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ORIGINAL PAPER

EFFECT OF FERTILIZATION ON THE Mo CONTENT IN POTATO TUBERS *(SOLANUM TUBEROSUM* L.) AND IN BIOMASS OF SUNFLOWER *(HELIANTHUS ANNUUS* L.) CULTIVATED ON A LUVISOL FORMED FROM LOESS*

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Abstract

Plant demand for molybdenum is small, but it is a micronutrient of great significance for the proper development and functioning of organisms. Its deficiencies may disturb the absorption and influence of other elements on living organisms. The availability of molybdenum for plants depends on many factors, including the fertilization used. The aim of the study was to determine the effect of liming and differentiated NPK mineral fertilization against the background of a constant level of Mg fertilization on the molybdenum content in potato tubers and in the green mass of fodder sunflower grown on loess soil in four and three rotations, respectively. The research was carried out as a long-term experiment on a field owned by the University of Rzeszow in Krasne near Rzeszow (Rzeszow Foothills). The soil on which the research was carried out was a Haplic Luvisols formed from loess. The experiment was set up in a random sub-block design with four replicates. The first variable factor was liming (A_2) or its lack (A_1), while the second one consisted of different doses of mineral fertilization (14 fertilizer objects) with constant magnesium nutrition. Triple superphosphate contained significant amounts of molybdenum: from traces to 18 mg Mo kg^{-1}. Plant samples were collected after potato and sunflower harvest from four rotations. Molybdenum in dry plant material was determined colorimetrically with the thiocyanate method. The molybdenum content in potato tubers ranged from 0.147 to 0.573 mg kg^{-1}, being much higher in the green mass of fodder sunflower, where it ranged from 0.467 to 2.280 mg kg^{-1}. Liming increased the molybdenum content in the green mass of fodder sunflower. This treatment caused significant changes in the content of this

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element in potato tubers. The mineral fertilization of NPK (regardless of liming) increased the molybdenum content in the green mass of fodder sunflower and in potato tubers compared to the object without mineral fertilization.

Keywords: molybdenum, liming, mineral fertilization, potato, fodder sunflower.

INTRODUCTION

Molybdenum is an element highly dispersed in the earth's crust and slowly activated during weathering processes. The content of molybdenum in soil ranges from 1 to 8 mg kg^{-1}, but the maximum values can be up to 300 mg kg^{-1}. Organic soil, clay minerals, Al, Fe and Mn oxides, as well as some cations (Pb^{2+}, Mn^{2+}, Cu^{2+}, Zn^{2+}, Ca^{2+}) and $CaCO_3$ participate in its binding within soil after its application to soil in excessive doses (Kabata-Pendias 1999, Kaiser et al. 2005). These properties are a direct cause of the relative molybdenum concentration in surface soil levels in relation to its occurrence in rocks (Kabata-Pendias 1999). Skarpa et al. (2013) indicate from 0.4 to 1.0 mg kg^{-1} as optimal content in soil for this element.

Plant demand for molybdenum is small, but it is a micronutrient of great significance for the proper development and functioning of organisms, and molybdate nutrition has an impact on plants globally (Bittner 2014). Its deficiencies may disturb the absorption and influence of other elements on living organisms. Among more than 50 Mo-containing enzymes known in all organisms, the vast majority are associated with Fe metabolism (Hille 2013). A large group of these enzymes participate in oxygen transfer (Hille 2013). In plants, molybdenum is a component of nitrogenase and nitrate reductase, i.e. the key enzymes that participate in nitrogen assimilation and nitrate reduction in higher plants (Haque 1987, O'Sullivan et al. 1997, Westermann 2005, Anke, Seifert 2007). It also activates xanthine dehydrogenase and xanthine oxidase, which play a key role in purine metabolism, widespread in animals and humans (Haque 1987). Along with iron and sulfur, molybdenum seems to interact closely at various levels within the common metabolic network (Bittner 2014). Molybdenum itself appears to be biologically inactive unless it is complexed by a cofactor that binds to various apoproteins, so that the Mo center can interact with other components of the enzyme electron transport chain (Mendel, Hänsch 2002).

Molybdenum is taken up by plants in the form of molybdate ions: MoO_4^{2-}, $HMoO_4^{-}$ (Bodi et al. 2015, Rutkowska et al. 2017). Plants take up molybdate ions in proportion to its concentration in the soil solution. Despite the lack of direct evidence, there is an implication in favour of active uptake of Mo by plants. In long distance transport, Mo is easily transferred via the xylem as well as the phloem of plants, but the form in which this element is transported is unknown (Balík et al. 2006).

