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[1]D. MURARIU, PhD hability
ORCID: 0000-0002-0431-1557
[1]D.D. PLACINTĂ, first rank researcher
ORCID: 0000-0003-3441-8459
[1]D.C. BATIR RUSU, third rank researcher
ORCID: 0009-0006-9757-022X
[2]C.V. HATNEAN, researcher
ORCID: 0009-0004-3569-9867
[1]Suceava Genebank, B-dul 1 Mai No. 17, 720264, Suceava, Romania
[2]Agricultural Research and Development Station of Suceava,
B-dul 1 Decembrie 1918 nr. 15, Suceava, Romania
e-mail: danela.murariu@svgenebank.ro, domnica_p@yahoo.com; dia_sv@yahoo.com; cezarhatnean84@gmail.com

ASSESSMENT OF THE PRESENCE OF NITRATES AND OTHER CHEMICALS IN SOIL AND IN MAIZE PLANTS BY NITROGEN FERTILIZATION

The main purpose of this study was to evaluate the effect of nitrogen fertilization, with different levels and type of fertilizers, on the agrochemical evolution of the soil superficial horizon and on nitrates levels in maize leaves in different growth stages (5 leaves, flowering and milk maturity). Two type of nitrogen fertilizers (Ammonium nitrate and Urea) and five nitrogen levels (80 kg/ha; 120 kg/ha; 200 kg/ha and 240 kg/ha) were applied in experimental trails. Filed experiments were conducted at the Agricultural Research and Development Station (ARDS) of Suceava, Romania, during years 2021 and 2022. The pH of the soil in the conditions of fertilization with ammonium nitrate, was acid with values between 4.88—4.65 in the first vegetation stages, and between 4.36—4.3 at the end of the vegetation period. Referring to response of maize plant to the fertilization levels and type of fertilizers showed some influences on chemical content of maize leaves in different growth stages. Concerning the presence of nitrates in maize plants, this study showed that the nitrates contents was highest in the first growth stage of maize plants, particularly when ammonium nitrate fertilizer was used.

ammonium nitrate; urea; chemical fertilizer; maize leaves; faeoziom soil

Introduction. Maize (*Zea mays* L.) is one of the most important food crops on the Terra, being used in human consumption, animal feed and

biofuel production [1]. Nitrogen is essential for the development of maize plants and therefore for yield capacity. The use of the correct doses is crucial both for the environment and for plant health. Nitrogen play an important role in photosynthetic activity and crop production [2]. Nitrogen fertilization is necessary to achieve high maize production, but the nitrogen recovery efficiency of maize is usually less than 40% [3; 4]. Some authors reported that nowadays the levels of nitrogen fertilizer used in the maize crop can be involved with the aquifer contamination or any type of natural resources, decreasing its quality [5; 6]. Also, some agronomical practices can help the nitrogen efficiency [7], such as using a narrow row spacing, decreasing the fertilizer through increasing of recovery efficiency [8], crop rotation and the use of organic fertilizer, [9] .

In this paper we studied the impact of differentiated nitrogen fertilization in the Suceava Plateau on a faeoziom soil. Based on field experiments, soil and plant analyzes were performed in the laboratory, in order to see the influence of different doses of nitrogen and two types of fertilizers (ammonium nitrate and urea) on the evolution of the faeoziom soil fertility, in the superficial horizon and on the presence of macro-elements and nitrates in the maize leaves, in order to be able to offer solutions to the farmers, from this area.

Materials and methods. The experiments were accomplished in the experimental field of the ARDS Suceava, placed in the Suceava Plateau, within Maize Breeding Laboratory, on a faeoziom soil. The experiment was projected according to the method of subdivided plots with the following graduations: factor a — fertilization levels with 6 graduations and factor b — two types of nitrogen fertilizers.

As biologic material the trilinear maize hybrid Suceava M was used, being created, by breeders from ARDS of Suceava (2019), well adapted for the Suceava Plateau (FAO range 200-280).

