

CONTENT AND UPTAKE OF MICROELEMENTS (CU, ZN, MN, FE) BY MAIZE (*Zea mays* L.) AND ACCOMPANYING WEEDS

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Abstract

A field experiment was conducted in the years 2008–2010 at the Research Station of the Faculty of Agricultural Sciences, University of Life Sciences in Lublin, on brown soil with slightly acidic pH and average abundance of copper, zinc, manganese, and iron. The experiment was set up in a randomized split-plot design with four replications, with two methods for controlling weed infestation: I. mechanical – weeding of inter-rows twice; II. chemical – the herbicide Afalon Dyspersyjny 450 SC, directly after sowing (a.i. linuron, 900 g × ha⁻¹).

Next, the copper, zinc, manganese and iron content were determined in the maize and dominant weed species. Nutrient uptake from an area of 1 ha and the species specificity coefficient (SSC) were also calculated. All the weed species examined contained more copper in their biomass than maize, but their percentage share in total uptake was small, on average 1.7%. The content of zinc in maize biomass and in the segetal species was similar, except for *Cirsium arvense* L. which accumulated considerably less zinc than maize as well as the other weed species. The percentage share of weeds in zinc uptake was only 1.4 % of total uptake of this nutrient by the maize crop. Competitiveness of weeds in the accumulation of manganese and iron showed high species specificity. *Chenopodium album* L. and *Galinsoga parviflora* Cav. were the most competitive in accumulating manganese, while *Cirsium arvense* L. showed high ability to accumulate iron, considerably much higher than maize and other weeds species. The share of weeds in total manganese uptake was relatively large, on average 7.2% for the experiment.

Key words: *Zea mays* L., weed control, copper, zinc, manganese, iron, uptake

INTRODUCTION

Mineral content in the plant depends primarily on the nature of the soil environment and biological properties of the species. Cultivated plants and weeds,

growing side by side and competing for factors necessary for growth and development, exhibit differences in response depending on the subject of competition and habitat conditions (P a r y l a k , 1996). A different content of a specific nutrient in plants, growing in the same location or habitat, indicates their unequal ability to use soil resources (O ś w i t and S a p e k , 1982). Weeds, as inseparable elements of agrocenoses, compete with crop plants not only for place, light, and water, but also for mineral nutrients.

The competitiveness of weeds in the uptake of nutrients and their mineral composition depend on the species and its development stage, degree of weed infestation, abundance of available forms of nutrients in the habitat, and the use of agricultural practices (D u e r , 1986; Q a s e m and H i l l , 1995; Y i n et al. 2006; T r a b a and W i a t e r , 2007; R o g ó ż and N i e m i e c , 2010). The pattern of weather conditions is also not without significance. D z i d a et al. (2004) reported that weed species such as *Capsella bursa-pastoris* (L.) Medik, *Chenopodium album* L., *Elymus repens* (L.) Gould, *Plantago maior* (L.) S. Str., *Stellaria media* L. Vill, *Taraxacum officinale* Web., and *Urtica dioica* L. are more competitive in the uptake of zinc than barley. However, in the case of copper only *Plantago maior* and *Taraxacum officinale* were characterized by higher microelement accumulation capability. P a r y l a k and Z a w i e j a (2004) showed the influence of crop density on the competitiveness of *Avena fatua* L. to spring barley in the uptake of micronutrients, which was higher only under thinned crop conditions. Also M a l i c k i and B e r b e c i o w a (1986) point to the impact of weed species and the crop in which it occurs on changes micronutrient content in their biomass.

The aim of the study was to determine the content of microelements – copper, zinc, manganese, and

iron – in maize and in weeds dominant in its cultivation as well as the magnitude of uptake of these nutrients in the biomass of maize and weeds under conditions of mechanical and chemical methods of weed control.

MATERIALS AND METHODS

A field experiment was carried out in the years 2008–2010 at the Research Station of the Faculty of Agricultural Sciences in Zamość (50°42'N, 23°16'E), University of Life Sciences in Lublin, on brown soil with slightly acidic pH (pH 1 n KCl – 6.2) and an average content of available forms of microelements, i.e. copper – 5.1 mg × kg⁻¹, zinc – 12.9 mg × kg⁻¹, iron – 1005 mg × kg⁻¹, and manganese – 208 mg × kg⁻¹. Dent maize, 'Celio', was grown in a site where spring barley had previously been cultivated. This is a medium early variety (FAO 250), with the type of grain semident/dent. The experiment was set up in a randomized split-plot design with four replications, with two weed control methods: I. mechanical – weeding of inter-rows twice (the first time at the 5–6 leaf stage of maize and again two weeks later); II. chemical – the herbicide Afalon Dyspersyjny 450 SC immediately after sowing (a.i. linuron, 900 g × ha⁻¹).

