INVOLVEMENTS OF NUTRITIVE IMBALANCES IN MAIZE PROTEIN SYNTHESIS

Silviu Popescu[1)], Alina Idriceanu [1)], Silvia Stan [1)] and Florin Povarnã[2)]

ABSTRACT

Macro- and microelements absorption by maize plants and their contribution to protein synthesis under nitrogen fertilization has been investigated. The results showed that application of nitrogen fertilizers in an acid soil was associated with nutritive imbalances, expressed as increase of aluminium and manganese concentration in plants to the detriment of phosphorus, potassium, magnesium and iron absorption, this limiting the use of absorbed nitrogen for protein synthesis.

Key words: maize, nitrogen fertilization, nutritive imbalances, protein synthesis.

INTRODUCTION

The production of crops with high protein content is conditioned by plant nitrogen supply along the whole season, this imposing the application of adequate amounts of nitrogen fertilizers, mainly in soils with reduced natural fertility. The results of maize trials on acid soils revealed a low efficacy of nitrogen fertilization upon protein accumulation in kernel. In agreement with investigations conducted by Hera et al. (1988) and Popescu et al. (1992), nitrogen fertilization resulted in maize protein content increase by 1.3 - 1.8% on reddish-brown soil at ªimnic, and by 0.8 - 1.5% on albic luvisol at Albota-Piteºti, whereas on the cambic chernozem at Fundulea it determined an increase of this index by 2.4 - 2.8%.

In order to clear up the factors limiting the effect of nitrogen fertilizers application on the above-mentioned soils, research on the possibility of apparition of nutritive imbalances, under these conditions, is necessary. In this context, the long-term application of mineral fertilizers can lead to side-effects, as expressed by changes in soil solution reaction, mobilization or immobilization of some soil nutritive elements, apparition of ionic antagonism phenomena, which determine lower plant concentrations of some macro- and microelements involved in various sequences of nitrogen metabolism. As a consequence of these phenomena, protein synthesis can be affected, this fact being reflected both on absolute values of this index, and also its amplitude variation under the fertilization influence.

MATERIALS AND METHODS

Investigations were performed within the long-term experiments placed on albic luvisol at Albota, presenting the following agrochemical properties: pH (in H_2O) - 5.2 - 5.4; humus - 1.80%; total nitrogen - 0.090%; mobile phosphorus (A.L.) - 10-12 ppm P; mobile potassium (A.L.) - 70-80 ppm K.

Nitrogen fertilizers were applied as ammonium nitrate at rates of 50, 100, 150 and 200 kg a.i./ha

Turda 215 maize hybrid was cropped in wheat - maize rotation.

Macro - and microelements concentrations were determined in plants harvested at 6 - 8 leaves as well as pure protein.

Total nitrogen was determined by Kjeldahl method and pure protein by precipitation in trichloracetic acid, followed by nitrogen dosage in a precipitate, by Kjeldahl method.

For phosphorus, potassium and magnesium determination, the plant material was mineralized with a mixture of H_2SO_4 and $HClO_4$, while for determination of microelements and aluminium it was calcinated at 500ºC. Phosphorus was colorimetrically dosed by the method with ammonium vanadate-molybdate, potassium was determined by flame-photometry, while magnesium and microelements by spectrophotometry with atomic absorption.

Aluminium dosage was colorimetrically carried out by the method with aluminone. Nitrate determination was performed by reduction to nitrites and their colorimetrical dosage by Griess reaction.

[1)] Research Institute for Cereals and Industrial Crops, 8264 Fundulea, Cãlãraºi County, Romania
[2)] Agricultural Research Station, 0310 Piteºti, Argeº County, Romania

RESULTS AND DISCUSSIONS

Data in table 1 reveal a lower total nitrogen in maize in the phase with 6-8 leaves of the variant without fertilization, compared to the average values determined by research on diagnosis of mineral nutrition state of plants (Neubert, 1982). Application of nitrogen fertilizers contributed to correct this deficiency inducing the increase of total nitrogen concentration by 0.86%. Nitrogen fertilization also led to accumulation of higher amounts of proteic nitrogen and protein in plants. Unlike the total nitrogen, these latter indices significantly changed only under the influence of 100-200 kg N/ha rates. In the variant with maximum nitrogen rate, 200 kg a.i./ha, protein concentration exceeded by 2.19% the value achieved in the unfertilized variant.