Referring to the agrochemical traits of the analyzed faeonziom soil, it noticed the following parameters:

pH_{H2O}	horizon Ap = 4.75; horizon Bt = 4.98;
N-total (% d.m.)	horizon Ap = 0.186; horizon Bt = 0.042;
P- mobile (ppm)	horizon Ap = 5.32; horzizon Bt = 13;
K- mobile (ppm)	horizon Ap = 117; horzizon Bt = 87;
Humus (%)	horizon Ap = 3.91; horzizon Bt = 1.02;
Clay (<0,002 mm)	horizon Ap = 27.96; horzizon Bt = 30.04;
Al mobile (ppm)	horizon Ap = 0.35; horzizon Bt = 0.1.

All these parameters of the analyzed soil indicated a moderate fertility with acidic pH, suitable for few crops, including maize.

After the emergence of the maize plants two nitric fertilizers (Ammonium Nitrate and Urea), were applied, using the following variants: V1-unfertilized control; V2-N_{80}; V3-N_{120}; V4-N_{160}; V5-N_{200}; V6-N_{240}.

For laboratory analysis of soil samples, from each variant, 0.5 kg sol, at 100 cm deep, during vegetation period of the maize plants, in four phenophases (when the plants had 5 leaves, at flowering, at maturity in milk and at full maturity), were taken.

For laboratory analysis of maize plants, from each variant, during vegetation period, we collected 100 gr of green leaves in three phases: when the plants had 5 leaves, at flowering, and at maturity in milk.

All chemical analyses of soil and plants were performed by chemical and physico-chemical methods (Schollemberger method; Kacinscki method; Kjeldah method, Sokolov method, Conductometric method, Scheibler method, Flamfotometric method, Gravimetric method, Colorimetric method), in the AWSYSTEMS Laboratory of Suceava

Statistical analyses

All analyses were conducted using GraphPad Prism 6. The effect of two fertilizers in different doses were evaluated by two way ANOVA.

Correlation coefficients were also calculated for the factors studied, which highlighted the effects of nitrogen fertilizers on chemical and phisico-chemical traits and on the nitrates in both the green organs of maize plants and in the soil.

Results and disscusions

1. Soil pH, electrical conductivity, soil Al, P, K, N, soluble salts, and nitrate contents

The influence of the two fertilizers (Ammonium Nitrate and Urea) on phisico-chemical traits (pH, electrical conductivity, soluble salts, total nitrogen, phosphorus pentoxide, potassium, nitrates) of the analyzed faeonziom soil, in different stages of maize plants development are presented. The soil pH was lowest (Figure 1) in the urea treatment (4.18—160 kg/ha) at full maturity of maize plants.

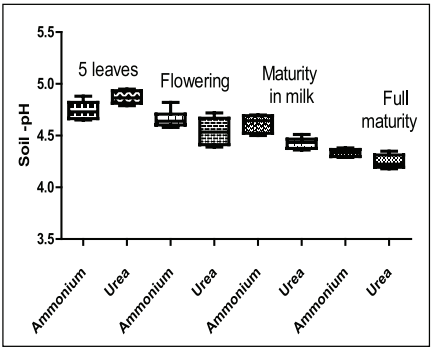

Fig.1. Effects of two nitrogen fertilizers on soil pH, in different growth stages of maize plants

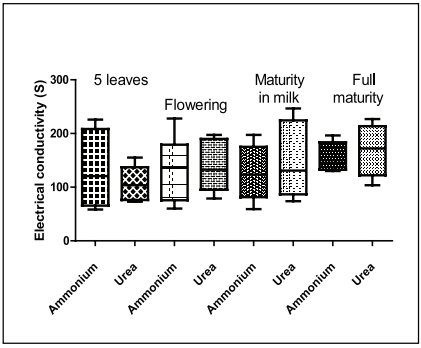

Fig.2. Effects of two nitrogen fertilizers on soil electrical conductivity in different growth stages of maize plants

Regardless of the electrical conductivity of the analyzed soil, the biggest value in the urea treatment, at maturity in milk (246.6 S — 200 kg/ha) was registered (Figure 2).

The N source affected the N, P, K and Al concentrations in soil during vegetation period of the maize plants.