The availability of molybdenum for plants depends on many factors, e.g. the content of this element in the soil, soil's pH value, content of organic matter, amounts of iron oxides, manganese and aluminium, soil textural composition as well as interaction of nutrients and degree of water drainage (Haque 1987, Kaiser et al. 2005, Anke, Seifert 2007, Shinmachi et al. 2010, Bittner 2014, Bodi et al. 2015, Rutkowska et al. 2017).

Plants growing on soils with lower pH values as well as on loess soils, sandy deluvial formations and alluvial riverside soils contain less molybdenum (Anke, Seifert 2007, Rutkowska et al. 2017). There are areas, such as northern plains in China, where alkaline soils show molybdenum deficiency (Zheng et al. 1983). Liming applied to acidic soils increases the availability of molybdenum for plants (Kabata-Pendias 1999, Kaiser et al. 2005, Upjohn et al. 2005, Bodi et al. 2015), but deficiencies of this element may occur in soils with a pH below 5.0 and in very weathered soils (Steiner, Zoz 2015). However, the use of higher doses of lime may cause its adsorption to $CaCO_3$ (Kaiser et al. 2005).

Plants fed molybdenum produce more viable pollen. Deficiency of this element contributes to incorrect plant reproduction and disruption of nitrogen and phosphorus metabolism, which leads to disorders of nitrogen metabolism and reduction in the amount of protein in a plant. Then, plants (including sweet potatoes) show signs of nitrogen deficiency, i.e. chlorosis, growth retardation or small leaves (O'Sullivan et al. 1997). In contrast, symptoms of molybdenum excess in plants are rare (Kaiser et al. 2005).

Potatoes, same as carrots, celery, rice and peaches, belong to plants tolerant to molybdenum deficiency, unlike lettuce, cauliflower, broccoli or legumes (peas, beans), in which molybdenum plays an important role in nitrogen metabolism (Haque 1987). Legumes, which accumulate more molybdenum than grasses and herbs, gather most of this element in roots (Anke, Seifert 2007). Liming and magnesium treatment of strongly acidic brown soil and the use of combined calcium and magnesium fertilization resulted in a multiple increase in the molybdenum content in aerial parts of sunflower (Gorlach, Gorlach 1983).

Addition of molybdenum to Chernozems containing $CaCO_3$ caused an increase in the content of this element in roots and shoots of sunflower (O'Sullivan et al. 1997). Foliar application of molybdenum is more effective than soil dressing (Valenciano et al. 2011). It increases the nitrogen uptake and sunflower yield, especially on acidic soils, and is most effective when used in the early stages of plant development (Steiner, Zoz 2015). Foliar application of molybdenum in plants growing on soils with slightly acidic to neutral reaction, increased the yield of sunflower and its content in dry matter of leaves (ten and more times) and stems (several times). It also had a positive effect on the production of achenes and their oil content (Skarpa et al. 2013). Early symptoms of molybdenum deficiency in sunflower are leaf pallor, followed by yellowing, drying out and the appearance of burnt edges as a result of nitrate accumulation (Weir 2004).

Molybdenum deficiency is rarely seen in humans, and the main symptoms of Mo deficiency are tachycardia, headache, psychiatric disorders and coma (Gupta et al. 2011). Feeding animals with a feed containing a high Mo content causes toxicity, often associated with Cu deficiency (Kaiser et al. 2005, Gupta et al. 2011).

The aim of the study was to determine the effect of liming and differentiated NPK mineral fertilization against the background of constant Mg fertilization, on the molybdenum content in potato tubers and in the green mass of fodder sunflower grown on loess soil in four and three rotations, respectively.

MATERIAL AND METHODS

The research was carried out as a long-term experiment on a field owned by the University of Rzeszow in Krasne near Rzeszow, situated in the Rzeszow Foothills (50°02′ N; 22°03′ E, 220 m a.s.l.).