Particularly intense was the absorption of nitric nitrogen, whose concentration in the variant fertilized with 200 kg N/ha was 2.5 times higher than in the unfertilized.

Though the value of protein concentration in plants in 6-8 leaves stage increased by 2.19% under the influence of fertilization with nitrogen, within the kernel it changed only by 0.99%. Related to this outcome, data in table 2 reveal the increase under the influence of nitrogen fertilizers of nitric nitrogen proportion from the total amount of nitrogen absorbed by plants in the phase of 6-8 leaves, in spite of the nitrogen use for protein synthesis.

In this sense, it can be remarked that proteic nitrogen proportion did not significantly changed by applying rates of 50-150 kg N/ha being yet, negatively influenced by 200 kg N/ha rate. For the same rate, the proportion of ammonium nitrogen significantly increased, this being not used in the synthesis of organic nitrogen compounds. Data mentioned reflect the inefficacy of mineral nitrogen inclusion in the protein structure, this phenomenon being able to be pointed out, according to the evolution of mineralization processes under soil and climate conditions along the season.

The outstanding factor conditioning the effect of nitrogen fertilizers application on the albic luvisol at Albota is soil acidity, associated with aluminium and manganese mobilization and intensification of absorption of these elements by plants.

According to data in figure 1, manganese concentration in plants is positively correlated with the nitrogen rate applied. Accumulation in higher amounts in plants of this microelement constitutes a limitative factor to protein synthesis, due to reduction of concentration of other elements of mineral nutrition involved in this process, through competition

Table 1. Influence of mineral fertilizers with nitrogen on concentration of nitrogen compounds in maize plants of 6-8 leaves, on albic luvisol of Albota-Pite°ti

Rate of N kg/ha	Total N			Proteic N			Pure protein			$N\text{-}NO_3$			$N\text{-}NH_3$		
	%	diff.	signif.	%	diff.	signif.	%	diff.	signif.	mg/100g	diff.	signif.	mg/100g	diff.	signif.
0	3.12	-	-	1.75	-	-	10.94	-	-	186	-	-	114	-	-
50	3.37	0.25	***	1.82	0.07	-	11.38	0.44	-	329	143	***	125	11	*
100	3.71	0.59	***	2.01	0.26	***	12.56	1.62	***	373	187	***	139	25	***
150	3.85	0.73	***	2.08	0.33	***	13.00	2.06	***	409	223	***	145	31	***
200	3.98	0.86	***	2.10	0.35	***	13.13	2.19	***	457	271	***	155	41	***
LSD 5%		0.041			0.071			0.445			16.5			8.0	
1%		0.056			0.099			0.616			22.8			11.1	
0.1%		0.078			0.136			0.850			31.5			15.3	

Table 2 Modification of the relative content of proteic, nitric and ammoniacal nitrogen in maize plants of 6-8 leaves, depending on nitrogen fertilizer application

Rate of N kg/ha	Proteic N			$N\text{-}NO_3$			$N\text{-}NH_3$		
	% reported to total N	diff.	signif.	% reported to total N	diff	signif.	% reported to total N	diff	signif.
0	56.1	-	-	5.96	-	-	3.65	-	-
50	54.0	2.1	-	9.76	3.80	***	3.71	0.06	-
100	54.2	1.9	-	10.05	4.09	***	3.75	0.10	-
150	54.0	2.1	-	10.62	4.66	***	3.77	0.12	-
200	52.8	3.3	°°	11.48	5.52	***	3.89	0.24	*
LSD 5%		2.17			0.48			0.23	
1%		3.01			0.67			0.32	
0.1%		4.15			0.92			0.45	

occurring during absorption. The same data show that nitrogen fertilization determined excessive accumulation of aluminium in plants, whose concentration in the fertilized variant with 200 kg N/ha reached 854 ppm.

