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EFFECT OF FORM AND DOSE OF SELENIUM ON YIELDING AND CONTENTS OF MACRONUTRIENTS IN MAIZE

WPŁYW FORMY I DAWKI SELENU NA PLONOWANIE ORAZ ZAWARTOŚĆ MAKROSKŁADNIKÓW W KUKURYDZY

Abstract: The purpose of the conducted experiment was to estimate the influence of the form and dose of selenium on yielding and N, P, K, Ca, Mg and S content in the above ground parts of maize. The experiment was established in Wagner type pots with a capacity of 5 kg of soil in three replications. The substrate was a slightly acidic light loam with an average content of P, K, Mg and S and low Se content. Selenium was applied in the form of Na_2SeO_4 and Na_2SeO_3, and doses of: 0; 0.10; 0.25; 0.50; 0.75; 1.0; 2.0; 3.0 and 4.0 mg · kg^{-1} of soil. The 'Lober' strain of maize was used as a test plant and was cut down during the BBCH 73 phase.

The conducted research demonstrated that the after entering into the soil 0.1 mgSe · kg^{-1}, form in which the element was used, did not affect the weight of the harvested crop corn. At all the rest selenium dosage levels the biomass cultivated in soil enriched with sodium selenate was higher than the biomass obtained after the application of sodium selenite. The application of selenium in the form of selenate (Na_2SeO_4) and selenite (Na_2SeO_3) caused a substantial increase in the content of this trace element in maize. The effect of the selenate was such that average Se content in plants was 13 times higher than the predetermined average for maize cultivated in soil with the selenite supplement. The introduction of selenium into the soil, especially in higher doses, triggered changes in the chemical composition of the maize. With the greater doses of Se(VI) the content of nitrogen, potassium and calcium content in plants decreased. The impact of that form of selenium upon phosphorus and sulphur content depended on the size of the applied doses. Selenium introduced in doses of 0.1–0.5 mg · kg^{-1} increased the content of P and limited the amount of S. At greater doses the reverse relationship was observed. Maize cultivated in soil enriched with Na_2SeO_3 contained less nitrogen and sulphur but more phosphorus, potassium, and calcium than that cultivated in soil with the selenate supplement.

Keywords: Na_2SeO_4, Na_2SeO_3, maize, yielding, macronutrients content

Introduction

Selenium belongs to the group of elements essential to the normal development and functioning of human and animal organisms. However, it is yet to be shown that it is

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indispensable to the majority of plants [1]. The average selenium content in plants that are not its natural depository is 0.05 mg · kg^{-1}. However, when those plants are cultivated in soils or nutrient media with high Se content they can accumulate significant amounts of this microelement [1–6]. Selenium content in soil varies enormously, but in most soils it averages 0.01–2 mg · kg^{-1} [7]. Research conducted in recent years has shown that most soils in Poland contain low amounts of selenium [8, 9]. According to Piotrowska [10], Se content varies from 0.04 to 0.65 mgSe · kg^{-1}, for arable soils in the Wroclaw region Patorczyk-Pytlik and Kulczycki [9] provide a range of 0.081–0.494 mgSe · kg^{-1}, and in the soils of the Pomerania and Kujawy regions Borowska et al [8] estimated from 0.035 to 0.332 mgSe · kg^{-1} soil.

An additional reason for a low plant intake of selenium is the soils' significant acidity [11–14]. The form in which selenium appears in soils, the changes it undergoes, and its availability for plants are determined by many physicochemical factors such as: soil pH, oxidoreduction potential, contents of humus, clay minerals, Fe oxides and other elements, microbiological activity and also the nature and character of the absorbing surfaces [3, 13–15]. The best selenium uptake is from alkaline, well-aired soils, and the lowest from acidic, gleyic soils, which contain lerge amounts of organic matter [3, 11, 13, 14].