The soil on which the research was carried out was a Luvisol formed from loess (*Haplic luvisol* according to IUSS Working Group WRB (2015)). The textural composition analysis showed an average of 8% sand fraction, 78% silt fraction and 14% clay fraction. Prior to the experiment (the year 1986), the soil was characterized by very high acidification: pH_{KCl} = 3.92 in the plough humus horizon (Ap) and pH_{KCl} = 3.89 in the enrichment horizon (Bt), with considerable values of hydrolytic acidity: 4.87 cmol (+) kg^{-1} in the Ap horizon and 3.6 cmol (+) kg^{-1} in the Bt horizon. The soil was low in available P and K, but moderately rich in available magnesium, and contained 0.87 g kg^{-1} DM total N and 7.6 g kg^{-1} DM organic C (Kaniuczak 1998). Before the experiment, the bulk density of soil was 1.405 Mg m^{-3}, porosity equalled 45.33 m^3 100 m^{-3}, and the water content at $pF_{2.0}$ was 24.17 kg 100 kg^{-1}. Regarding micronutrients, the concentrations of available boron, zinc and molybdenum (Mo soluble in 1 mol HCl dm^{-3}: 0.08 mg kg^{-1}) were low, but the soil was rich in available manganese and copper.

The experiment was set up in a randomized split-plot design with four replicates. The first variable factor was liming (A_2) or its lack (A_1), while the second one consisted of different doses of mineral fertilization (14 fertilizer objects) with constant magnesium nutrition. The following crops were cultivated in a crop rotation system: potato, spring barley, fodder sunflower (fodder cabbage in the 1st crop rotation cycle) and winter wheat. The study covered 4 crop rotation cycles (for sunflower three rotations).

Basic doses of mineral fertilization $N_1P_1K_1$ with constant magnesium nutrition were as follows: potato: N_1 = 120 kg N, P_1 = 43.6 kg P, K_1 = 132.8 kg K ha^{-1}, spring barley: N_1 = 80 kg N, P_1 = 43.6 kg P, K_1 = 99.6 kg K ha^{-1}, fodder sunflower: N_1 = 100 kg N, P_1 = 34.9 kg P, K_1 = 99.6 kg K ha^{-1}, winter wheat: N_1 = 90 kg N, P_1 = 34.9 kg P, K_1 = 83.0 kg K ha^{-1}. Constant magnesium fertilization was applied before sowing in each experimental sub-block at a 24.1 kg Mg ha^{-1} for potato, spring barley and winter wheat, and a 72.4 kg Mg ha^{-1} for fodder crops. From 1994 on, the magnesium dose was reduced to 24.1 kg Mg ha^{-1}, applied to all experimental crops. Liming with a relative dose of 4 t CaO ha^{-1} was used prior to the experiment and after the harvest of the last crop in a rotation. Mineral fertilizers NPK, Mg and Ca were applied in forms of ammonium nitrate, triple superphosphate, potassium salt KCl (58%), magnesium sulfate and CaO or $CaCO_3$ (dose to according 1 value of the hydrolytic acidity). Of the fertilizers used, only the triple superphosphate contained significant amounts of molybdenum: from traces to 18 mg Mo kg^{-1}.

Plant samples were collected after potato and sunflower harvest. Molybdenum in the dry plant material was determined colorimetrically with the thiocyanate method according to the procedure described by Czuba et al. (1970) and using analytical grade reagents. The accuracy of the method was estimated by comparing the result of the SRM 1547 – Peach Leaves analysis, to ensure that the obtained Mo content did not differ by more than 9.6% of the certified value.

The results were presented as medium and value ranges and statistically processed using a two-factor analysis of variance (liming, mineral NPK fertilization), calculating the lowest significant difference with the Tukey's tests at the significance level of p = 0.05. The calculations were performed using the software Statistica v.13 and Microsoft Excel 2013.

RESULTS AND DISCUSSION

The molybdenum content in potato tubers grown on the non-limed soil ranged from 0.223 to 0.343 mg kg^{-1}, with an average content of 0.287 mg kg^{-1} (Table 1). In potato tubers originated from the limed soil, the molybdenum content was in a wider range, i.e. from 0.147 to 0.573 mg kg^{-1}, with an average of 0.321 mg kg^{-1}. Liming did not have a statistically proven effect increasing the content of this element in the plant. Liming caused an increase in the molybdenum content in potato tubers grown on loessial soil (Kaniuczak 1996). Mercik (1969) showed a distinct increase in the molybdenum content in potatoes under the influence of liming used in a long-term of field experiments conducted in Skierniewice.