The mineral fertilizer was applied uniformly in the following amounts: N – 140 kg × ha⁻¹ (ammonium nitrate), P – 35 kg × ha⁻¹ (triple superphosphate), K – 100 kg × ha⁻¹ (potassium chloride). Phosphorus and potassium fertilization was applied once, before spring pre-sowing treatments, while the application of nitrogen was split [half before sowing and half for top dressing at the 5–6 leaf stage of maize (BBCH 15/16)]. Maize was sown on 28 April, 4 May, and 10 May, at 65 cm row spacing using a one-row hand seeder. 10 rows of maize were seeded in the plot. There were 110,000 plants sown per hectare. Mechanical weed control was carried out using hand hoes with a working

width of 38 cm. The first weeding of the inter-rows was done to a depth of 5 cm, while the second one to a depth of 3 cm. Tillage was conducted according to the recommendations for maize.

The maize was harvested at the early dough stage (BBCH 79/83). After harvesting, dry weight yield was calculated per hectare. Two weeks before harvest, weeds were collected from 1 m² of each plot (two sampling areas of 0.5 m² each). The majority of weeds were at the blooming stage or after blooming. Determinations were made of their number and botanical composition, after which they were air-dried and the dry weight of the above-ground parts of particular species was determined as well as their total biomass. Next, copper, zinc, iron and manganese content were determined in the maize and in the dominant weed species, i.e. *Chenopodium album* L. (White Goosefoot), *Galinsoga parviflora* Cav. (Gallant Soldier), *Echinochloa crus-galli* (L.) P. Beauv. (Barnyardgrass), *Cirsium arvense* L. (Creeping Thistle), and *Polygonum lapathifolium* L. subsp. *lapathifolium* (Curlytop Knotweed), following mineralization by flame atomic absorption spectrometry (PN-EN ISO 68 69: 2002). The data on the number and weight of weeds are given in Table 1. The results for maize and weed biomass were discussed in an earlier paper (Głowacka, 2011). Based on the dry weight yield of maize and the biomass of particular weed species, nutrient uptake from an area of 1 ha was calculated. The species specificity coefficient (SSC) was also determined. It expresses the ratio of the content of a given mineral nutrient in the plant tested to the mean content in all the species tested in the plant community (Lambert et al. 1973). A value of SSC > 1 indicates high accumulation of a given element by the species. The results of the study were analysed statistically by calculating coefficients of variation and Pearson's linear correlation coefficients.

Table 1
Number and above-ground dry weight of weeds in maize before harvest
and maize biomass depending on the weed control method (mean for 2008–2010) (Głowacka, 2011)

Weed species	Number (no. × m ⁻²)			Dry weight (g × m ⁻²)		
	I*	II	Mean	I	II	Mean
Total	35.6	19.4	27.5	148.1	90.2	119.2
<i>Echinochloa crus-galli</i> (L.) P. Beauv	18.0	10.3	14.2	100.3	72.3	86.3
<i>Galinsoga parviflora</i> Cav.	3.6	1.4	2.5	5.7	0.7	3.2
<i>Chenopodium album</i> L.	5.0	2.7	3.8	30.2	9.4	19.8
<i>Cirsium arvense</i> L.	2.0	1.0	1.5	2.9	0.9	1.9
<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>	2.0	1.0	1.5	0.7	2.4	1.6
Others	5.6	3.0	4.3	8.3	4.5	6.4
Maize biomass (tonnes d.w. per hectare)				9.6	11.6	10.6

Explanation: *methods of weed control I – mechanical, II – chemical

RESULTS

All the examined dominant weed species had higher copper content in their biomass than maize (Table 2). Among the weeds, the lowest content of Cu was found in *Chenopodium album* L. – $8.39 \text{ mg} \times \text{kg}^{-1} \text{ d.w.}$

(dry weight). Other weed species had higher contents of this micronutrient, but the differences among them were small, which confirms the low value of the coefficient of variation. In the case of both maize and segetal species, the applied weed control methods did not significantly influence the content of copper.

