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EFFECT OF COPPER AND TEMPERATURE ON THE GROWTH AND CHLOROPHYLL CONTENT OF SCENTLESS MAYWEED (*Tripleurospermum indorum* (L.) SCHULTZ-BIP.) ORIGINATED FROM VICINITY OF GLOGOW COPPER SMELTER

WPŁYW MIEDZI I TEMPERATURY NA WZROST I ZAWARTOŚĆ CHLOROFILU U MARUNY BEZWONNEJ (*Tripleurospermum indorum* (L.) SCHULTZ-BIP.) POCHODZĄCEJ Z OKOLICY HUTY MIEDZI „GŁOGÓW"

Abstract: Scentless mayweed (*T. indorum* (L.) Schultz-Bip., *Asteraceae*), as the dominant weed in winter cereals, on account of producing big biomass makes dangerous concreation for the crops cultivated in the vicinity of GLOGOW Copper Foundry (GCF) situated in the Silesia region. The aim of this study was to compare the influence of increasing doses of copper in two temperature ranges on the growth and chlorophyll content among biotypes of scentless mayweed coming from the vicinty of GCF and Wielkopolska province. The experiments were conducted in greenhouse conditions in two temperature ranges: 40/10 °C and 25/5 °C (day/night). The seedlings of *T. indorum* were grown in pots filled with the soil including different doses of copper ($CuSO_4 \cdot 5H_2O$): 0, 50, 100, 200, 400, 600 and 800 mg Cu/kg of dry soil. The higher doses of copper inhibited the shoot growth and decreased leaf chlorophyll content. The reduction rate of both parameters was considerably slower in lower temperatures.

Keywords: Chlorophyll, copper, plant growth, industrial pollution, *Tripleurospermum indorum*

In the Lower Silesia province of Poland, agricultural areas situated in the vicinity of GLOGOW Copper Foundry (GCF) have been polluted by heavy metals included in the dust emitted into the atmosphere. Within the last ten years, thanks to intensive modernizing activities by GCF, the condition of agricultural environment got radically better. At present, increased contents – mainly of copper and lead – are detected in cultivated fields situated in the nearest vicinity of the copper foundry [1]. The results of the latest

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investigations showed that over 80 % of total concentration of Cu in a soil arable layer is bound in the fraction hardly available to plants [2].

In the region of GCF 60–70 % of cultivated crops are cereals. Scentless mayweed, as the dominant dicotyledonous weed in winter cereals, on account of producing big biomass, makes dangerous competition for these crops. In agricultural environment weeds and crops are often exposed to the co-occurrence of different abiotic stresses such as heat, drought, cold, salt, high light, mechanical injuries or abundance of heavy metals [3].

The aim of this study was to compare the influence of increasing doses of copper in two temperature ranges on the growth and chlorophyll content among biotypes of scentless mayweed coming from the vicinity of GCF and the Wielkopolska province.

Material and methods

Seeds of *T. indorum* (L.) Schultz-Bip., *Asteraceae* were collected from two cultivated fields (marked as G-1 and G-2) in the vicinity of GCF in the Lower Silesia province. Comparative seeds were collected from the fields in Skoków (Sw) in Wielkopolska province (about 120 km far from Glogow). The level of copper content in soils from which seeds were collected amounted to 223, 88 and 28 mg/kg of dry matter of soil respectively for localizations G-1, G-2 and Sw. Polish standard concentration of copper in soil – according to the law: Journal of Laws, No. 165 Item 1359 – amount to 150 mg/kg of dry matter of soil.

Seedlings obtained from seeds collected near Glogow (G-1, G-2) and near Poznan (Sw) were grown in greenhouse conditions. Plants were grown in pots filled with mix of compost soil and sand (2 : 1) including different doses of copper (as $CuSO_4 \cdot 5H_2O$): 0, 50, 100, 200, 400, 600 and 800 mg Cu/kg of dry soil. In such prepared soils pH in 1M KCl ranged from 7.02 to 6.71 according to the dose of copper. Four pots per treatment were used, with 5 seedlings in each pot. Each experimental combination was made in two replications. After four weeks, the aboveground parts (shoots) of plants were cut and the fresh weight [in g] of 5 shoots per pot was estimated. Presented results are the average of eight measurements for each combination of copper level.

Experiments were conducted in two terms: in summer – with the temperature ranges of 40/10 °C (day/night) and in autumn with temperature 25/5 °C (day/night).