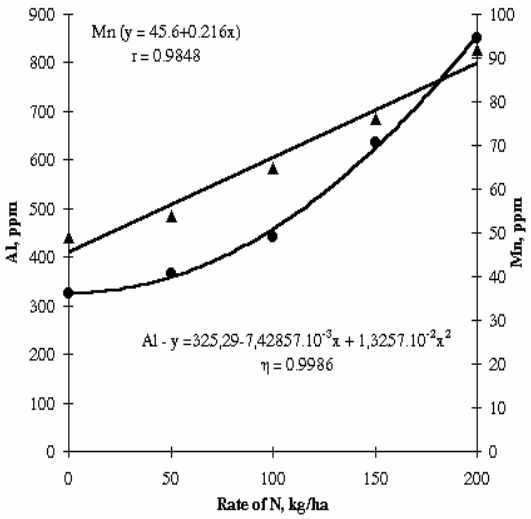

Figure 1. Aluminium and manganese accumulation in maize plants of 6-8 leaves, depending on nitrogen fertilizer application

Aluminium excess affected the process of protein synthesis, mainly due to imbalances induced through phosphorus absorption by plants and at the same time due to perturbations caused in phosphorus metabolization, by blocking phosphate groups of nucleic acids (Mengel and Kirkby, 1982). Under these conditions, higher amounts of non-protein nitrogen forms are accumulated and accumulation of proteic compounds is diminished. In this sense, data presented in figure 2 show that phosphorus percentage is negatively correlated with the aluminium concentration in plants.

Decrease of phosphorus concentration by nitrogen fertilization could also be ascribed to negative nitrogen-phosphorus interaction. Thus, Bergmann (1992) showed the possibility of phosphorus absorption inhibition as a result of nitrogen fertilizer application in a nitric form. Likewise, investigations performed by Borlan et al. (1994) revealed that, at high nitrogen concentrations in the nutritive medium, achieved by application of high fertilizer amounts containing this element, the antagonism nitrogen - phosphorus is manifested, with negative consequences on nitrates reduction and amino-acids and protein synthesis.

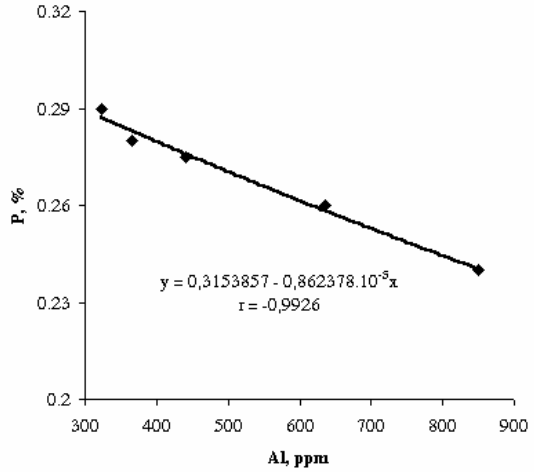

Figure 2. Relantionship between phosphorus and aluminium concentration in maize plants of 6-8 leaves under nitrogen fertilizer application conditions

Decrease of soil pH solution by nitrogen fertilization determines, simultaneously with aluminium and manganese mobilization, iron mobilization (Borlan and Hera, 1984). Under these conditions, the increase of iron availability is also reflected in its absorption by plants, this phenomenon being also revealed by the experiment placed on Albota soil, however only up to the rate of 100 kg N /ha (Figure 3). For higher nitrogen fertilizer rates some ionic interactions occur, affecting the absorption of this microelement.

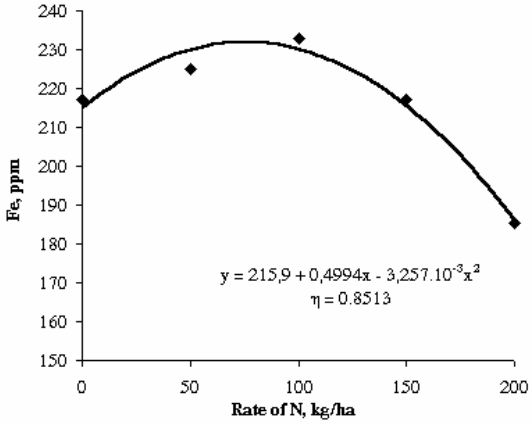

Figure 3. Modification on iron concentration in maize plants of 6-8 leaves, under nitrogen fertilizer aplication conditions

At increased soil manganese concentrations, a competitive action with iron ions is produced in the process of plant absorption (Adriano, 1986; Bergmann, 1992; Borlan et al., 1994). Competitive effects on iron absorption by plants are also exerted by zinc ions

(Mengel and Kirkby, 1982). In this sense it should be pointed out that nitrogen fertilizer application in the albic luvisol at Albota contributed to accumulation of high zinc amounts in maize plants, reaching up to 58 ppm.