Table 2
Content of copper in above-ground parts of dominant weed species and maize and its uptake by plants depending on the weed control method (mean for 2008–2010)

Species	Copper					
	Content ($\text{mg} \times \text{kg}^{-1} \text{ d.w.}$)			Uptake ($\text{mg} \times \text{ha}^{-1}$)		
	I*	II	Mean	I*	II	Mean
<i>Echinochloa crus-galli</i> (L.) P. Beauv	10.3	10.5	10.4	1030.0	730.0	880.0
<i>Galinsoga parviflora</i> Cav.	10.4	10.1	10.2	60.0	10.0	40.0
<i>Chenopodium album</i> L.	8.3	8.5	8.4	250.0	80.0	160.0
<i>Cirsium arvense</i> L.	10.1	9.8	9.9	30.0	30.0	10.0
<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>	9.5	10.0	9.7	10.0	10.0	30.0
<i>Zea mays</i> L.	6.9	6.0	6.5	66400	69800	68100
Coefficients of variation (%)	14.9	18.8	16.5	239	241	240

Explanation: *methods of weed control: I – mechanical, II – chemical

Among the group of weed species tested, *Polygonum lapathifolium* L. subsp. *lapathifolium* had the highest zinc content in its biomass and it was higher than in the biomass of maize (Table 3). *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. Beauv. and *Galinsoga parviflora* Cav. had a similar zinc content

as maize. However, *Cirsium arvense* L. accumulated much less of this micronutrient compared to maize and the other weed species. The maize from the plots where chemical weed control methods were applied contained significantly less Zn than that from the sites where only the mechanical method was used.

Table 3
Content of zinc in above-ground parts of dominant weed species and maize and its uptake by plants depending on the weed control method (mean for 2008–2010)

Species	Zinc					
	Content ($\text{mg} \times \text{kg}^{-1} \text{ d.w.}$)			Uptake ($\text{mg} \times \text{ha}^{-1}$)		
	I*	II	Mean	I*	II	Mean
<i>Echinochloa crus-galli</i> (L.) P. Beauv	23.9	24.4	24.1	240.0	174.0	207.0
<i>Galinsoga parviflora</i> Cav.	25.0	24.2	24.6	140.0	20.0	80.0
<i>Chenopodium album</i> L.	24.8	23.7	24.2	750.0	220.0	470.0
<i>Cirsium arvense</i> L.	16.5	16.9	16.7	50.0	20.0	40.0
<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>	26.5	25.8	26.1	20.0	60.0	40.0
<i>Zea mays</i> L.	24.3	14.5	19.4	233.3	168.2	200.7
Coefficients of variation (%)	15.1	21.6	18.4	240.8	241.4	241.1

Explanation: *methods of weed control: I – mechanical, II – chemical

The manganese content in the dominant weed species was several times higher than in maize (Table 4). *Cirsium arvense* L., which accumulated the least amount of Mn among the weeds, had 4 times higher content of manganese than maize. The highest concentration of this element was found in *Galinsoga parviflora*

Cav. and *Chenopodium album* L. and it was 10 times higher than in maize biomass. Considerable variation in the content of Mn among the investigated species is confirmed by the high coefficient of variation. The weed control methods did not affect significantly the changes in manganese content in the studied plants.

Table 4
Content of manganese in above-ground parts of dominant weed species
and maize and its uptake by plants depending on the weed control method (mean for 2008–2010)

Species	Manganese					
	Content (mg × kg ⁻¹ d.w.)			Uptake (mg × ha ⁻¹)		
	I*	II	Mean	I*	II	Mean
<i>Echinochloa crus-galli</i> (L.) P. Beauv	72.4	71.3	88.4	7260.0	5150.0	6490.0
<i>Galinsoga parviflora</i> Cav.	101.0	104.3	102.7	580.0	70.0	330.0
<i>Chenopodium album</i> L.	102.0	103.0	102.5	3080	980.0	2030.0
<i>Cirsium arvense</i> L.	42.2	43.5	42.8	120.0	40.0	80.0
<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>	58.4	59.0	58.7	40.0	140.0	90.0
<i>Zea mays</i> L.	10.7	11.0	10.9	102700.0	127600.0	115200.0
Coefficients of variation (%)	54.8	54.9	54.8	216.8	231.1	224.0

Explanation: *methods of weed control: I – mechanical, II – chemical

The concentration of iron in *Chenopodium album* L. and *Polygonum lapathifolium* L. subsp. *lapathifolium* was lower than in fodder maize, whereas *Galinsoga parviflora* Cav. and *Echinochloa crus-galli* (L.) P. Beauv accumulated more of this element (Table 5). *Cirsium arvense* L. was a species that accumulated

a lot of Fe; in its biomass, it contained 4 times more of this microelement than maize and much more than the other weed species studied. The value of the coefficient of variation for Fe was the highest among the examined micronutrients.

