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RELATIONSHIP BETWEEN MOLYBDENUM AND NITRATE NITROGEN IN PLANTS AND THEIR YIELD

D. Kostova*, D. Haytova

Agricultural University – Plovdiv,
12 Mendeleev Str., 4000 Plovdiv, Bulgaria
****E-mail: deny_kostova@yahoo.com***

ABSTRACT

The influence of leaf fertilizer Fitona, Hortigrow and Humustim upon the content of molybdenum in the fruit of marrows has been investigated. The researches show that in soil and leaf fertilization the highest molybdenum content responds to the highest amount of nitrate nitrogen, which is being assimilated by plants. The influence of the incorporated in different fertilizers nitrogen upon the content of molybdenum in the fruit has been investigated as well. A relationship between the content of molybdenum in the fruit and the obtained yield in leaf and mixed fertilization has been traced out. The experimental data show that in leaf fertilization the yield decreases with the increase of the amount of molybdenum. A positive influence of molybdenum upon the yield has been determined in soil and leaf fertilization.

Key words: *molybdenum, triphenyltetrazolium chloride, plants, fertilization*

INTRODUCTION

Molybdenum is a micronutrient required by plants in very small amounts. Molybdenum complex is part of both nitrate reductase, whereby nitrate is reduced to nitrite, and nitrogenase whereby nitrogen-fixing bacteria convert nitrogen gas into ammonia.

The transition element molybdenum is essential for most organisms and occurs in more than 60 enzymes catalyzing diverse oxidation-reduction reactions. Several molybdoenzymes including nitrogenase, nitrate reductase, aldehyde oxidase are of significance to plants. Because of its involvement in the processes of N_2 fixation, nitrate reduction, and the transport of nitrogen compounds in plants, molybdenum plays a crucial role in nitrogen metabolism of plants [1–3].

The essential nature of molybdenum as a plant nutrient is based solely on its role in the NO_3^- reduction process via nitrate reductase. This enzyme occurs in most plant species as well as in fungi and bacteria, and is the principal molybdenum protein of vegetative plant tissues. However, the requirement of molybdenum for nitrogenase activity in root nodules is greater than the requirement of molybdenum for the activity of nitrate reductase in the vegetative tissues. Because nitrate is the major form of soil nitrogen absorbed by plant roots, the role of molybdenum as a functional component of nitrate reductase is of greater importance in plant nutrition than its role in N_2 fixation [4,5].

Molybdenum and nitrate are both required for the induction of nitrate reductase in plants, and the enzyme is either absent [6], or its activity is reduced [7], if either nutrient is deficient.

The objective of this study is to explore the influence of molybdenum upon the nutritious value of fruit of marrows and to clarify the opportunity of using 2,3,5-triphenyltetrazolium chloride (TTC) [8–15] as a reagent for determination of microquantities of molybdenum in plant samples.

MATERIAL AND METHODS

The experiment was carried out in eight variants: non fertilized, leaf fertilization and mixed fertilization (soil with leaf).

Variants of the experiment:

1. Control – non fertilized
2. Leaf fertilization 0.3 % Fitona
3. Leaf fertilization 0.3 % Hortigrow
4. Leaf fertilization 0.3 % Humustim
5. Soil fertilization $N_{16}P_{16}K_{16}$
6. $N_{16}P_{16}K_{16}$ + Fitona 0.3 %
7 $N_{16}P_{16}K_{16}$ + Hortigrow 0.3 %
8. $N_{16}P_{16}K_{16}$ + Humustim 0.3 %

Apparatus

Spectrophotometer UV-VSU with 1-cm light path quartz cells; Flame Atomic Absorption Spectrophotometer „Perkin Elmer" (Germany)

Determination of molybdenum(VI) in plant samples

1g from the plant material was reduced to ashes in an oven in 450 – 500^o C. The dry residuum was dissolved in a dilute hydrochloric acid (1:1). Obtained solution was transferred into a volumetric flask of 50 mL and diluted to the mark with distilled water. Aliquot parts of this solution were taken for analysis.