The molybdenum content in the green mass of fodder sunflower grown on non-limed soil was much higher and ranged from 0.467 to 1.327 mg kg^{-1}, with an average of 0.970 mg kg^{-1} (Table 2). In the same plant cultivated on limed soil, the content of this element ranged from 1.060 to 2.280 mg kg^{-1} with an average of 1.568 mg kg^{-1}. The impact of liming in this case was sta-

Table 1

Content of molybdenum in potato tubers cultivated on loessial soil (mg kg^{-1} DM)

No.	Treatments of fertilizers (B)	A_1		A_2		Mean (B)
		mean	range	mean	range	
1.	$N_0 P_0 K_0$	0.247	0.17-0.39	0.243	0.20-0.32	0.245
Increasing doses of N at constant P and K						
2.	$N_0 P_1 K_1$	0.260	0.19-0.39	0.297	0.20-0.46	0.278
3.	$N_{0,5} P_1 K_1$	0.313	0.25-0.38	0.467	0.28-0.72	0.390
4.	$N_1 P_1 K_1$	0.287	0.20-0.42	0.243	0.20-0.28	0.265
5.	$N_{1,5} P_1 K_1$	0.223	0.14-0.38	0.147	0.08-0.20	0.185
Increasing doses of P at constant N and K						
6.	$N_1 P_0 K_1$	0.340	0.30-0.40	0.573	0.48-0.72	0.457
7.	$N_1 P_{0,5} K_1$	0.240	0.17-0.37	0.227	0.20-0.28	0.234
4.	$N_1 P_1 K_1$	0.287	0.20-0.42	0.243	0.20-0.28	0.265
8.	$N_1 P_{1,5} K_1$	0.343	0.31-0.38	0.413	0.32-0.52	0.378
Increasing doses of K at constant N and P						
9.	$N_1 P_1 K_0$	0.250	0.17-0.40	0.310	0.20-0.52	0.280
10.	$N_1 P_1 K_{0,5}$	0.327	0.26-0.37	0.313	0.20-0.38	0.320
4.	$N_1 P_1 K_1$	0.287	0.20-0.42	0.243	0.20-0.28	0.265
11.	$N_1 P_1 K_{1,5}$	0.327	0.28-0.36	0.447	0.40-0.52	0.387
Increasing doses of N, P and K						
1.	$N_0 P_0 K_0$	0.247	0.17-0.39	0.243	0.20-0.32	0.245
12.	$N_{0,5} P_{0,5} K_{0,5}$	0.307	0.11-0.41	0.260	0.10-0.48	0.283
4.	$N_1 P_1 K_1$	0.287	0.20-0.42	0.243	0.20-0.28	0.265
13.	$N_{1,5} P_{1,5} K_{1,5}$	0.277	0.20-0.42	0.273	0.20-0.36	0.275
14.	$N_2 P_2 K_2$	0.273	0.21-0.39	0.280	0.26-0.30	0.277
Mean(A)		0.287	-	0.321	-	-
LSD		A = n.s, B = 0.080 A x B = n.s				

A_1 – NPK fertilization + Mg constans, A_2 – NPK fertilization +Mg Ca constans, LSD – lowest significant difference for: A – liming, B – mineral fertilization (irrespective from liming), AB – interaction between liming and mineral fertilization, n.s. – no significant differences

tistically significant, with the average molybdenum content in sunflower biomass increasing more than threefold. Gorlach and Gorlach (1983) showed a multiple increase in the molybdenum content in the aerial parts of sunflower grown on strongly acidic brown soils after the application of calcium carbonate. In contrast, magnesium treatment ($MgCO_3$) had an even stronger effect in this respect. More rapid reaction changes may occur in magnesium-treated soil, resulting in an increased molybdenum solubility in comparison with limed soil. In our research, fixed Mg fertilization (72.4 kg ha^{-1})

Table 2

Content of molybdenum in green mass of sunflower cultivated on loessial soil (mg kg^{-1} DM)