The average plant selenium content is 0.05 mg · kg^{-1}, with the exception of plants originating from regions commonly referred to as the selenium regions, seldom exceeds 1.0 mg · kg^{-1} of dry mass [3, 7, 15]. The plant selenium content is influenced mainly by three factors: Se content in soil, agents that create a Se form of appearance and also specific properties of plants [4, 13–16]. Selenium uptake occurs mainly through plant roots in the form of selenate, to a lesser extent in the form of selenite, and also in an organic form as selenocysteine and selenometionine [17]. The reason for the lower uptake of selenite than selenate may be its higher rate of absorption in soil [18]. Hawkesford and Zhao [19] report that selenates are characterized by higher solubility and mobility than selenites, and are also more often subject to washout into deeper soil layers [20]. Additionally, the uptake mechanism of these two forms is not the same. Selenate is absorbed from soil solution during an active process with use of sulphur carriers through the plasma membrane of plant roots. Selenite uptake in turn occurs during a process of passive diffusion [3, 19, 21]. Rosen and Liu [22], Li et al [23], as well as Hopper and Parker [24] report that, selenate intake proceeds like that of sulfates, and selenite intake like that of phosphates. In addition, selenite is accumulated mainly in plant roots, whereas selenate is rapidly translocated to the above ground parts [6, 25–28].

It has been shown in many studies that selenium applied in small doses (0.1 to 1.0 mg · kg^{-1}) has a beneficial effect upon plant growth and development. This may be a result of selenium impact on the glutathione peroxidase (GSH-Px) activity [2, 28], and the increase of plant stress resistance to salinity [29], UV radiation [2, 30, 31] and drought [32]. Hartikainen et al [2] in their research confirmed the stimulating effect of small doses of selenium on a common ryegrass yield, and Turakainen [33] observed the same effect on potato yield. Broadley et al [34], Ducsay et al [35], Curtin et al [36] and Grant et al [37] showed no effect of selenium on a yield of wheat.

Plants cultivated in soils/water culture with high selenium content can accumulate significant amounts of this element in their tissues. That in turn may inhibit the plants' growth and development [2, 4]. This is caused by factors such as a decrease in the amount of chlorophyll and carotenoids [6], a suppression of protein synthesis [3], a decrease in the starch content [38], disorders in the intake of the macro and microelements [5, 6, 16, 39–41].

Most of the studies regarding the impact of selenium on the accumulation of other elements is conducted using the water culture method [6, 24, 39–42] and most often encompasses the impact of one particular chemical form of selenium. It allows the precise determination of the effect of the tested agent, but does not take into account the changes, which will be underwent selenium compounds applied to the soil. Properties of the soil can substantially modify the form of the Se presence, and thereby the availability of this component for the plants.

The purpose of the research conducted was the comparison of the impact of different selenium doses introduced into the soil on the maize yield and content of Se in the above ground parts of maize, as well as the macroelements content in maize biomass. Selenium doses were introduced into the soil in the form of Na_2SeO_4 or Na_2SeO_4.

Material and methods

The experiment was conducted in Wagner pots with a capacity of 5 kg of soil. It was carried out using a completely random system with three repetitions. The substrate used was a light loam with an average content of the available phosphorus, potassium, sulphur and a low content of the available magnesium (Table 1).

Table 1

Selected properties of soil substrate

pH_{KCl}	Organic C	Available form			Total S	SO_4-S	Total Se	DTPA Se
		P	K	Mg				
	[$g \cdot kg^{-1}$]	[$mg \cdot kg^{-1}$]					[$\mu g \cdot kg^{-1}$]	
6.1	7.6	57	118	22	310	11.4	143	13.8

The total selenium content (Table 1) oscillated below the average value determined by Piotrowska [10] (280 $\mu g \cdot kg^{-1}$) and Patorczyk-Pytlik and Kulczycki [9] (206 $\mu g \cdot kg^{-1}$) for light loam. The identical mineral fertilization was applied in all the pots. The pre-sowing fertilization was applied in doses: 0.5 gN (NH_4NO_3), 0.4 gP and 0.5 gK (KH_2PO_4) and 0.3 gMg ($MgSO_4 \cdot 7H_2O$) per pot, and the top dressing with doses: 1.5 gN (NH_4NO_3), 0.5 gK (KCl) and 0.3 gMg ($MgSO_4 \cdot 7H_2O$) per pot. During the first phase of the experiment selenium was introduced into soil in the form of a water solution of Na_2SeO_4 and Na_2SeO_3, in the following doses: 0.10; 0.25; 0.50; 0.75; 1.0; 2.0; 3.0 and 4.0 mgSe $\cdot$ kg^{-1} of soil. The control object was soil with natural selenium content. When planning the amount of input of selenium in the soil mostly included the recommended dose (0.1 mg · kg^{-1}) and an amount that lets to enhance the content to the level approved as medium to high (0.25–3.0 mg · kg^{-1}) and high (4 mg · kg^{-1}) [19].