The following solutions were introduced into a separatory funnel of 100 mL: 0.5 mL of phosphoric acid, $2x10^{-2}$ M; 0.5 mL of TTC, $1x10^{-3}$ M; and an aliquote of the prepared plant sample solution. The mixture was diluted up to 10 mL with distilled water. Then 3 mL of 1,2-dichloroethane were added and the funnel was shaken for 30 sec. The organic phase was filtered through a dry paper into a 1 cm cuvette and the absorbance was measured at 250 nm [8]. A blank was run in parallel. A calibration graph was constructed with similarly treated standards.

RESULTS AND DISCUSSION

The influence of leaf fertilizer Fitona, Hortigrow and Humustim upon the content of molybdenum in the fruit of marrows has been investigated (Table 1). Molybdenum in plant samples was determined with an extraction-spectrophotometric method with TTC [8]. The accuracy of the method was checked up using atomic-absorption spectrometry (AAS). The experimental data (Table 1) show a good agreement between the results obtained by the two methods.

The leaf feeding up was done with 0.3% solutions of these fertilizers. The experimental data (Fig. 1) show that the highest amount of Mo 3.99 mg/kg can be accumulated in the fruit of marrows in leaf feeding-up with Fitona. The content of molybdenum is lowest 3.42 mg/kg in fertilization with Humustim, as in the control (non fertilized) the content of molybdenum is almost the same.

In mixed fertilization (soil and leaf) the content of molybdenum increases in the same variants of fertilization with the leaf fertilizers Fitona, Hortigrow, Humustim. All this indicates that soil fertilization commonly helps accumulation of higher amount molybdenum in the fruit of plants in leaf fertilization. In the control sample it was fertilized only with $N_{16}P_{16}K_{16}$ and the content of molybdenum was low 3.37 mg/kg. This value was approximately like that in variant 6 ($N_{16}P_{16}K_{16}$ + Fitona). In the variants of fertilization 7 ($N_{16}P_{16}K_{16}$ + Hortigrow) and 8 ($N_{16}P_{16}K_{16}$ + Humustim) the molybdenum content in the fruit increased.

Table 1. *Content of molybdenum in the fruit of marrows in leaf fertilization and mixed fertilization*

№	Variants	Mo, mg kg^{-1} TTC method	RSD* %	Mo, mg kg^{-1} AAS	Nitrate mg/kg
1	Control – non fertilized	3.46	1.1	3.55	120
2	0.3 % Fitona	3.99	1.7	3.80	90
3	0.3 % Hortigrow	3.94	1.5	4.00	250
4	0.3 % Humustim	3.42	1.8	3.60	175
5	$N_{16}P_{16}K_{16}$	3.37	1.2	3.50	115
6	$N_{16}P_{16}K_{16}$ + 0.3 % Fitona	3.28	1.9	3.15	135
7	$N_{16}P_{16}K_{16}$ + 0.3 % Hortigrow	4.32	1.2	4.45	100
8	$N_{16}P_{16}K_{16}$ + 0.3 % Humustim	4.35	1.4	4.40	250

*Relative Standard Deviation for TTC method (bazed on 5 determination)

Indices:

N_{16} – introduced as NH_4NO_3 (34 % N)
P_{16} – introduced as $Ca(H_2PO_4)_2$ (46 % P_2O_5)
K_{16} – introduced as K_2SO_4 (50 % K_2O)

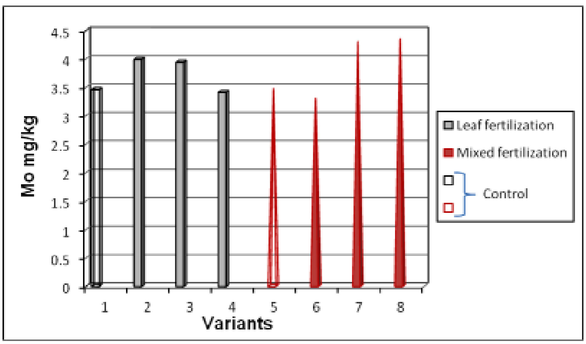

Figure 1. *Content of Mo in the fruit of marrows in leaf and mixed fertilization (soil and leaf) fertilization. Variants: 1 – Control; 2 – Fitona; 3 – Hortigrow; 4 – Humustim; 5 – Control ($N_{16}P_{16}K_{16}$); 6 – $N_{16}P_{16}K_{16}$ + Fitona; 7 – $N_{16}P_{16}K_{16}$ + Hortigrow; 8 – $N_{16}P_{16}K_{16}$ + Humustim*

