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The effect of foliar application of Ekolist fertilizer on maize yielding and chemical composition

Wpływ nawozów dolistnych Ekolist na plon i skład chemiczny kukurydzy

Summary. A pot experiment was conducted in Wagner-type pots of 5 kg soil capacity. The medium used for the investigation was light loam containing 22% of silt and clay. The plant subjected to testing was Blask variety of maize collected in caryopsis milk stage. The experimental scheme involved foliar application of Ekolist fertilizers: Mikro K, Mono Zn and Mono B within the frames of two levels of N fertilization 0.8 g (N1) and 1,6 g (N2) per one pot as well as control object without foliar fertilizer used. The research showed that foliar application of Ekolist fertilizers at a lower nitrogen dose did not significantly affect the increase of maize dry matter yield in comparison to control object. Fertilization with a higher nitrogen dose by foliar application of Ekolist Mono Zn and Ekolist Mono B fertilizers did significantly affect the increase in dry matter yield of maize in comparison to the control object. The highest content of microelements applied (Zn and B) was found in leaves and stems of maize for foliar application of Ekolist Mono and the mean content of analyzed microelements in aboveground parts of maize was higher with N-1 nitrogen dose in comparison to a higher nitrogen dose N-2.

Key words: foliar application of fertilizer, microelements, maize, pot experiment

INTRODUCTION

Recently in Poland there has been observed a continuous increase in maize cultivation, which can be proved by its gradually extending area, as well as by considerably higher yields [Wróbel and Korzeniowska 2008]. Taking into account the soil-climate conditions, a high yield of maize can be obtained when optimized technology of its cultivation is applied. An important element of modern cultivation systems is intensive soil fertilization supported by foliar application of fertilizers. Supplementation of microele-

ments through foliar fertilizers plays an essential role with the low content of easily-available forms of microelements in soil. Maize is the kind of plant especially sensitive to zinc insufficiency and the first plant to prove indispensability of this element for plants [Broadley *et al*. 2007]. Boron belongs to the most deficient plant nutrients, which combined with the highest deficit of this element, regarding its available forms, in the soils in Poland (79%) [Czuba 2000] can be the factor limiting high yields of maize.

The aim of the investigation, carried out as a pot experiment, was determination of the effect of foliar application of microelement fertilizer on maize yielding, as well as micro- and macroelements content in maize cobs and aboveground parts – leaves and stems.

MATERIAL AND METHODS

The pot experiment was conducted in four replications in Wagner type pots of 5 kg soil capacity. Light loam of pH 6.9 assayed in 1 M KCl·dm^{-3}, containing 22% silt and clay (<0.02 mm) was the medium used for maize growing. The content of macroelements soluble in the soil amounted to as follows: phosphorus – very high (184 mg·kg^{-1}), potassium – average (145 mg·kg^{-1}) and magnesium – average (52 mg·kg^{-1}). Phosphorus and potassium was assayed in soil according to Egner-Riehm method, while magnesium content by Schachtschabel method. Microelements soluble forms content in the soil was: manganese – low (65 mg·kg^{-1}), copper – average (6,2 mg·kg^{-1}) and zinc – high (42 mg·kg^{-1}). Microelements were assayed by Rinkis method involving shaking soil from 1 M HCl·dm^{-3}. The plant subjected to testing was maize of Blask variety collected in the caryopsis milk stage.

Before sowing maize to the soil the following fertilizing pattern was applied: nitrogen in the form of ammonium nitrate in two doses 0.8 g N per pot (N–1) and 1.6 g N per pot (N–2), phosphorus in the dose of 0.5 g P per pot, potassium – 0.75 g per pot in the form of K_2HPO_4 and magnesium amounting 0.3 g Mg per pot in the form of $MgSO_4 \cdot 7H_2O$. Within the frames of two levels of nitrogen fertilization there was introduced foliar application of Ekolist fertilizers out of which one was of multicomponent type and two others – monocomponent. Ekolist Mikro K-microelement multicomponent fertilizer contained, in weight percentage, macroelements such as N – 4%, Mg – 5%, S – 4% and microelements: Cu – 0.24%, Zn – 1.10%, Mn – 0.42%, B – 0.30%, Fe – 0.40% and Mo – 0.016%. In the experiment there were used two types of microelement monocomponent fertilizers: Ekolist Mono Zn (8% Zn, 6% N and 3% S) and Ekolst Mono B (11% B). Foliar application of fertilizer was performed by hand using water solutions of fertilizers of 10% concentration for Ekolist K and Mono B. As far as Ekolist Mono Zn is concerned, the first date of fertilization involved 10% fertilizer concentration, while for subsequent spraying 5% concentration was used.