Table 5
Content of iron in above-ground parts of dominant weed species
and maize and its uptake by plants depending on the weed control method (mean for 2008–2010)

Species	Iron					
	Content (mg × kg ⁻¹ d.w.)			Uptake (mg × ha ⁻¹)		
	I*	II	Mean	I*	II	Mean
<i>Echinochloa crus-galli</i> (L.) P. Beauv	109.0	107.0	10.1	10930.0	7740.0	9340.0
<i>Galinsoga parviflora</i> Cav.	85.1	85.9	85.5	490.0	60.0	280.0
<i>Chenopodium album</i> L.	57.6	58.2	57.9	1740.0	550.0	1150.0
<i>Cirsium arvense</i> L.	249.0	253.0	251.0	720.0	220.0	470.0
<i>Polygonum lapathifolium</i> L. subsp. <i>lapathifolium</i>	58.6	59.3	58.9	40.0	140.0	90.0
<i>Zea mays</i> L.	67.4	54.6	61.0	647040.0	633360.0	640200.0
Coefficients of variation (%)	70.3	74.0	72.2	238.8	241.0	240.0

Explanation: *methods of weed control: I – mechanical, II – chemical

The amount of micronutrients taken up from the soil was mainly the result of the quantity of biomass produced by the crop plant and its accompanying weeds, which confirms the value of the linear correlation coefficient for, respectively: Cu – $r = 0.997$; Mn – $r = 0.998$; Fe – $r = 0.993$; and Zn – $r = 0.961$ ($n = 24$, $p < 0.01$). Maize yield was on average $10.6 \text{ t} \times \text{ha}^{-1}$ d.w. per hectare, and total weed biomass $0.23 \text{ t} \times \text{ha}^{-1}$ d.w., hence the differences in the uptake of elements were significant. The percentage of weeds in total copper uptake from the soil was 2.0% for mechanical weed control and 1.3% for the chemical method (Fig. 1).

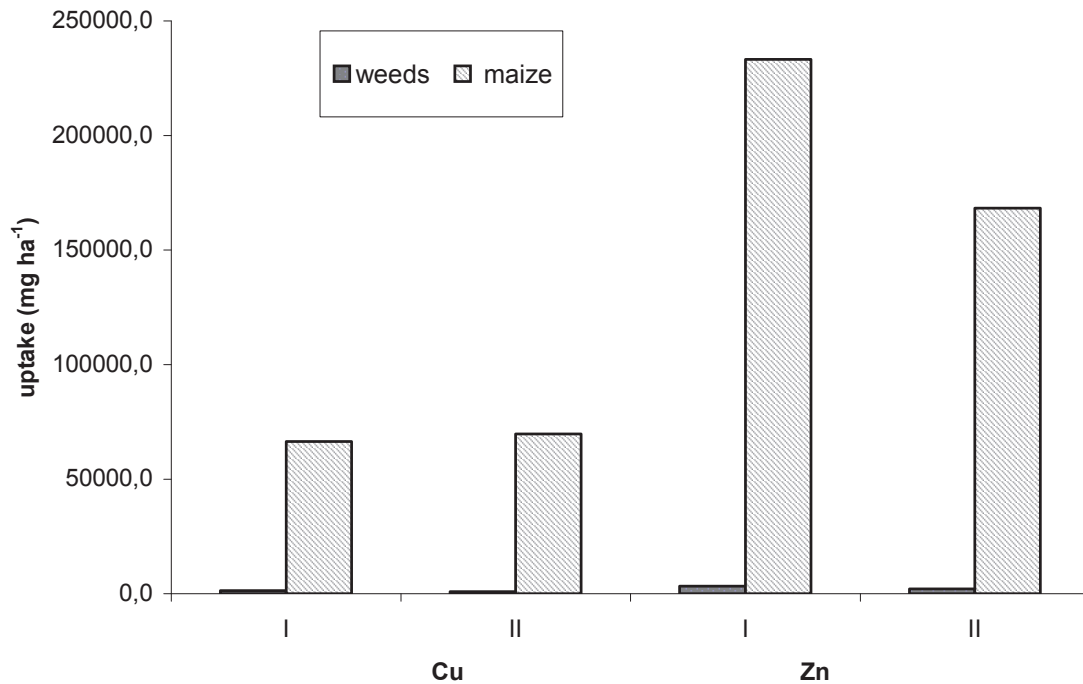
A negative correlation was shown between Cu content in plants and total uptake ($r = -0.743$). Total