Chlorophyll content was determined in 80 % acetone extract, using spectrophotometer measuring the absorbeance at $\lambda = 645$ and 663 nm (UV/VIS Helios alfa, UNICAM, Great Britain). Chlorophyll $a + b$ were calculated according to Arnon method [4]. Results are presented as arithmetical average from two series in which two parallel analyses were made. Statistical evaluation has been made using the analysis of variance, ANOVA test.

Results and discussion

Both shoot growth and chlorophyll content in leaves of the plants from Glogow and Skokow locations changed according to the amount of Cu content in the soil and temperature. In all experiments copper at sublethal concentrations (600 and 800 mg Cu^{2+}/kg of dry soil) reduced shoot growth as well as chlorophyll content, but these reduction rates were considerably slower at lower temperatures (Table 1 and 2). At temperatures 40/10 °C and 25/5 °C, the fresh biomass of three weed populations increased in the range of supplied copper 0–200 mg Cu^{2+}/kg of dry soil. Additionally for population G-2 at low temperatures fresh biomass still increased at the level of 400 mg Cu^{2+}/kg of dry soil. In high temperatures, reduction of chlorophyll content was observed already at the lowest level of copper dose applied. However in low temperatures the reduction of chlorophyll content was still observed at 600 and 800 mg Cu^{2+}/kg of dry soil, but there was not significant decrease.

Table1

Fresh weight of shoots [g] of *T. indorum* populations in respect of copper dose and temperature range

Population	Dose of copper [mg Cu/kg dry matter of soil]						
	0	50	100	200	400	600	800
Temperature 40/10 °C (day/night)							
Sw	*5.51 a	5.54 a	5.75 a	5.81 a	5.40 a	4.25 b	2.04 c
G-1	5.65 a	5.89 a	5.85 a	5.99 a	5.49 a	4.49 b	2.94 c
G-2	5.65 a	5.80 a	5.97 a	5.83 a	5.54 a	4.61 b	2.73 c
Temperature 25/5 °C (day/night)							
Sw	2.25 a	2.27 a	2.42 a	2.31 a	2.07 ab	1.80 bc	1.42 c
G-1	2.57 a	2.58 a	2.62 a	2.64 a	2.50 ab	2.43 ab	2.07 b
G-2	2.44 ab	2.55 ab	2.75 a	2.62 ab	2.51 ab	2.28 bc	1.98 c

* Values in lines marked by the same letter are not significantly different at $p<0.05$

Table 2

Chlorophyll *a* + *b* content [mg/g fresh mass] in leaves of *T. indorum* populations in respect of copper dose and temperature range

Population	Dose of copper [mg Cu/kg dry matter of soil]						
	0	50	100	200	400	600	800
Temperature 40/10 °C (day/night)							
Sw	*1.88 a	1.80 ab	1.72 b	1.72 b	1.42 c	1.16 d	0.68 e
G-1	1.89 a	1.84 ab	1.76 bc	1.69 c	1.45 d	1.20 e	0.87 f
G-2	1.89 a	1.84 a	1.77 ac	1.70 bc	1.48 d	1.18 e	0.87 f
Temperature 25/5 °C (day/night)							
Sw	1.63 a	1.66 a	1.71 a	1.67 a	1.64 a	1.58 a	1.53 a
G-1	1.77 a	1.82 a	1.83 a	1.81 a	1.79 a	1.73 a	1.69 a
G-2	1.78 a	1.80 a	1.82 a	1.81 a	1.79 a	1.74 a	1.68 a

* Values in lines marked by the same letter are not significantly different at $p < 0.05$

Although the influence of copper on the growth and the metabolism of several photosynthetic organisms has been extensively studied, little information is still available concerning the relationship between the growth and metabolism of plant for different levels of copper concentrations. Many authors reported that, photosynthesis and growth respond to the presence of different Cu^{2+} levels separately. Perales-Vela at al, found that the growth is more sensitive to Cu^{2+} than metabolism [5].

In agricultural environment, often several abiotic stress factors appear simultaneously rather than a particular stress factor. Plants' response to a combination of two different abiotic stresses may be unique and cannot be directly inferred from the response of plants to each of the different stresses applied individually. In addition, combined different stresses might evoke conflicting or antagonistic responses. Heavy metal stress might pose that problem to plants when combined with heat stress because enhanced transpiration could result in enhanced uptake of heavy metals [3, 6].

There are some reports about weed species growing on naturally metalliferous sites, near copper mines or on piles with metallic ores which developed different tolerance strategies that protected them against copper toxicity [7–9]. Near the copper smelter LEGNICA situated in the Lower Silesia province, among many weed species spontaneously migrating to the area around the emitter, copper tolerant *Agropyron repens* and *Convolvulus arvensis* were found. Activity of this oldest smelter in Poland (with constantly high emissions of fly-ash, reduced distinctly only in the nineties) theoretically gave some weed species a sufficient period to develop tolerance [10]. The results of presented studies *in vivo* showed small differences in the reaction of plant growth and its chlorophyll content to Cu stress between populations of *T. indorum* originated from the vicinity of GCF and from the site studied in Wielkopolska province.