Ekolist fertilizers were applied three times during maize growth in the assumed phenological stages: I term – 6–7 leaf stage, II term – 9–12 leaf stage, and III term – 1 jointing stage. The control object was also included in the experiment and it did not undergo any foliar fertilization. Maize was harvested after 158 days of vegetation in the development stage no. 73 according to BBCH. Separation of maize cobs together with covering leaves took place after completion of the experiment. Aboveground parts of the plant

and the cobs were subjected to grinding and dry mineralization in order to obtain ash enabling preparation of basic solution. In the latter one after mineralization the following data were assayed: P content – due to colorimetry method, as well as K, Ca and Na by flame photometry method. Magnesium, manganese, zinc and copper content was determined according to atomic absorption spectrophotometry. Boron was assayed using ICP–AES method. Total nitrogen in plant material previously wet mineralized with salicylic-sulphuric acid, was determined due to Kjeldahl method. Yield results were subjected to statistical analysis applying variance analysis and Tukey semi-interval for $\alpha = 0.05$.

RESULTS AND DISCUSSION

Foliar application of Ekolist fertilizers wih a lower nitrogen dose (N-1) did not affect the yield of maize aboveground parts as compared to the control object (tab. 1 and fig. 1).

At a higher dose of nitrogen the yield of maize did significantly increase as a result of Ekolist Mono B and Ekolist Mono Zn fertilization in comparison to fertilization with Ekolist Mikro K and to the control object (fig. 2).

Table 1.The yield of maize dry matter
Tabela 1. Plon suchej masy kukurydzy

Objects Obiekty		Total yield of maize dry matter g from one pot Łączny plon suchej masy kukurydzy g w jednym wazonie
N-1	control – kontrola	124.9
	Ekolist Mikro K	127.3
	Ekolist Mono Zn	127.8
	Ekolist Mono B	127.9
	$LSD_{0.05}$	r.n.
N-2	control – kontrola	150.4
	Ekolist Mikro K	150.8
	Ekolist Mono Zn	153.4
	Ekolist Mono B	155.9
	$LSD_{0.05}$	2.51
Mean values for nitrogen fertilization Średnie wartości dla nawożenia azotowego	N-1	127.0
	N-2	152.6
	$LSD_{0.05}$	2.35

A higher nitrogen dose significantly increased the yield of dry mass of maize in comparison to the yield obtained from the objects with a lower nitrogen dose (N-1).

Adiloglu and Adiloglu [2006] report that in the conditions of a pot experiment with boron fertilization the yield of maize dry matter decreased, while zinc application increased the mentioned yield. Mickiewicz and Wróbel [2008] report that foliar application of baron and zinc increased the yield of corn and straw of maize cultivated in monoculture. Bukovic *et al*. [2003] proved that foliar application of zinc fertilization did influence

Fig. 1. The effect of foliar application of Ekolists fertilizers on maize cultivated at lower nitrogen dose
Rys. 1. Wpływ dolistnego zastosowania nawozów Ekolist na kukurydzę uprawianą przy niższej dawce azotu

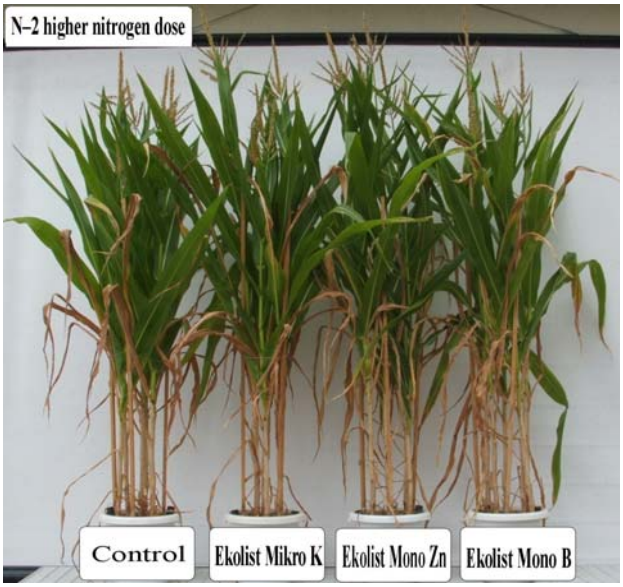

Fig. 2. The effect of foliar application of Ekolist fertilizers on maize cultivated at higher nitrogen dose
Rys. 2. Wpływ dolistnego zastosowania nawozów Ekolist na kukurydzę uprawianą przy wyższej dawce azotu