The results presented in figure 4 express a sharp negative action of nitrogen fertilizers on potassium concentration in plants, which explains the perturbations in protein metabolism, induced by high rate application. This phenomenon is determined both by the fact that aluminium accumulation in soil solution reduces the availability of potassium to plants, and also by the manifestation of an antagonism NH_4^+ - K^+.

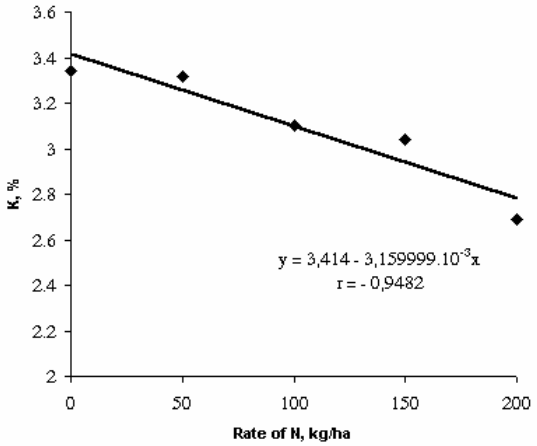

Figure 4. Influence of nitrogen fertilizer application on potasium concentration in maize plants of 6-8 leaves

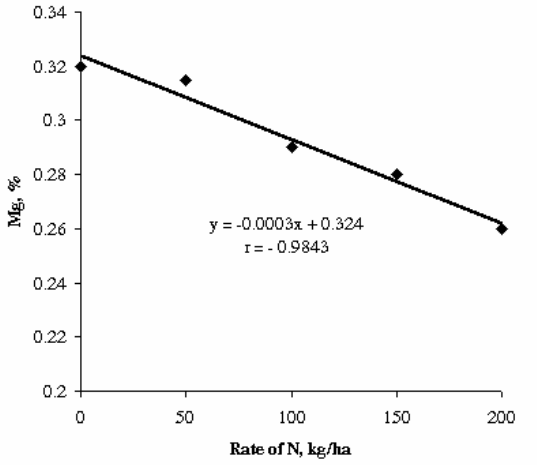

Figure 5. Influence of nitrogen fertilizer application on magnesium concentration in maize plants of 6-8 leaves

The accentuation of soil acidity by application of nitrogen fertilizers detrimentally influences magnesium plant nutrition due to the competition between Al^{3+} and Mg^{2+} ions. Likewise, under these conditions the competition of Mn^{2+} and Mg^{2+} is also possible.

Data presented in figure 5 show the magnesium concentration decrease from 0.324% in the unfertilized variant, up to 0.262% in the variant fertilized with 200 kg N /ha. Magnesium deficiency induced as a result of ionic interactions already mentioned constitutes a limitative factor both for nitrates reduction (Bergmann, 1992) and the protein synthesis (Amberger, 1975).

CONCLUSIONS

The systematic application of mineral fertilizers can lead to the alteration of soil solution reaction, mobilization or immobilization of some soil nutritive elements and to manifestation of ionic antagonism phenomena, which determine the concentration decrease in plants of some macro - and microelements involved in the nitrogen metabolism.

The application of nitrogen fertilizers determined the increase of nitric nitrogen proportion within the total nitrogen amount absorbed by plants, to the detriment of protein synthesis.

The lower efficacy of nitrogen fertilization in the albic luvisol of Albota was determined from the standpoint of contribution to protein synthesis in maize, by the concentration increase of aluminium and manganese in plants and also by limitation of phosphorus, potassium, magnesium and iron absorption.

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