fertilization			Mean II	Level of fertilization			Mean II
	0	I	II		0	I	II	
Chlorophyll *a*								
A	0.879 ab*	1.118 b	0.962 ab	0.986 b	0.844 a	0.888 a	0.937 a	0.890 a
B	0.611 a	0.859 ab	0.921 ab	0.797 a	0.623 a	0.864 a	0.928 a	0.805 a
C	0.782 ab	0.866 ab	0.947 ab	0.865 ab	0.854 a	0.871 a	0.774 a	0.833 a
Mean I	0.757 a	0.948 b	0.943 b		0.774 a	0.874 a	0.880 a	
Chlorophyll *b*								
A	0.447 b	0.466 b	0.505 b	0.473 b	0.427 a	0.446 a	0.486 a	0.453 b
B	0.303 a	0.441 b	0.479 b	0.408 a	0.290 b	0.421 a	0.485 a	0.399 a
C	0.459 b	0.457 b	0.462 b	0.459 b	0.466 a	0.432 a	0.433 a	0.444 b
Mean I	0.403 a	0.455 b	0.482 b		0.394 a	0.433 ab	0.468 b	
Chlorophyll *a*+*b*								
A	1.327 ab	1.585 b	1.467 b	1.460 b	1.271 ab	1.334 b	1.423 b	1.343 a
B	0.914 a	1.300 ab	1.400 ab	1.205 a	0.913 a	1.285 ab	1.413 b	1.204 a
C	1.241 ab	1.323 ab	1.408 b	1.324 ab	1.320 b	1.302 b	1.207 ab	1.277 a
Mean I	1.161 a	1.402 b	1.425 b		1.168 a	1.307 ab	1.348 b	
Carotenoids								
A	0.475 ab	0.506 ab	0.527 b	0.503 a	0.459 ab	0.504 b	0.532 b	0.499 a
B	0.366 a	0.470 ab	0.500 ab	0.445 a	0.357 a	0.477 ab	0.518 b	0.451 a
C	0.444 ab	0.442 ab	0.490 ab	0.459 a	0.436 ab	0.449 ab	0.495 ab	0.460 a
Mean I	0.428 a	0.473 ab	0.506 b		0.417 a	0.477 ab	0.515 b	

* Averages denoted with the same letters do not differ significantly at the level of significance $\alpha = 0.05$.

Increasing fertilization with NPK caused, independently of the type of soil, an increase in the amount of both chlorophyll and carotenoids in the celery leaves. A particularly significant positive impact of the largest dose of fertilizer was observed. Similar results were recorded by Podsiadlo et al [9] and by Smolik and Malinowska [10]. They showed a stimulating effect of mineral NPK fertilization on the content of chlorophyll *a* and *b* and carotenoids in the leaves of legumes and spring wheat.

Conclusions

1. Increasing doses of NPK resulted in an increase in the content of chlorophyll in the leaves of celery var. *rapaceum* cultivated in all types of soil.
2. The smallest amount of assimilation pigments was characteristic of the leaves of the indicator plant, non-fertilized with NPK.
3. The least favourable properties in respect of the influence on the content of chlorophyll in the photosynthetic organs of celery was characteristic of a muck soil.

4. Diverse physicochemical properties of soils did not affect the content of carotenoids in the assimilation organs of celery.

References

[1] Chroboczek E. and Skąpski H. : Ogólna uprawa warzyw, PWRiL, Warszawa 1982.
[2] Orłowski M. and Kołota E.: Uprawa warzyw, Wyd. Brasika, Szczecin 1992.
[3] Mikiciuk G.: Folia Univ. Agric. Stetin. 2000, **209**, Agricultura (83), 99–112.
[4] Lichtenthaler H.K. and Wellburn A.R.: Biochem. Biophys. Acta 1983, **20**, 449–461.
[5] Arnon D.J., Allen M.B. and Halley F.: Biochem. Biophys. Acta 1956, **20**, 449–461.
[6] Krzywański Z. and Wójcik-Wojtkowiak D.: Zarys Fizjologii Roślin, Wyd. AR, Poznań 2001.
[7] Hall D.O. and Rao K.K.: Fotosynteza. WNT, Warszawa 1999.
[8] Devlin R.M. and Barker A.V.: Photosyntesis, Van Nortrand Reinhold Co, New York 1971, 571 pp.
[9] Podsiadło C., Jaroszewska A., Biczak R. and Herman B.: Zesz. Probl. Post. Nauk Roln. 2003, **495**, 01–210.
[10] Smolik B. and Malinowska K.: Zesz. Probl. Post. Nauk Roln. 2006, **515**, 371–379.

WPŁYW TRZECH TYPÓW GLEB I ZRÓŻNICOWANEGO NAWOŻENIA MINERALNEGO NA ZAWARTOŚĆ BARWNIKÓW ASYMILACYJNYCH W LIŚCIACH SELERA KORZENIOWEGO (*Apium graveolens* L. var. *rapaceum* (Mill.) Gaud.)

[1] Katedra Ogrodnictwa
[2] Zakład Fizjologii Roślin
Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

Abstract: W Stacji Doświadczalnej Katedry Warzywnictwa Akademii Rolniczej w Szczecinie, w miejscowości Dołuje koło Szczecina przeprowadzono dwuletnie, dwuczynnikowe doświadczenie wegetacyjne (mikropoletkowe), w układzie kompletnej randomizacji, w trzech powtórzeniach. Pierwszy czynnik doświadczalny stanowił typ gleby: czarna ziemia właściwa, gleba murszowa i gleba opadowo-glejowa właściwa. Drugim czynnikiem był poziom nawożenia NPK (0 – 0, 0, 0 kg · ha^{-1}; I – 75, 33, 100 kg · ha^{-1}; II – 150, 66, 200 kg · ha^{-1}). Biologiczny materiał badań stanowił seler korzeniowy, odmiana Diamant. W pięciu terminach zbioru oznaczono zawartość w liściach selera barwników asymilacyjnych (chlorofilu *a*, chlorofilu *b*, całkowitego oraz karotenoidów). Stwierdzono statystycznie istotny wpływ obu czynników doświadczalnych na koncentrację zarówno chlorofilu, jak i karotenoidów w liściach badanej rośliny.

Słowa kluczowe: *Apium graveolens* L. var. *rapaceum*, nawożenie NPK, barwniki asymilacyjne, czarna ziemia właściwa, gleba murszowa, gleba opadowo-glejowa właściwa