the yield of maize dry matter regarding aboveground parts of the plant according to phosphorus fertilization used. In the case of the objects not fertilized with phosphorus foliar application of zinc fertilization did increase maize yield, while on the objects with the highest phosphorus dose it increased the dry matter yield in relation to the control object. Leach and Hameleers [2001] sprayed maize at three dates with foliar fertilizer containing zinc and phosphorus, and they did not record any considerable effect on the dry matter yield of the plant cultivated. Wróbel and Korzeniowska [2008] stated that spraying maize with foliar boron fertilizer did significantly affect the increase in the maize grain yield (average 14%) on acid soil, while on the soil of a neutral reaction the increase in the maize grain yield was lower and it amounted on average to 2% for maize varieties cultivated.

Foliar application of Ekolist Mikro K fertilizer influenced an increased content of all the examined microelements, both at N-1 and N-2 nitrogen doses, leaves and stems of maize as compared to the control object (tab. 2).

Table 2. Macro- and microelements content in dry matter of leaves and stems
Tabela 2. Zawartość makro- i mikroelementów w suchej masie liści i łodyg

Objects – Obiekty		N	P	K	Ca	Mg	Zn	B	Mn	Cu
		%					$mg \cdot kg^{-1}$			
N-1	control – kontrola	0.39	0.19	1.20	0.25	0.22	37	24	47	3.1
	Ekolist Mikro K	0.39	0.15	1.42	0.25	0.20	123	38	75	18.5
	Ekolist Mono Zn	0.42	0.15	1.51	0.22	0.19	515	27	29	4.5
	Ekolist Mono B	0.48	0.17	1.59	0.25	0.18	42	388	24	3.3
N-2	control – kontrola	0.53	0.14	1.04	0.31	0.25	49	40	32	3.5
	Ekolist Mikro K	0.53	0.13	1.15	0.36	0.28	116	41	72	18.8
	Ekolist Mono Zn	0.53	0.13	1.03	0.31	0.24	311	35	26	3.0
	Ekolist Mono B	0.59	0.13	1.27	0.38	0.29	48	310	31	3.5
Mean values for nitrogen fertilization Średnie wartości nawożenia azotowego	N-1	0.42	0.17	1.43	0.24	0.20	179	183	43.7	7.36
	N-2	0.55	0.13	1.12	0.34	0.27	131	106	40.4	7.21

Foliar application of Ekolists Mono resulted in a considerable increase in the content of microelements introduced with spraying (Zn or B) in the sprayed part of maize. There was recorded an increased value of nitrogen and potassium content in aboveground parts (leaves and stems) of plants as compared to the control object, which resulted from maize spraying with Ekolist Mono B.

Analyzing the effect of nitrogen doses on the average content of macroelements in leaves and stems of maize there were observed increased values of nitrogen, calcium and magnesium under the influence of the higher nitrogen dose (N-2). Yet, the mean values of all the examined microelements contents in the sprayed part of maize were higher at a lower dose of this component (N-1).

Adiloglu *et al*. [2006] reported the increase in N, P and K content in aboveground parts of maize after maize fertilization with boron and zinc. In the conditions of water cultures Jasiewicz [1984] stated that the increase in nitrogen content in maize was accompanied by an increased demand for copper and the highest copper content in maize was recorded for NO_3^- anion present in the solution.

Wróbel and Korzeniowska [2008] proved that boron content in maize leaves caused by foliar fertilization with this element was higher in maize cultivated on acid soils. Leach and Hameleers [2001] sprayed maize with foliar fertilizer containing zinc and phosphorus in three dates recording a significant increase in zinc content in maize leaves 12–14 days after spraying.

Bukovic *et al*. [2003] spraying maize leaves with a 0.5% solution of zinc in the form of $ZnSO_4 \cdot 7H_2O$ increased zinc content in maize leaves six times as compared to this value in the control object. Wrońska *et al*. [2007] reported that the use of zinc from fertilizers and efficiency of this element were higher with a lower nitrogen dose applied for maize cultivation.