Molybdenum is of great significance for the circum rotation of nitrogen and its assimilation by plants. Being incorporated in the composition of the enzyme nitrate_reductase, molybdenum itself ensures the assimilation of the nitrate nitrogen sources by plants. In this respect a subordination was traced out between the content of molybdenum and nitrate nitrogen in the fruit of marrows in leaf fertilization and mixed (soil and leaf) fertilization. The experimental data (Fig. 2) show that in leaf fertilization the nitrate nitrogen can be assimilated to the highest extent, 250 mg/kg, in the content of Mo, 3.94 mg/kg, in the fruit of marrows. In soil and leaf fertilization the highest content of Mo, 4.35 mg/kg, responds to the highest amount of nitrate nitrogen, 250 mg/kg, which is being assimilated by plants.

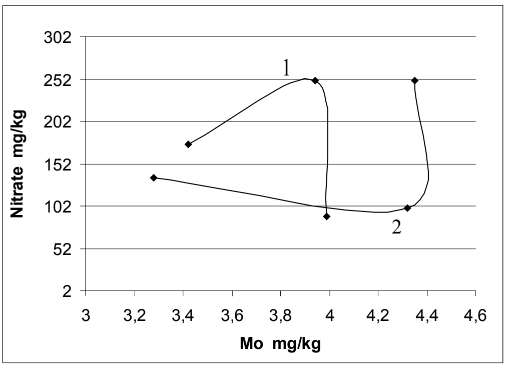

Figure 2. *A subordination between the content of Mo a nd nitrate nitrogen (NO_3 – N) in the fruit of marrows:* ***1*** *– leaf fertilization;* ***2*** *– soil and leaf fertilization*

In order to trace out what is the influence of the different fertilization leaf and mixed one, we have investigated the influence of nitrogen that is being incorporated in different fertilizers upon the content of molybdenum in the fruit of marrows. A certain subordination is traced between the content of nitrogen in the leaf fertilizers Humustim, Fitona and Hortigrow and the assimilation of molybdenum by plants. The subordination between Mo in fruit and nitrogen in fertilizer is represented in Fig. 3. The experimental data (Fig.3, curve 1) show that at the lowest content of nitrogen in leaf fertilizer (3%) the content of Mo in fruit is also lowest (3.42 mg/kg). With the increase of the percentage of nitrogen in fertilizer, the content of Mo increased to 3.99 mg/kg for 7.2 % nitrogen, and respectively 3.94 mg/kg Mo for 20 % nitrogen in leaf fertilizer.

Consequently the higher content of nitrogen in fertilizer helps the accumulation of higher amount of molybdenum in the fruit of plants.

The subordination between molybdenum in the fruit of marrows and nitrogen in leaf fertilizer in mixed fertilization is represented in Fig. 3, curve 2. It cannot be seen a definite subordination between the two parameters if leaf fertilization is done together with soil one ($N_{16}P_{16}K_{16}$).

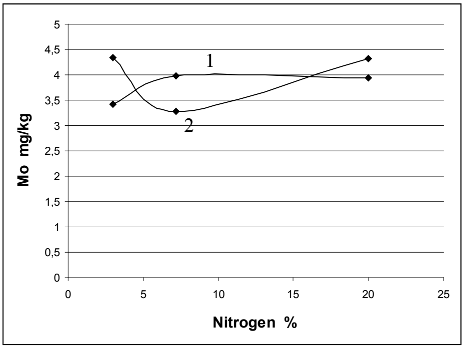

Figure 3. *A subordination between the content of Mo in the fruit of marrows and nitrogen in leaf fertilizer in **1** – leaf fertilization and **2** – soil and leaf fertilization*