The 'Lober' strain of maize was used as a test plant. Plants were sown in a distribution of 12 seeds per pot and after 10 days that number was reduced to 6 per pot. Maize was cut down during the BBCH 73 phase. The vegetation period lasted 90 days. In order to avoid selenium losses through methylation at a temperature higher than 30 ^{o}C, the collected biomass was dried at room temperature. In the dry mass were determined: the total nitrogen content after the mineralization of the samples with the salicylic-sulphuric acid using the Kjeldahl method, and the sulphur content – using the Butters-Chenery method. After the mineralization of the samples at a temperature of 450 ^{o}C the ash was dissolved in a 1 mol · dm^{-3} of HNO_3 solution. In obtained solutions the following elements were determined: the phosphorus by the calorimetric vanadium-molybdenum method, the potassium and calcium content by the emissive spectrophotometric method using a AAS 3 apparatus, and the magnesium by the atomic-absorption spectrophotometric method using a Spectra 220 FS Varian apparatus. The selenium content was determined according to procedures specified in the annex to an ordinance from the Ministry of Agriculture dating on 23rd January, 2003 [43]. The measurement of the selenium concentration was done by the AAS method in conjunction with a generation of hydrides using the SpectrAA FS Varian apparatus with a VGA-76 add-on.

All the measurements were performed twice for each pot and the results shown in the tables are their averages. The certified plant material INCT-TL-1 was used to appraise the mineralization and measurement conditions. The statistical analysis was performed using the STATISTICA 8.0 and Microsoft Office Excel 2010 programs. The simple correlation coefficients were calculated at a significance level of $p \leq 0.05$ and the two-factor variation analysis was performed using the Duncan test.

Results and discussion

The research conducted showed that the amount of maize yield was dependent on the form and dose of the applied selenium (Table 2).

After entering into the soil 0.1 mgSe · kg^{-1}, form in which the element was used, did not affect the harvested crop of maize. At all the rest selenium dosage yield of maize cultivated in soil enriched with sodium selenate was higher than amount of biomass obtained after the application of sodium selenite. Ramos et al [28] and Xue et al [31] confirmed a similar dependency in their research. However, in studies conducted by Sharma et al [44] rape in the blooming phase produced more mass when it was cultivated in soil with added Na_2SeO_3, than with Na_2SeO_4. Also Cartes et al [26] showed that selenite applied in doses up to 10 mg · kg^{-1} of soil did not have any effect upon ryegrass yield. However, a dose of 2 mg · kg^{-1} of selenium introduced in the form of selenate inhibited plant growth. This shows that different plant species react differently to selenium present in soil.

Comparing the yield-forming activity of both selenium chemical forms shows that the application of this element in the form of Na_2SeO_4 did not limit plant growth. The

Table 2

Effects of form and dose of selenium on the amount of yield and on the Se content in above ground parts of maize

Dose of Se [mg · kg^{-1} of soil]	Yield [g d.m. per pot]			Content of selenium [mg · kg^{-1} d.m.]		
	Na_2SeO_4	Na_2SeO_3	Means for doses	Na_2SeO_4	Na_2SeO_3	Means for doses
0	217.3		217.3	0.095		0.095
0.1	219.2	220.2	219.7	0.758	0.184	0.47
0.25	232.2	218.5	225.4	1.524	0.215	0.87
0.50	215.0	212.0	213.5	2.573	0.246	1.41
0.75	211.5	201.8	206.7	3.842	0.303	2.07
1.0	213.7	195.6	204.7	5.061	0.448	2.75
2.0	212.4	185.7	199.1	10.780	0.645	5.71
3.0	210.6	186.0	198.3	18.796	1.050	9.92
4.0	209.6	185.0	197.3	20.469	1.774	11.12
Means for forms	215.7	202.5	—	7.100	0.551	—
$LSD_{0.05}$ for:	Se form – 2.32; Se dose – 8.04; interaction – 7.80			Se form – 0.060; Se dose – 0.21; interaction – 0.28		