The content of all the examined microelements in maize cobs showed a tendency to increase (with an exception of Mn in the object with a higher nitrogen dose) under the influence of spraying with Ekolist Mikro K in comparison to the control object by two levels of N-fertilization (tab. 3).

Table 3. Macro- and microelements content in maize cobs
Tabela 3. Zawartość makro- i mikoelementów w kolbach kukurydzy

Objects – Obiekty		N	P	K	Ca	Mg	Zn	B	Mn	Cu
		%					$mg \cdot kg^{-1}$			
N-1	control – kontrola	1.28	0.28	0.96	0.08	0.26	79	7.5	15	2.2
	Ekolist Mikro K	1.28	0.30	1.05	0.08	0.30	85	10.2	18	4.7
	Ekolist Mono Zn	1.27	0.30	1.15	0.08	0.30	106	7.7	19	2.8
	Ekolist Mono B	1.27	0.31	1.25	0.08	0.30	86	13.3	18	2.8
N-2	control – kontrola	1.25	0.33	0.87	0.05	0.24	57	4.5	13	2.5
	Ekolist Mikro K	1.28	0.35	0.91	0.05	0.26	65	5.9	13	4.8
	Ekolist Mono Zn	1.29	0.35	0.95	0.05	0.27	71	4.7	13	2.5
	Ekolist Mono B	1.32	0.33	0.86	0.05	0.27	64	7.8	12	2.0
Mean values for nitrogen fertilization Średnie wartości nawożenia azotowego	N-1	1.28	0.30	1.10	0.08	0.29	89	9.7	17	3.1
	N-2	1.29	0.34	0.90	0.05	0.26	64	5.7	13	3.0

In maize cobs the content of Zn and B also increased as a result of Ekolist Mono Zn and B fertilization, but that increase was lower than in the case of leaves and stems of maize. There was recorded a higher mean content of microelements in cobs with a lower nitrogen dose; a similar relation was observed for aboveground (leaves and stems) of maize. As far as macroelements content is concerned, there was not recorded any directed effect of foliar fertilizer on the changes in their content in maize cobs.

Maksimow [1954] reported that an excessive dose of boron could result in a higher content of nitrogen in plants and that plant tissues insufficiently supplied with boron contain a higher percentage of nitrogen, phosphorus, iron and magnesium content than plants rich enough in boron.

CONCLUSIONS

1. Foliar application of Ekolist fertilizers at a lower nitrogen dose did not significantly affect the increase of maize dry matter yield in comparison to control object.

2. Fertilization with a higher nitrogen dose by foliar application of Ekolist Mono Zn and Ekolist Mono B fertilizers did significantly affect the increase in the dry matter yield of maize in comparison to the control object.

3. The highest content of microelements applied (Zn and B) was found in leaves and stems of maize for foliar application of Ekolist Mono.

4. Mean content of analysed microelements in aboveground parts of maize was higher by N-1 nitrogen dose in comparison to a higher nitrogen dose N-2.

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Streszczenie. Doświadczenie przeprowadzono w wazonach typu Wagner o pojemności 5 kg. Użyto gleby lekkiej zawierającej 22% mułu i gliny. Rośliną testowaną była odmiana kukurydzy Blask zebrana w mlecznej fazie ziarniaków. Model doświadczenia obejmował dolistne zastosowanie nawozów Ekolist: Mikro K, Mono Zn oraz Mono B w ramach dwóch poziomów nawożenia azotowego: 0,8 g (N1) i 1,6 (N2) na wazon oraz obiekt kontrolny bez użycia nawożenia dolistnego. Badanie pokazało, że dolistne zastosowanie nawozów Ekolist przy niższej dawce azotu nie miało istotnego wpływu na wzrost plonu suchej masy kukurydzy w porównaniu z obiektem kontrolnym. Nawożenie wyższą dawką azotu za pomocą dolistnego zastosowania Ekolist Mono Zn i Ekolist Mono B nie wpłynęło znacząco na przyrost plonu suchej masy kukurydzy w porównaniu z obiektem kontrolnym. Najwyższą zawartość zastosowanych mikroelementów (Zn i B) stwierdzono w liściach i łodygach kukurydzy przy dolistnym stosowaniu Ekolist Mono, natomiast średnia zawartość analizowanych mikroelementów w naziemnych częściach kukurydzy była wyższa przy poziomie azotu N-1 niż N-2.

Słowa kluczowe: dolistne zastosowanie nawozu, mikroelementy, kukurydza, doświadczenie wazonowe