References

[1] Rosada J. and Urbańczyk J.: *Ocena stopnia zanieczyszczenia gleb i roślin w rejonie Huty Miedzi „Głogów" w świetle nowych ustaw o dopuszczalnym poziomie metali ciężkich*, [in] Kwas Siarkowy – Nowe Wyzwania, (eds.) Grzesiak P., Schroeder G., Pruszyński S., IOR Poznań 2003, 245–252.

[2] Rosada J., Grzesiak J., Grzesiak P., Schroeder G., Orlicka A., Ratajczak J. and Rissmann I.: *The application of AAS and ICP techniques for the speciation of trace metals insulated by sequential chemical extraction*, [in:] Development in Production and Use of New Agrochemicals, (eds.) Górecki H., Dobrzański Z., Kafarski P.: Chemistry for Agriculture, 2005(6), 464–477.

[3] Mittler R.: *Abiotic stress, the field environment and stress combination*, Trends in Plant Sci. 2006, **11**(1), 15–19.

[4] Arnon D.J.: *Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris*, Plant Physiol. 1949, **24**, 1–15.

[5] Perales-Vela H.V., González-Moreno S., Montes-Horcasitas C. and Cañizares-Villanueva R.O.: *Growth, photosynthetic and respiratory responses to sub-lethal copper concentrations in Scenedesmus incrassatulus (Chlorophyceae)*, Chemosphere, 2007, **67**(11), 2274–2281.

[6] Anand P., Isar J., Saran S. and Saxena R.K.: *Bioaccumulation of copper by Trichoderma viride*, Biores. Tech. 2006, **97**(8), 1018–1025.

[7] Boojar M.M.A. and Goodarzi F.: *The copper tolerance strategies and role of antioxidative enzymes in three plant species grown on copper mine*, Chemosphere, 2007, **67**(11), 2138–2147.

[8] Liu J., Xiong Z., Li T. and Huang H.: *Bioaccumulation and ecophysiological responses to copper stress in two populations of Rumex dentatus L. from Cu contaminated and non-contaminated sites*, Environ. Exp. Bot. 2004, **52**(1), 43–51.

[9] Masarovičová E. and Holubová M.: *Effect of copper on growth and chlorophyll content of some herbs*, Rostlinná Výroba, 1998, **44**(6), 261–265.

[10] Brej T.: *Heavy metal tolerance in Agropyron regens (L.) P. Bauv. populations from the Legnica copper smelter area, Lower Silesia*, Acta Soc. Bot. Pol. 1998, **67**(3–4), 325–333.

WPŁYW MIEDZI I TEMPERATURY NA WZROST I ZAWARTOŚĆ CHLOROFILU U MARUNY BEZWONNEJ (*Tripleurospermum indorum* (L.) SCHULTZ-BIP.) POCHODZĄCEJ Z OKOLICY HUTY MIEDZI „GŁOGÓW"

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Abstrakt: Maruna bezwonna to chwast dwuliścienny, dominujący w zbożach ozimych uprawianych na terenie Śląska, gdzie usytuowana jest Huty Miedzi „GŁOGÓW" (HMG). Ze względu na wytwarzanie dużej biomasy stanowi ona silną konkurencję dla rośliny uprawnej. Celem badań było porównanie wpływu wzrastających dawek miedzi w dwóch zakresach temperatur na wzrost i zawartość chlorofilu między biotypami maruny bezwonnej pochodzącymi z rejonu oddziaływania emisji przemysłowych HMG a biotypem pochodzącym z Wielkopolski. Doświadczenia prowadzono w warunkach szklarniowych w przedziale temperatur: 40/10 °C i 25/5 °C (dzień/noc). Siewki maruny rosły w doniczkach wypełnionych ziemią zawierającą wzrastające dawki miedzi ($CuSO_4 \cdot 5H_2O$): 0, 50, 100, 200, 400, 600 i 800 mg Cu/kg suchej gleby. Większe dawki miedzi hamowały wzrost pędów oraz zmniejszały zawartość chlorofilu w liściach. Tempo zmniejszania się obu badanych parametrów ulegało znacznemu spowolnieniu w niższych temperaturach.

Słowa kluczowe: chlorofil, huta miedzi, miedź, temperatura, *Tripleurospermum indorum*, wzrost roślin