maize yield grown in soil with a dose up to 0.25 mgSe · kg^{-1} applied was significantly greater than that from the control object. A positive impact of small selenium doses on plant yield was also confirmed by other authors [2, 7, 28, 42]. In the experiment the test plants reacted differently to selenite. The addition of low selenium doses (0.1 and 0.25 mgSe · kg^{-1}) as Na_2SeO_3 to the soil did not affected the biomass yield of maize harvested in comparison with the control object. However, the increase of the applied Se in that form limited the maize yield. The yield of plants cultivated in soils with the addition of doses 2.0; 3.0 and 4.0 mgSe · kg^{-1} was the same and about 15 % less than that obtained from the control object.

The research conducted confirmed, as cited in the literature [1–4, 6, 14–16, 18, 27, 35, 38, 42], the high plant ability to accumulate selenium when cultivated in soils with high Se content. It was shown that the addition of selenium to soil in both forms (Na_2SeO_4 and Na_2SeO_3) contributed to the significant increase of that element content in maize above ground parts (Table 2). In the conditions of executed test, the average Se content in the above ground parts of plants taken from objects with Se(VI) addition was almost 13 times higher than the predetermined average for maize collected from soil where selenite had been added. Similar dependencies were also shown by other authors [26, 28, 44]. After addition of 0.1 mgSe · kg^{-1} in the form of selenate, this element content in plants was 8 times higher, and after the highest dose (4 mgSe · kg^{-1}) was over 200 times higher than the predetermined content in maize from the control treatment (Table 2). Under the same conditions selenite application caused an increase of Se content of 2 and 18 times, respectively. The reason for the smaller plant uptake of selenium from selenite than from selenate probably is the significant sorption of that form in soil [18, 45], and also different mechanisms of their uptake [3, 22–24, 28], as was previously mentioned.

The introduction of selenium into soil, especially at higher doses caused changes in the chemical composition of the cultivated maize. The maize nitrogen content decreased together with an increase of the selenium doses (Table 3).

Table 3

Effect of form and dose of selenium on the N, K and Ca content in maize

Se dose [mg · kg^{-1}]	N			K			Ca		
	[g · kg^{-1} d.m.]								
	Na_2SeO_4	Na_2SeO_3	Mean	Na_2SeO_4	Na_2SeO_3	Mean	Na_2SeO_4	Na_2SeO_3	Mean
0	11.7		11.7	12.4		12.4	0.504		0.504
0.1	11.2	9.8	10.5	10.6	11.6	11.1	0.550	0.519	0.534
0.25	10.7	9.6	10.2	10.1	11.2	10.7	0.488	0.670	0.579
0.5	9.8	9.3	9.6	9.0	10.6	9.8	0.460	0.632	0.546
0.75	10.0	9.1	9.6	8.6	8.8	8.7	0.435	0.550	0.493
1.0	9.8	9.1	9.5	8.4	8.4	8.4	0.426	0.552	0.489
2.0	9.4	9.0	9.2	8.2	8.0	8.1	0.407	0.552	0.479
3.0	9.3	8.6	8.9	8.0	8.0	8.0	0.405	0.524	0.465
4.0	9.2	7.5	8.4	7.9	8.0	7.9	0.394	0.526	0.460
Mean	10.1	9.3	—	9.3	9.7	—	0.452	0.559	—
$LSD_{0.05}$ for:	form – 0.12; dose – 0.23; interaction – 0.32			form – 0.14; dose – 0.20; interaction – 0.29			form – 0.005; dose – 0.012; interaction – 0.017		

It was found that selenite limited the accumulation of N more than selenate, since after the application of its highest dose in the form of Na_2SeO_4 the nitrogen content decreased by 21 % in comparison with the plants from the control object. After it application in the form of Na_2SeO_3 the nitrogen content was smaller by 36 %. The reduction of the nitrogen content in mustard with increasing higher doses of selenium was confirmed by Singh [46], and in barley by IIbas et al [16].

