J. Elementol. 2009, 14(2): 323–330

EFFECT OF UREA APPLIED WITH COMPOSTS ON CONCENTRATION OF Cu, Zn AND Mn IN CORN FRESH MATTER

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Abstract

Corn was grown for green matter in a pot experiment, in which soil was fertilized with composts alone or in combination with 3 g N per pot (urea). The composts were made in wooden boxes, measuring 50×60×60 cm. They were composted for 3.5 months, until the temperature in the composts became stable and equal to the ambient temperature. Rates of the composts were balanced with amounts of added nitroge, such as 6.0 g N per pot. A one-factor experiment was conducted in Kick-Brauckmann pots, kept in a greenhouse at the University of Warmia and Mazury in Olsztyn. After harvest, fresh matter of stems and leaves as well as corn cobs was determined. Next, the plant samples were dried to determine the dry matter content and finally, after mineralisation, the concentration of Cu, Zn and Mn was determined by atomic absorption spectrophotometry. The composts significantly reduced the concentration of zinc and manganese in the vegetative yield of cor (lstems and leaves). Urea applied in combination with the composts very strongly increased the concentration of manganese and, to a lesser degree, the level of zinc and copper in vegetative organs. In corn cobs, the application of urea increased only the content of manganese. Urea had a stronger effect on increasing the weight of cobs rather than the vegetative mass of corn plants. The uptake of Cu, Zn and Mn was more evidently conditioned by the accumulation of these elements in dry matter than by the total weight of corn plants. The extent of the relationship between the uptake of Cu, Zn and Mn and their concentration of corn biomass is expressed the by corresponding correlation coefficients: 0.66, 0.65 and 0.68.

Key words: corn, composts, urea, Cu, Zn and Mn.

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DZIAŁANIE MOCZNIKA STOSOWANEGO ŁĄCZNIE Z KOMPOSTAMI NA ZAWARTOŚĆ Cu, Zn I Mn W ZIELONEJ MASIE KUKURYDZY

Abstrakt

W doświadczeniu wazonowym uprawiano kukurydzę na zieloną masę, którą nawożono kompostami lub kompostami z dodatkiem 3 g N na wazon (mocznik). Komposty założono w skrzyniach z desek o wymiarach 50×60×60 cm. Okres kompostowania wynosił 3,5 miesiąca, do ustabilizowania temperatury równej otoczeniu. Dawki kompostów były zrównoważone ilością wprowadzonego azotu, tj. 6,0 g N na wazon. Doświadczenie jednoczynnikowe przeprowadzono w hali wegetacyjnej UWM w Olsztynie, w wazonach typu Kick-Brauckmanna. Po zbiorze kukurydzy określono świeżą masę łodyg i liści oraz kolb, po wysuszeniu – zawartość suchej masy, po mineralizacji próbek oznaczono koncentrację Cu, Zn i Mn metodą absorpcyjnej spektrometrii atomowej. Komposty istotnie ograniczały koncentrację cynku i manganu w wegetatywnym plonie kukurydzy (łodygi + liście). Mocznik zastosowany łącznie z kompostami bardzo silnie zwiększał koncentrację manganu oraz w mniejszym stopniu cynku i miedzi w organach wegetatywnych. Pod wpływem mocznika w kolbach zwiększyła się jedynie zawartość manganu. Mocznik silniej zwiększał masę kolb niż masę wegetatywną kukurydzy. O pobraniu Cu, Zn i Mn w większym stopniu decydowało ich nagromadzenie w suchej masie niż całkowita masa kukurydzy. Siłę zależności pobrania Cu, Zn i Mn od ich zawartości w biomasie kukurydzy określają współczynniki korelacji, odpowiednio: 0,66, 0,65 i 0,68.

Słowa kluczowe: kukurydza, komposty, mocznik, Cu, Zn, Mn.

INTRODUCTION

Corn is one of the most popular crops. Discovered in Central America, it was brought to Europe in 1494, after the second travel of Christopher Columbus to America. At that time it was described as a very large plant with a beautiful stem and golden grain. Corn is a popular crop mainly because it is capable of producing high yields, consisting of nutritious green matter and grain (BILSKI et al. 1997). However, for the plant to give large, good quality yields, it needs to be supplied with suitable nutrients. Corn is very sensitive to organic and mineral fertilization (SIENKIEWICZ 2003).

Apart from macronutrients, corn often needs microelements (SPIAK 2000). Sound fertilization regimes can satisfy plants' requirements for micronutrients (MAZUR, MAZUR 2002, RUTKOWSKA et al. 2002). Plants which receive all necessary nutrients are able to produce large yields which are of superior nutritional quality. This also concerns micronutrients, which are better to be given to animals in feeds and to people in foodstuff than as chemical supplements.

Using bio-waste, such as sludge, in agriculture is still a controversial issue. Processed (composted) sewage sludge generates much better results than fresh sludge (HERMANN, HARASIMOWICZ-HERMANN 2006). Concern is raised by the trace elements which can enter soil along with sewage sludge

(McBride et al. 2004, Bowszys et al. 2007). This can lead to excessive accumulation of such elements in plants (Rattan et al. 2005), especially when grown on moist soils (Diatta 2008).