No.	Treatments of fertilizers (B)	A_1		A_2		Mean (B)
		mean	range	mean	range	
1.	$N_0P_0K_0$	0.467	0.40-0.70	1.167	1.12-1.20	0.817
Increasing doses of N at constant P and K						
2.	$N_0P_1K_1$	0.800	0.78-0.82	1.603	1.56-1.64	1.202
3.	$N_{0,5}P_1K_1$	0.567	0.52-0.60	2.280	2.10-2.44	1.423
4.	$N_1P_1K_1$	0.943	0.85-1.08	2.207	2.10-2.32	1.575
5.	$N_{1,5}P_1K_1$	1.010	0.90-1.12	2.000	1.90-2.20	1.505
Increasing doses of P at constant N and K						
6.	$N_1P_0K_1$	0.713	0.68-0.74	1.060	1.00-1.10	0.887
7.	$N_1P_{0,5}K_1$	1.170	1.05-1.36	1.210	1.18-1.25	1.190
4.	$N_1P_1K_1$	0.943	0.85-1.08	2.207	2.10-2.32	1.575
8.	$N_1P_{1,5}K_1$	1.067	1.00-1.20	1.273	1.22-1.32	1.170
Increasing doses of K at constant N and P						
9.	$N_1P_1K_0$	1.327	1.20-1.48	1.407	1.38-1.44	1.367
10.	$N_1P_1K_{0,5}$	1.287	1.10-1.46	1.570	1.55-1.60	1.428
4.	$N_1P_1K_1$	0.943	0.85-1.08	2.207	2.10-2.32	1.575
11.	$N_1P_1K_{1,5}$	1.243	1.20-1.48	1.420	1.30-1.56	1.332
Increasing doses of N, P and K						
1.	$N_0P_0K_0$	0.467	0.40-0.70	1.167	1.12-1.20	0.817
12.	$N_{0,5}P_{0,5}K_{0,5}$	0.983	0.90-1.05	1.527	1.48-1.58	1.255
4.	$N_1P_1K_1$	0.943	0.85-1.08	2.207	2.10-2.32	1.575
13.	$N_{1,5}P_{1,5}K_{1,5}$	0.957	0.85-1.02	1.623	1.60-1.64	1.290
14.	$N_2P_2K_2$	1.040	0.90-1.12	1.610	1.55-1.68	1.325
Mean(A)		0.970	-	1,568	-	-
LSD		A = 0.040, B = 0.175 A x B = 0.248				

Explanations as in Table 1.

was used in fodder sunflower cultivation every year, which could have stimulated soil deacidification. In acidic soils, molybdate anions are strongly adsorbed on Fe, Mn, Al oxides and clay minerals, which usually reduces the availability of molybdenum considerably (KABATA-PENDIAS 1999, RUTKOWSKA et al. 2017).

Mineral fertilization (regardless of liming) differentiated the molybdenum content in potato tubers. With constant phosphorus and potassium (P_1K_1) fertilization, the dose of $N_{0.5}$ resulted in a significant increase in the amount of Mo in potato tubers, whereas the increased level of nitrogen fertilization caused a decrease in the content of this trace element (Table 1). Gąsior (1996) demonstrated that increasing the dose of nitrogen resulted in a decrease in the content of this element in mature potato tubers also grown on loessial soil. The molybdenum content in immature potato tubers increased with an increase of the nitrogen dose to 100 kg N ha^{-1} but decreased at higher doses. Addition of phosphorus to soil in the amount of half the nominal dose ($P_{0.5}$) with constant nitrogen and potassium fertilization (N_1K_1) caused a significant decrease in the Mo content in tubers, both in relation to the object without phosphorus and the one without fertilization ($N_1P_0K_1$, $N_0P_0K_0$). However, as the phosphorus fertilization increased, starting from the object with half the dose ($N_1P_{0.5}K_1$), the content of this element increased. Potatoes are classified as plants with low sulfur requirements, hence the small amounts introduced with superphosphate initially produced an antagonistic effect towards molybdenum. The sulfate ion is a strong inhibitor of molybdenum uptake by plants, and low soil sulfate concentrations favor the molybdate uptake (Balík et al. 2006, Kirchmann et al. 2009, Shinmachi et al. 2010, Bittner 2014). However, with a further increase in the superphosphate doses, the phosphate ion stimulation effect prevailed. An increase in the amount of molybdenum in the soil solution is observed along with an increase in the available phosphorus content, which may affect its higher Mo uptake by plants (Rutkowska et al. 2017). The Mo-P interaction is often considered to produce an enhancing effect of phosphorus on molybdenum availability in acidic soils, apparently due to greater solubility of the phosphoromolybdate complex as well as to the greater mobility of Mo in plant tissues. However, Mo-P interactions are variable and depend on different soil factors as well as metabolite processes (Kaiser et al. 2005, Ribera et al. 2010). Kaiser et al. (2005) believe that molybdate is bound and transported through the plasma membrane by the phosphorus transport system, but it seems that in good growth conditions, where the soil has sufficient phosphorus available, this has a limited effect on the molybdenum transport. Mercik (1969) indicated that phosphorus fertilization did not significantly affect the molybdenum content of potatoes grown on lessive soils. Our study did not show a clear effect of potassium fertilization or a clear effect of increasing NPK mineral fertilization (at constant N:P:K ratios) on the Mo content in potato tubers. However, ($N_{1.5}P_1K_1$ and $N_1P_{0.5}K_1$), the molybdenum content significantly decreased in relation to the object without fertilization ($N_0P_0K_0$) only in two fertilizing treatments, while a significant increase in the content of this element in potato tubers was found in the other treatments. Ruszkowska et al. (1996) found lower molybdenum content in potato tubers grown on sandy soil in treatments with increased NPKMg doses, which can be explained by the effect of increased acidification. In the above experiment, conducted on loess and loam soil, a slight increase in the content of this element in potato tubers was found.