The introduction of increasingly higher selenium doses caused a decrease of the potassium content in maize (Table 3). A similar dependency was demonstrated by other authors [5, 39, 42]. However, Zembala et al [40] did not confirm an impact of selenium on the accumulation of potassium. In the studies conducted by Kopsell et al [41] an increase of potassium content was observed after the addition of Na_2SeO_4 to the nutrient medium. The differences between the impact of selenate and selenite on the accumulation of potassium occurred only after the application of small doses. The potassium content in plants collected from soils to which doses of 0.1; 0.25 and 0.5 mgSe · kg^{-1} were applied in the form of Na_2SeO_3 was lower than the predetermined content in the plants from the control treatment. However, it was significantly higher than in maize grown in soil to which the Se doses were introduced in the form of Na_2SeO_4.

The greater average calcium content was observed in plants cultivated in soils with the addition of selenite than after selenate application (Table 3). In comparison with the content determined in the control plants, an increase in the content of calcium occurred only in maize collected from soil with the addition of selenium in the form of Na_2SeO_4 and a dose of 0.1 mg · kg^{-1}. The continued increase of the amount of selenium caused a decrease in the Ca accumulation. Plants collected from soil with 4.0 mgSe · kg^{-1} addition contained 22 % less Ca than those from the control object. Filek et al [39] also demonstrated a diminish in the calcium content in rape after the addition of Na_2SeO_4 to the nutrient medium. However, in the studies of Zembala et al [40] selenate did not cause any difference in the amounts of Ca accumulated in the above ground parts of rape and wheat.

In comparison with the control object, only when the dose of 0.25 mgSe · kg^{-1} was applied in the form of Na_2SeO_3, increased calcium contents in the plants were found. Bigger doses of selenium introduced into soil caused a slow decrease in the amount of accumulated calcium. However, these amounts were significantly greater than those determined in the plant biomass from the control treatment.

The average magnesium content in the above ground parts of plants collected from soils where selenates and selenites were added, were about the same but higher than those found in maize from the control object (Table 4).

Table 4

Effect of form and dose of selenium on the Mg, P and S content in maize

Se dose [mg · kg^{-1}]	Mg			P			S		
	[g · kg^{-1} d.m.]								
	Na_2SeO_4	Na_2SeO_3	Mean	Na_2SeO_4	Na_2SeO_3	Mean	Na_2SeO_4	Na_2SeO_3	Mean
0	0.158		0.158	2.62		2.62	1.275		1.275
0.1	0.167	0.151	0.159	2.85	3.15	3.00	1.091	1.362	1.227
0.25	0.161	0.173	0.167	2.91	3.62	3.27	0.997	1.025	1.011
0.5	0.166	0.178	0.172	3.05	3.94	3.50	0.819	0.997	0.908
0.75	0.169	0.180	0.174	2.94	4.20	3.57	1.113	0.822	0.968
1.0	0.163	0.182	0.172	2.96	4.28	3.62	1.171	0.579	0.875
2.0	0.170	0.168	0.169	2.85	4.25	3.55	1.544	0.506	1.025
3.0	0.176	0.161	0.168	2.74	4.40	3.57	1.828	0.647	1.238
4.0	0.179	0.160	0.170	2.62	4.35	3.49	1.950	0.806	1.378
Mean	0.168	0.168	—	2.84	3.87	—	1.310	0.891	—
$LSD_{0.05}$ for:	form – i.d.; dose – 0.005; interaction – 0.008			form – 0.13; dose – 0.18; interaction – 0.26			form – 0.026; dose – 0.042; interaction – 0.061		

Explanation: i.d. – insignificant difference.

The magnesium content in plants increased with the selenate dose. In maize cultivated in soil enriched with Na_2SeO_3, such dependency occurred only up to a dose of 1.0 mgSe · kg^{-1}. With higher selenium doses the magnesium content oscillated around the same level for all objects (Table 4). The research of Feng et al [5] with *Pteris vittata* L. as the test plant, shows that addition of selenium in the form of Na_2SeO_3 and a dose of up to 20 mg · kg^{-1} of soil limited magnesium accumulation. Similar dependency for rape cultivated in a nutritional medium enriched with Na_2SeO_4 was demonstrated by Filek et al [39] and for wheat by Zembala et al [40].