The purpose of this study has been to analyse the influence of urea applied in combination with various composts on the content of three micronutrients (Cu, Zn and Mn0 in corn.

MATERIAL AND METHODS

Sewage sludge from the wastewater treatment plant in Olecko was used to produce composts. It was composted with sawdust, lignite and molasses brewing extract (Table 1). The composts were placed into wooden boxes measuring 50x60x60 cm located at the Wastewater Treatment Plant in Olecko. They were composted for 3.5 months, that is until the temperature inside the composts became stable and equal the ambient temperature. The composts were preserved for the pot trials. Kick-Brauckmann pots were filled with 9 kg of soil taken from the arable horizon and previously mixed with the composts. The grain size distribution of the soil material was as follows: 44% sand, 39% dust and 7% floatable particles. The content of organic carbon and total nitrogen was 10.9 and 0.54 $g \cdot kg^{-1}$, respectively. The soil was moderately abundant in K and Mg but low in P whereas the concentration of available micronutrients (Cu, Zn and Mn) was within the middle range.

Table 1

Content of macro- and micronutrients in composts

Compost	Composition[x]	N	P	K	Mg	Cu	Zn	Mn
		$g \cdot kg^{-1}$ of dry matter				$mg \cdot kg^{-1}$ of dry matter		
1	70% sludge + 30% sawdust	20.20	9.55	7.69	1.54	106.2	210.7	191.5
2	70% sludge + 20% sawdust + 10% lignite	21.90	12.19	9.40	2.71	118.3	221.3	209.9
3	60% sludge + 20% sawdust +10% lignite + 10% extract[xx]	21.00	18.24	14.51	2.65	98.5	205.9	180.6

[x]dry matter, [xx]fresh matter

A one-factor experiment with four replications was conducted in a greenhouse, at the UWM in Olsztyn. After emergence, 7 plants were left in each plot. The corn plants were harvested after 80 days of vegetative growth.

The experiment consisted of 7 objects:
1) no fertilization (control),
2) compost 1,
3) compost 2,
4) compost 3,
5) compost 1 + urea (3 g N per pot),
6) compost 2 + urea (3 g N per pot),
7) compost 3 + urea (3 g N per pot).

The rates of the composts applied were balanced with the amounts of nitrogen introduced to the post, such as 6.0 g N per pot. After harvest, fresh yield was determined (stems + leaves, and corn cobs). Once the samples were dried and mineralized, the concentration of Cu, Zn and Mn was determined with the AAS method. The results underwent statistical processing, using analysis of variance for a one-factor experiment.

RESULTS

The fertilization treatments differentiated the content of copper, zinc and manganese in dry matter of stems and leaves as well as cobs (Table 2). The composts led to a considerable reduction in the concentration of zinc and manganese in the vegetative mass of corn (stems + leaves). This may have been caused by the enhanced binding of these metals to the organic matter introduced to soil along with the composts. Organic matter strongly inhibits the uptake of trace elements by plants (SAHA et al. 1999). Weber et al. (2003) claims that composts improve the base saturation of the sorptive complex, which limits the uptake of trace metals. No such dependence occurred for copper, although this metal is very strongly bounded to organic

Table 2

Content of Cu, Zn and Mn in corn (mg·kg^{-1} of dry mattrer)

Fertilization	Cu		Zn		Mn	
	leaves and stems	corncobs	leaves and stems	corn cobs	leaves and stems	corn cobs
Control	4.96	-	35.56	-	62.12	-
Compost 1	5.09	7.60	11.82	71.64	36.20	29.24
Compost 2	4.64	7.13	24.44	47.38	36.88	21.96
Compost 3	5.41	8.19	24.88	52.76	41.48	18.90
Compost 1 + urea	6.63	7.75	35.74	54.00	130.14	35.52
Compost 2 + urea	5.96	5.20	39.98	51.80	134.50	27.72
Compost 3 + urea	4.96	6.00	22.94	44.92	107.90	22.62
$LSD_{0.01}$	0.60	067	0.37	0.97	0.54	0.33

matter. It can be suspected that during the mineralization process, more available copper was present in the soil. In turn, urea applied along with one of the composts very strongly increased the concentration of manganese and, to a lesser degree, the levels of zinc and copper in the vegetative parts of corn plants. Under the effect of urea, corn cobs were found to be richer only in manganese. The increase in the concentration of these metals in corn is attributable to their greater availability in soil, which was improved by soil's acidification due to nitrification of ammonium (following the ammonification of urea). It can also by hypothesized that translocation of Cu and Zn to cobs was restricted to a greater extent than that of manganese. Comparison of the means from the series with the composts and the objects receiving the composts with urea showed that N-min significantly differentiated the content of the micronutrients. Assuming that the content of the micronutrients in the series without N0min was 1.0, any increase or decrease in the concentration of the elements is represented by the following values:

Micronutrient	leaves and stems	cobs
Cu	1.16	0.83
Zn	1.61	0.88
Mn	3.18	1.19

The above proves that the N-min fertilization had the strongest influence on the content of Mn, while affecting the most weakly the level of Cu. The amounts of the trace elements in corn are different from the ones reported by SĄDEJ et al. (2004). Considering the mean values, the Cu concentration was approximately 2-fold higher in our study than in the cited paper. The difference in the content of Mn was even greater. Kaczor et al. (2006), who tested oilseed rape fertilized with sewage sludge, obtained very high concentration of Mn in plants during the inflorescence stage and in straw and seeds after harvest. In turn, the concentrations of zinc reported by SĄDEJ et al. (2004) was only slightly higher than that obtained in our study. According to WEBER et al. (2002), a single dose of sludge, be it a high one, containing large amounts of trace elements may not lead to soil pollution or raised levels of such elements in plants, even when they grow on light soils. DE HANN (1981) claims that higher availability of nitrogen in environment favours increased concentrations of trace elements in plants. The present tests involved urea, which significantly raised the concentration of Cu, Zn and Mn in corn.

Also the quantities of fresh and dry matter of corn per pot were significantly varied depending on the fertilization system (Table 3). Relative to the control, fertilization with the composts alone caused a three-fold increase in green matter. A combination of a compost and urea led to a further increase of fresh weight, now corn yielded 3.2-fold more green matter than the control object. Plants from the two objects without N-min. had more dry matter. This was reflected in the dry matter yield, which was 3.4 and 3.5-fold

Table 3

Fresh and dry master of maize in g per pot

Fertilization	Fresh matter			Dry matter		
	leaves and stems	corn cobs	sum	leaves and stems	corn cobs	sum
Control	239.0	-	-	68.8	-	-
Compost 1	706.7	36.0	742.7	259.7	3.5	257.2
Compost 2	696.0	48.3	744.3	246.4	5.7	252.1
Compost 3	676.0	41.6	717.6	212.3	5.2	217.5
Compost 1 + urea	876.7	415.0	1291.7	225.3	56.8	282.1
Compost 2 + urea	928.0	401.6	1329.6	246.8	52.2	299.0
Compost 3 + urea	874.7	460.0	1334.7	255.4	68.5	323.9
$LSD_{0.01}$	114.3	90.1	123.1	240.0	11.9	39.5

higher, respectively, than the control. Mineral nitrogen produced a particularly strong influence on the weight of cobs, whose fresh matter increased by 101.3% and dry matter by 123.35 versus the corn growing on soil fertilized exclusively with the composts.

The uptake of the analyzed micronutrients by corn harvested for green matter depended on fertilization (Table 4). Compared to the control, higher uptake was observed in the objects fertilized with one of the composts together with N-min. than receiving only a dose of compost. The improved uptake of micronutrients stimulated by N-min. was: 44.7% for Cu, 116.1% for Zn and 232.4% for Mn. With such a large increment in the assimilation of manganese, the relative ratio of Cu and Zn in the total mass of micronutrients taken up by plants was lower than in the series which did not receive N-min.

Table 4

Uptake of microelements (g per pot)

Fertilization	Cu	Zn	Mn
Control	0.34	2.45	4.27
Compost 1	1.32	3.25	9.18
Compost 2	1.18	6.29	9.09
Compost 3	1.19	5.55	8.81
Mean	1.23	5.03	9.03
Compost 1 + urea	1.93	11.11	29.32
Compost 2 + urea	1.74	12.57	33.19
Compost 3 + urea	1.68	8.94	27.56
Mean	1.78	10.87	30.02

The calculated correlations have demonstrated that the uptake of Cu, Zn and Mn was more strongly shaped by the accumulation of these elements in dry matter (weighted average of the content of micronutrients in vegetative parts: stems + leaves, and in cobs) than the total yield of corn. The dependence between the uptake of Cu, Zn or Mn and the content of these elements corn biomass is defined by the values of correlations: 0.66, 0.65 and 0.68, respectively. The lower values of the correlation coefficients obtained for the relationship between the uptake of the metals and corn yield suggest that copper, zinc and manganese could not be implied as factors limiting the growth of corn, neither when they are insufficient nor when they appear in excess in soil.

CONCLUSIONS

1. Urea used in combination with composts very strongly increased the concentration of manganese, less so the content of zinc and copper in vegetative parts of corn (stems and leaves). In corn cobs, it was only the level of manganese that increased under the influence of urea.

2. The uptake of Cu, Zn and Mn by corn is conditioned by the accumulation of these metals in dry matter rather than the total dry matter yield.

3. Sewage sludge-based composts with various added materials (sawdust, lignite or extract) can be used to fertilize corn.

4. Urea applied along with composts can have a favourable influence on the quality of green matter used for production of corn silage as such fertilization leads to increased contribution of cob weight to the total vegetative mass of harvested corn.

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