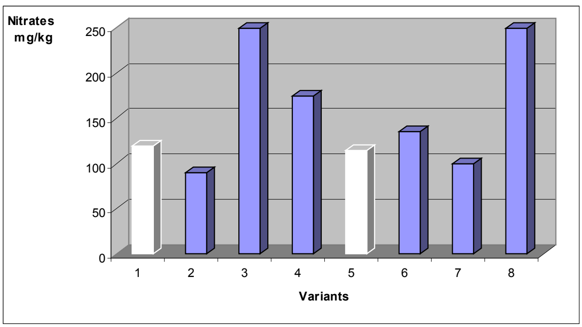

Figure 4. *Content of nitrate nitrogen (NO_3 – N) in the fruit of marrows. Variants: 1 – non fertilized, 2 – Fitona, 3 – Hortigrow, 4-Humustim, 5 – $N_{16}P_{16}K_{16}$, 6 – $N_{16}P_{16}K_{16}$ + Fitona, 7 – $N_{16}P_{16}K_{16}$ + Hortigrow, 8 – $N_{16}P_{16}K_{16}$ + Humustim*

The influence of the different kind of fertilization is investigated upon the content of nitrates in the fruit of marrows. In leaf fertilization the highest amount of nitrates, 250 mg/kg, is accumulated in the fruit in fertilization with Hortigrow, which comprises 20% nitrogen (Fig. 4, variants 1–4). It should be mentioned that leaf fertilizer Hortigrow has highest nitrogen amount in comparison with Fitona and Humustim. This fact explains the high content of nitrates in the fruit. The content of nitrates in the fruit in mixed fertilization (soil $N_{16}P_{16}K_{16}$ and leaf fertilization) is presented in Fig. 4, variants 5–8. The experimental data show that plants accumulate the biggest amount of nitrates, 250 mg/kg, in fertilization with $N_{16}P_{16}K_{16}$ + Humustim.

Molybdenum is one of the main nutritious elements for vegetable crops. That is the reason for which molybdenum is a factor that has an influence on yield and its quality. In this respect a certain subordination is traced out between the content of Mo in the fruit of marrows and the obtained yield in leaf and mixed fertilization.

The experimental data (Fig. 5) show that in leaf fertilization the yield decreases with the increase of the amount of Mo accumulated by plants. In soil and leaf fertilization there has been determined a positive influence of molybdenum upon the yield of marrows (Fig. 6). As distinct from leaf fertilization, mixed fertilization has a positive influence not only upon the content of molybdenum in the fruit of marrows, but upon the yield. With the increase of the content of molybdenum in the fruit of marrows the yield increases. This could be explained with the additional introduction of the main nutritious elements N, P and K in soil.

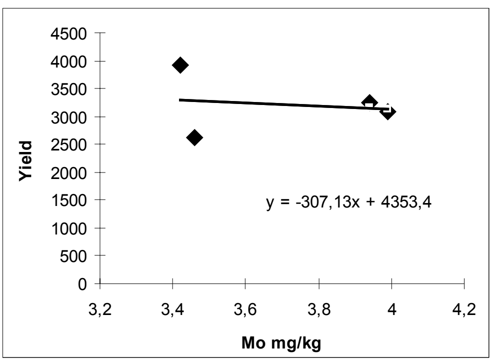

Figure 5. *A subordination between yield and the content of Mo in the fruit of marrows in leaf fertilization; Correlation coefficient: r= – 0.17*

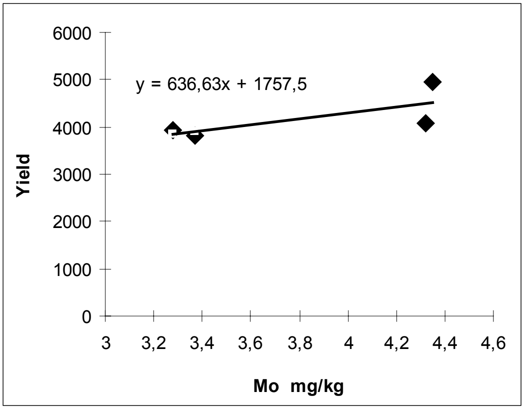

Figure 6. *A subordination between yield and the content of Mo in the fruit of marrows in mixed fertilization (soil and leaf); Correlation coefficient: r= 0,73*

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