Se addition also caused a difference in the phosphorus content of maize (Table 4). In comparison with plants grown in soil fertilized with selenate, the average P content was greater in plants from objects with selenite application. The lower doses of Na_2SeO_4 (0.1–2.0 mgSe · kg^{-1}) caused an increase, while the higher ones limited the phosphorus content in the above ground parts of maize in comparison with plants collected from the control object. After the application of 4 mgSe · kg^{-1} of soil the P content became the same as that determined in maize collected from the control object. The diminish in phosphorus content as a result of increased selenium(VI) amount in medium was also discovered by Kopsell et al [2000] in *Brassica oleracea* and Filek et al [39] in rape.

As opposed to the results obtained by Hopper and Parker [24], who discovered the phenomenon of antagonism between SeO_3^{2-} and PO_4^{2-} ions in their research using the water culture method, the phosphorus content in plants would increase with higher doses of Na_2SeO_3.

Similar geochemical properties of sulphur and selenium are the reason that their uptake by plants is determined by the quantitative ratio of their contents in soil or in the nutrient medium [3, 24, 47–49]. This dependency was confirmed by the research conducted (Table 5).

Table 5

Simple correlation coefficients between amount of yield, selenium content, and macroelement content

Specification	Content of Se after application of	
	Na_2SeO_4	Na_2SeO_3
Yield	–0.52	–0.76
N	–0.76	–0.78
P	–0.37	0.58
K	–0.70	–0.71
S	0.91	–0.49
Ca	–0.78	i.d.
Mg	0.76	i.d.

Explanation: Significant difference at $p < 0.05$; i.d. – insignificant difference.

On the basis of sulfur and selenium contents in the soil used as substrate in the experiment (Table 1) and the quantity of delivered Se dose was calculated that as a result of Se addition was narrowing S:Se ratio from 2168:1 in control soil to 75:1 after application of 4 mgSe · kg^{-1}.

The calculated average of object sulphur content in maize (Table 4) showed that Se introduced into soil in the form of selenite limits in larger degree S accumulation by maize than the selenate. Hawrylak-Nowak [6] and Rios et al [49] observed similar dependencies for lettuce.

In comparison with the plants collected from the control object, the sulphur content decreased with an increase of selenate doses up to 0.5 mgSe $\cdot$ kg^{-1}. An introduction of 0.75 and 1.0 mgSe $\cdot$ kg^{-1} into the soil caused the greater Se accumulation in maize biomass than that specified in plants collected from the soil with a supplement of 0.5 mgSe $\cdot$ kg^{-1}, but substantially smaller than that determined in plants grown in the control object.

Only when the selenium addition to the substrate was increased to 2.0; 3.0 and 4.0 mgSe $\cdot$ kg^{-1}, a significant increase in the sulphur content in maize was observed. A distinct reaction was observed in maize grown in soil enriched with Na_2SeO_3. The introduction of 0.1 mgSe $\cdot$ kg^{-1} of soil generated a significant increase in the sulphur content in those plants in comparison with the plants grown in the control object. A substantial decrease of the sulphur content in the above ground parts of maize followed an increase of Se doses from 0.25 to 2 mgSe $\cdot$ kg^{-1}. The biggest dose of selenate (4 mgSe $\cdot$ kg^{-1}) resulted in an increase of the S content in above ground parts of maize in comparison to a smaller dose of this element, but was still smaller than that specified in the control plants.

The presence of the ionic antagonistic/synergistic reaction according to the ratio of these elements in soil or nutrient medium and the applied form of selenium was also discovered by the other authors [6, 24, 47, 48].

The statistical analysis conducted demonstrated that the plant yield was significantly and negatively correlated with the selenium content in maize (Table 5). The greater value of correlation coefficient values stated for selenite than for selenate demonstrate that first Se form limited more plant yield. The effect of selenium introduced into soil on the content of the studied macroelements in maize biomass depended on the form in which it was applied. The phosphorus content in the above ground parts of maize was significantly and negatively correlated with the selenium quantity introduced in the form of selenite, however positively correlated when selenate was applied. The opposite dependency was determined for the sulphur content in plants. The Na_2SeO_4 introduced into the soil limited the content of N, P, K and Ca in maize biomass but stimulated the accumulation of S and Mg. After the application of Na_2SeO_3 the N, K and S content in maize turned out to be negatively correlated with the selenium content and the opposite affected phosphorus content which was positively correlated with dose of S applied as selenite.