The NPK mineral fertilization (regardless of liming) increased the molybdenum content in the green mass of fodder sunflower in most fertilizing objects (except for $N_1P_0K_1$). Under the influence of increasing doses of nitrogen fertilization (with constant phosphorus and potassium fertilization), the average Mo content increased compared to the object without nitrogen fertilization ($N_0P_1K_1$) and giving up the fertilization ($N_0P_0K_0$) – Table 2. Jurkowska et al. (1990), along with an increasing nitrogen dose, found lower molybdenum content in the aerial parts of sunflower. In the research on the influence of nitrogen fertilization on the Mo content in cabbage, no clear tendency was found, but the content of this element depended on the fertilizer application method and its type (Domagała-Świątkiewicz, Sady 2010).

In this experiment, increasing phosphorus fertilization (with constant N and K fertilization) and mineral fertilization (with constant N:P:K proportions) also increased the Mo content in the green mass of sunflower, up to the dose of $N_1P_1K_1$. This corresponds to the research results of Ribera et al. (2010), who observed a tendency to increasing the content of available molybdenum in acidic soil of the Andisol type under the influence of increasing doses of phosphorus (slightly stronger after liming the soil), which resulted in an increase in the Mo content in clover shoots. Such relationships were confirmed in a pot experiment carried out by Vistoso et al. (2012). The research results by Liu et al. (2010) additionally indicate that Mo and P act synergistically in the growth of *Brassica napus* by increasing the rate of photosynthesis through two different mechanisms, with Mo increasing the photosynthetic activity of mesophilic cells and P increasing the stomatal conductivity. Same as in potato tubers, no unequivocal effect of potassium fertilization on the Mo content in the green mass of fodder sunflower was found. In studies conducted on lessive soil developed from loess, the effect of NPK mineral fertilization (regardless of liming) on the increase in the molybdenum content in fodder sunflower biomass in comparison with the object without fertilization ($N_0P_0K_0$) was demonstrated. Kalembasa et al. (2012), researching the effect of phosphorus-potassium fertilization on chemical composition of *Galega orientalis* L., found that potassium fertilization of sandy soil (medium fertility in available forms of P and K) significantly reduced, while phosphorus fertilization increased the content of molybdenum in fodder galega. The interaction of phosphorus-potassium fertilization had a very beneficial effect on the Mo content in this plant.

The interaction of liming and NPK mineral fertilization has been revealed by an increase in the molybdenum content in the green mass of fodder sunflower grown on limed fertilized objects. The interaction of these treatments did not have a significant impact on the molybdenum content of potato tubers, but a trend was observed towards a higher Mo content on some limed fertilizer treatment.

Knowledge of interactions between fertilizer components can help design fertilizer treatments and optimize fertilization strategies in order to obtain high yields and good results in the use of nutrients (Rietra et al. 2017).

CONCLUSIONS

1. Liming increased the molybdenum content in the green mass of fodder sunflower, although it did not affect the content of this element in potato tubers.

2. The NPK mineral fertilization (regardless of liming) increased the molybdenum content in the green mass of fodder sunflower and in potato tubers compared with the treatment without mineral fertilization. However, higher doses (1.5 in the case of increasing P or K fertilization, also 1.5 and 2 in fertilization with a constant ratio between NPK) caused a decrease in the content of Mo in the green mass of sunflower.

3. Interaction of liming and mineral fertilization was revealed by an increase in the molybdenum content in the green mass of fodder sunflower grown on limed fertilized treatments on soil formed from loess. No interaction of liming and mineral fertilization was found in the Mo content in potato tubers. However, there was a tendency to increasing the content of this element in potato tubers, grown on some fertilizing treatments using liming.

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