zinc uptake in plant biomass of the maize crop was $236\,600 \text{ mg} \times \text{ha}^{-1}$ in the plots where mechanical weed control was applied, while the percentage of weeds in total uptake was only 1.4% and $170\,300 \text{ mg} \times \text{ha}^{-1}$ in the case of chemical weed control; and the percentage of weeds in total uptake was slightly lower and accounted for 1.2% (Fig. 1). Among the weed species tested, the highest amount of copper and zinc was taken up by *Echinochloa crus-galli* (L.) P. Beauv., regardless of weed control methods applied (Tables 2 and 3). Total uptake of manganese in plant biomass (maize + weeds) was $113\,800 \text{ mg} \times \text{ha}^{-1}$ and $136\,300 \text{ mg} \times \text{ha}^{-1}$, while the share of weeds in uptake was 9.7% and 4.8% for mechanical and chemical weed control methods, re-

spectively (Fig. 2). *Echinochloa crus-galli* (L.) P. Beauv. took up the largest amount Mn, because of its high biomass production. A considerable amount of this micronutrient, in comparison with other species, was also taken up by *Chenopodium album* L. (Table 4).

As in the case of Cu, the amount of Mn uptake was also negatively correlated with its content in

plants ($r = -0.649$). Among all analyzed trace elements, iron was the element taken up by the maize crop at the highest amount – on average $640\,000\text{ mg} \times \text{ha}^{-1}$. The percentage of weeds in iron uptake was much smaller than for manganese and amounted to 2.1% and 1.4%, respectively, for the mechanical and chemical weed control methods.



* methods of weed control: I – mechanical, II – chemical

Fig. 1. Total uptake of copper and zinc by maize and weeds depending on the weed control method.



* methods of weed control: I – mechanical, II – chemical

Fig. 2. Total uptake of manganese and iron by maize and weeds depending on the weed control method.

The value of the species specificity coefficient (SSC) confirms the greater ability of weeds to accumulate copper in comparison with maize (Table 6). With respect to zinc, the lowest value of SSC was for *Cirsium arvense* L. (0.7). Under conditions of mechanical weed control, maize and the other weed species had a similar value of the species specificity coefficient. On the other hand, in the treatments with chemical weed control, the value of SSC for maize was lower than for segetal species. These differences were due

to lower content of zinc in maize when the herbicides were used, in comparison to maize weeded only mechanically. All segetal species had a greater ability to accumulate manganese than maize, especially *Chenopodium album* L. and *Galinsoga parviflora* Cav. The calculated SSC coefficient indicates very high potential to accumulate iron by *Cirsium arvense* L. and substantially lower potential of *Chenopodium album* L. and *Polygonum lapathifolium* L. *subsp. lapathifolium*, similar to that of maize (Table 6).

Table 6
Value of the species specificity coefficient (SSC) for maize and dominant weeds.

Species	Microelement							
	Cu		Zn		Mn		Fe	
	I*	II	I	II	I	II	I	II
<i>Echinochloa crus-galli</i> (L.) P. Beauv.	1.12	1.17	1.06	1.04	1.12	1.11	1.04	1.02
<i>Galinsoga parviflora</i> Cav.	1.11	1.09	1.02	1.03	1.57	1.60	0.81	0.82
<i>Chenopodium album</i> L.	0.90	0.91	1.06	1.01	1.58	1.62	0.55	0.56
<i>Cirsium arvense</i> L.	1.09	1.06	0.70	0.72	0.65	0.67	2.38	2.42
<i>Polygonum lapathifolium</i> L. <i>subsp. lapathifolium</i>	1.03	1.08	1.13	1.10	0.91	0.92	0.56	0.57
<i>Zea mays</i> L.	0.75	0.65	1.03	0.62	0.17	0.17	0.56	0.52