Conclusions

The research conducted confirmed that maize should be classified as a group of plant which in the conditions of their cultivation in soils with a high content of selenium will contain substantial amounts of this element. This property should be taken into account when planning fertilization with this element. Even the highest Se dose (4 mg $\cdot$ kg^{-1})

used in a form of Na_2SeO_4 was not critical one for the yield of maize, while 1 mgSe · kg^{-1} in the form of Na_2SeO_3 resulted in a 10 % decrease in the amount of harvested mass. The content of selenium in maize grown on soil with 0.1 to 0.75 mgSe · kg^{-1} addition in form of Na_2SeO_3 was optimal for the quality of feed, but already 0.1 mgSe · kg^{-1} in the form of Na_2SeO_4 resulted in exceeding this value. The application of both selenium compounds resulted in changes of the chemical composition of a plant, from that selenite to a much greater extent than selenate limited the content of nitrogen and sulfur, however resulted in increase of calcium and phosphorus content in maize biomass.

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WPŁYW FORMY I DAWKI SELENU NA PLONOWANIE ORAZ ZAWARTOŚĆ MAKROSKŁADNIKÓW W KUKURYDZY

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Abstrakt: Celem przeprowadzonych badań była ocena wpływu formy i dawki wprowadzonego do gleby selenu na plonowanie oraz zawartość N, P, K, Ca, Mg i S w częściach nadziemnych kukurydzy. Doświadczenie założono w wazonach typu Wagnera o pojemności 5 kg gleby, w trzech powtórzeniach. Podłożem była lekko kwaśna glina lekka, wykazująca średnią zasobność w P, K, Mg i S oraz niską zasobność w Se. Selen zastosowano w formie Na_2SeO_4 i Na_2SeO_3 w dawkach: 0; 0,1; 0,25; 0,50; 0,75; 1,0; 2,0; 3,0 i 4,0 $mg \cdot kg^{-1}$ gleby. Rośliną testową była kukurydza odmiany 'Lober', zebrana w fazie BBCH 73.

Przeprowadzone badania wykazały, że po wprowadzeniu do gleby 0,1 $mgSe \cdot kg^{-1}$, forma w jakiej ten pierwiastek był zastosowany, nie miała wpływu na wielkość zebranego plonu biomasy kukurydzy. Pozostałe dodatki tego mikroelementu zwiększały istotnie plony biomasy roślin uprawianych na glebie z dodatkiem selenianu(VI) sodu w większym stopniu niż po zastosowaniu selenianu(IV) sodu. Zastosowanie selenu zarówno w postaci Na_2SeO_4, jak i Na_2SeO_3 spowodował istotne zwiększenie zawartości tego mikroelementu w kukurydzy. Pod wpływem selenianu(VI) średnia zawartość Se w roślinach była 13 razy większa od średniej zawartości w biomasie kukurydzy uprawianej na glebie z dodatkiem selenianu(IV). Wprowadzenie do gleby selenu, zwłaszcza jego większych dawek, spowodowało zmiany składu chemicznego uprawianej kukurydzy.

Wraz ze zwiększaniem dawki selenianu(VI) zmniejszała się zawartość azotu, potasu i wapnia w częściach nadziemnych roślin. Wpływ tej formy Se na zawartość fosforu i siarki zależał od wielkości zastosowanej dawki. Selen wprowadzony w dawkach 0,1–0,5 mg · kg^{-1} zwiększał zawartość P oraz ograniczał zawartość S. Po zastosowaniu większych dawek selenu zanotowano odwrotną zależność. Kukurydza uprawiana na glebie wzbogaconej w Na_2SeO_3 zawierała mniej azotu i siarki, a więcej P, K i Ca niż uprawiana na glebie z dodatkiem selenianu(VI).

Słowa kluczowe: Na_2SeO_4, Na_2SeO_3, kukurydza, plonowanie, zawartość makroskładników