Explanation: *methods of weed control: I – mechanical, II – chemical

DISCUSSION

Maize, due to its cultivation with wide inter-row spacing and its relatively slow growth at the early stages, is quite sensitive to competition from weeds. Weed competitiveness in relation to crop plants varies and it depends on habitat abundance, species and developmental stage, agricultural practices used, and the crop in which weeds occur (Rajcan and Swanton, 2001; Chikoye et al. 2004; Trąba and Wiater, 2007; Rogóż and Kołodziejczyk, 2007; Gugała et al. 2009; Głowacka, 2011). *Chenopodium album* L is one of expansive weeds showing high ability to adapt to habitat conditions (Rola and Rola, 1996). It usually takes up more minerals than crop plants and its competitive ability depends on soil type, fertilization, crop species, participation in weed infestation and type of nutrient taken up (Czuba and Wróbel, 1983; Malicki and Berbecio-wa, 1986; Parylak, 1999; Wiater and Trąba, 2002; Trąba and Wiater, 2004). In a study by Malicki and Berbecio-wa (1986), Cu content in *Chenopodium album* L. ranged from 6.4 to 13.1 mg × kg⁻¹ d.w., depending on the crop species among which it grew. *Echinochloa crus-galli* (L.) P. Beauv., *Polygonum lapathifolium* L. *subsp. lapathifolium* and *Cirsium arvense* L. accumulated much more of this micronutrient. Similarly in our study, among the five dominant weed species in maize *Chenopodium album* L.

accumulated the least Cu. A significantly higher amount of this micronutrient was found in the other taxa, such as *Echinochloa crus-galli* (L.) P. Beauv., *Galinsoga parviflora* Cav., *Cirsium arvense* L., and *Polygonum lapathifolium* L. *subsp. lapathifolium*, but the differences between them were negligible. Weeds tend to be more competitive in the uptake of nutrients than crop plants. It certainly depends of the element taken up. *Chenopodium album* L. and *Galinsoga parviflora* Cav. can accumulate 4 or 5 times more potassium than maize, while *Cirsium arvense* L., *Chenopodium album* L., and *Galinsoga parviflora* Cav. accumulate up to 10–12 times more calcium than a maize crop in which they grow (Głowacka, 2011). In the present study, all the weed species tested were also more competitive in the uptake of Cu than fodder maize. However, these differences were not as high as those reported for macroelements.

The natural content of Zn in wild plants is between 15 to 80 mg × kg⁻¹ d.w. (Rogóż and Niemiec, 2010). The competitiveness of weeds in the uptake of Zn depends on the species and crops in which they appear. The research of Malicki and Berbecio-wa (1986) showed that *Chenopodium album* L. is more competitive in the uptake of Zn than winter wheat and spring barley, and it accumulates this element in a lower amount than sugar beet and spring rape. A similar relationship was also demonstrated in the case of *Cirsium arvense* L. In our study, regardless of

the weed control method, *Cirsium arvense* L. accumulated less zinc than fodder maize. *Polygonum lapathifolium* L. subsp. *lapathifolium* was the most competitive in the uptake of this micronutrient.

The manganese content in plants is in a wide range and depends on the characteristics of the species, the content of available nutrient forms in soil and its pH (Rogóż and Niemiec, 2010). The concentration of Mn in maize was on average $10.9 \text{ mg} \times \text{kg}^{-1}$ and was significantly lower than that found by Rabińska and Piszcz (2004) and that reported as optimal in animal feed (Gorlach, 1991). In this study, the concentration of manganese in all the dominant weed species was significantly higher than in maize. *Chenopodium album* L. and *Galinsoga parviflora* Cav. were the species that accumulated the largest amount of manganese. The manganese content in *Chenopodium album* L. was significantly higher than that obtained by Dzida et al. (2004), similar to that found by Malicki and Berbeciowa (1986) when this taxon occurred in winter wheat, barley and rape, and much lower than that given by Trąba and Wiater (2004).

Chenopodium album L. and *Polygonum lapathifolium* L. subsp. *lapathifolium* accumulated similar amounts of iron as dent maize. *Cirsium arvense* L. was the species with the highest concentration of this micronutrient. The higher ability of this species to accumulate iron is confirmed by the species specificity coefficient (SSC). The value of SSC higher than 1 indicates the high potential of a given species to accumulate a particular mineral nutrient (Lambert et al. 1973). The content of Fe recorded in this study for all the dominant segetal species in maize was significantly lower than that reported by other authors (Malicki and Berbeciowa, 1986; Rogóż and Niemiec, 2010).

The quantity of nutrients taken up by weeds is determined more by the size of biomass produced by them than by the content of these components (Trąba and Wiater, 2007; Głowacka, 2011). It changes depending on crop rotation or weed control method (Zawiślak and Kostrzevska, 2000; Liszka-Podkowa and Sowiński, 2009). Parylak (1996) reports that the share of weeds in total uptake of potassium may amount to 36% and of calcium even 56%. According to Czuba (2000), the uptake of copper per hectare in maize cultivation is 118 grams. In our study, on average for the experiment, maize took up 68 g Cu in biomass produced. This result is similar to that given by Rabińska and Piszcz (2004) who found that maize accumulated 51.6 g Cu per hectare. The total uptake of micronutrients by weeds was low and for copper it was 2.1% and 1.3%, while for zinc 1.46% and 1.25% of

total uptake by the maize crop. The highest percentage of weeds in total accumulation of micronutrients was obtained for manganese, and it was 9.7% and 4.8% for mechanical and chemical methods of weed control, respectively. Such a high percentage was probably due to the low content of manganese in maize and thus its low uptake in plant biomass. On the other hand, iron was the element accumulated in the highest amounts by maize and its accompanying weeds.

CONCLUSIONS

1. All the weed species tested contained more copper than the maize plants in the biomass. The zinc content in maize and segetal species was similar, with the exception of *Cirsium arvense* L. which took up much less of this nutrient.
2. The ability to uptake manganese and iron shows high species specificity. *Chenopodium album* L. and *Galinsoga parviflora* Cav. accumulated more manganese, while *Cirsium arvense* L. exhibited much higher capacity to accumulate iron than maize and the other weed species.
3. The ability of the dominant weeds to accumulate micronutrients varied and depended on the species and element, but their percentage of total uptake of Cu, Zn, Mn and Fe by the maize crop was generally low.
4. *Echinochloa crus-galli* (L.) P.Beauv was the weed species that took up the highest amount of nutrients due to its quantitative dominance.

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**Zawartość oraz pobranie
mikroelementów (Cu, Zn, Mn, Fe)
przez kukurydzę pastewną (*Zea mays* L.)
oraz towarzyszące chwasty**

Streszczenie

Eksperyment polowy przeprowadzono w latach 2008–2010, w Stacji Doświadczalnej Wydziału Nauk Rolniczych, Uniwersytetu Przyrodniczego w Lublinie. Rośliny rosły na glebie brunatnej, o odczynie lekko kwaśnym oraz średniej zasobności w miedź, cynk, mangan i żelazo. W doświadczeniu założonym

w układzie losowanych podbloków, w czterech powtórzeniach uwzględniono dwie metody regulacji zachwaszczenia kukurydzy: I. mechaniczna – dwukrotne opielanie międzyrzędzi; II. chemiczna – herbicyd Afa-lon Dyspersyjny 450 EC bezpośrednio po siewie (s.a. linuron, w dawce $900 \text{ g} \times \text{ha}^{-1}$).

W kukurydzy i dominujących gatunkach chwastów oznaczono zawartość miedzi, cynku, manganu i żelaza. Wyliczono również pobranie składników z 1 ha oraz współczynnik specyfiki gatunkowej (WSG). Wszystkie badane gatunki chwastów zawierały w biomacie więcej miedzi niż kukurydza, ale ich udział w całkowitym pobraniu mikroelementu był niewielki, średnio 1,7%. Zawartość cynku w biomacie kukurydzy i gatunkach segetalnych była zbliżona, z wyjątkiem *Cirsium arvense* L., który gromadził znacznie mniej cynku niż kukurydza oraz pozostałe taksony chwastów. Pobranie cynku przez dominujące gatunki chwastów stanowiło tylko 1,4% ogólnego pobrania mikroelementu przez łan kukurydzy. Konkurencyjność chwastów w kumulacji manganu i żelaza wykazywała dużą specyfikę gatunkową. *Chenopodium album* L. i *Galinsoga parviflora* Cav. były najbardziej konkurencyjne w gromadzeniu manganu, zaś *Cirsium arvense* L. wykazał dużą zdolność do akumulacji żelaza, znacznie większą niż kukurydza oraz pozostałe gatunki chwastów. Udział chwastów w całkowitym pobraniu manganu był stosunkowo duży i wyniósł średnio dla doświadczenia 7,2%.