The total nitrogen (tN) content is influenced by level of fertilization, type of fertilizer, and development stage of maize plants, having smallest contents at maturity in milk (0.123% d.m.), when we're using 240 kg/ha Amonium nitrate (Figures 3). Instead the P-mobile content, had the smallest values at full maturity of maize plants (10.2 ppm), when we're using 240 kg/ha Amonium nitrate too (Figure 4)

The K-mobil content had a downward evolution, reaching the lowest values (71 ppm) at the end of the vegetation period, when applying the highest doses of urea (240 kg/ha) (Figure 5), but in the case of Al content, the highest concentration was identified at the full maturity of the plants (1.62 ppm), when we're using 240 kg/ha urea (Figure 6).

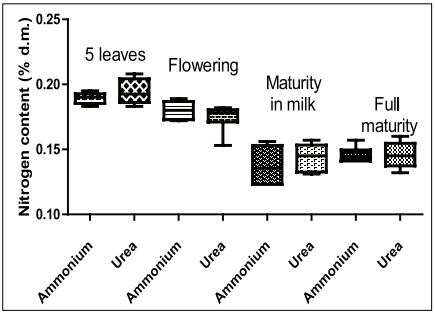

Fig.3. Effects of two nitrogen fertilizers on soil tN content, in different growth stages of maize plants

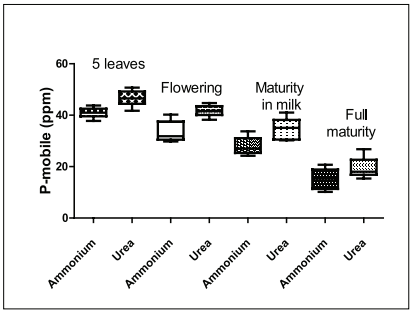

Fig. 4. Effects of two nitrogen fertilizers on soil P-mobile content, in different growth stages of maize plants

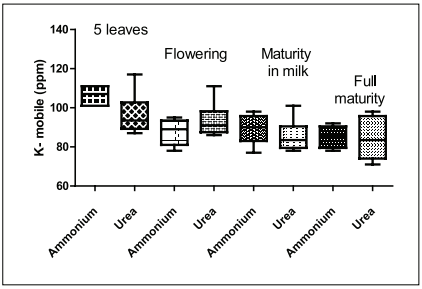

Fig. 5. Effects of two nitrogen fertilizers on soil K-mobile content, in different growth stages of maize plants

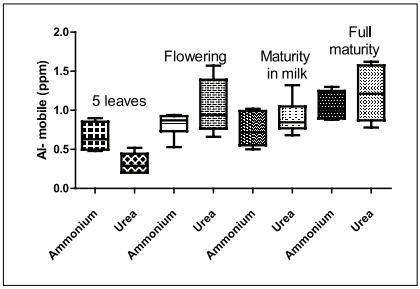

Fig. 6. Effects of two nitrogen fertilizers on soil Al-mobile content, in different growth stages of maize plants

The soil nitrate content was very high in the stage of 5 leaves, the highest values were recorded at maximum doses of Ammonium nitrate (267.7 ppm). In the soil, in all phases of vegetation the nitrate content was higher, when ammonium nitrate was used (Figure 7).

The content of soluble salts increases in limits from 19.9 ppm — unfertilized to 83.7 ppm — 240 kg/ha urea, the highest values being recorded to high doses of urea, at maturity in milk and full maturity (Figure 8).

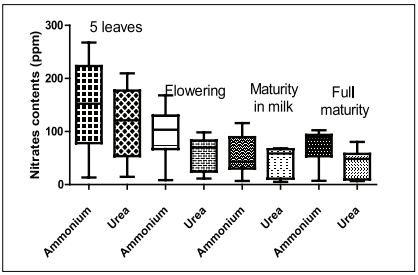

Fig. 7. Effects of two nitrogen fertilizers on soil N-NO_3 content, in different growth growth stages of maize plants

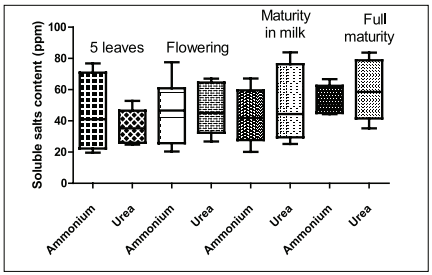

Fig. 8. Effects of two nitrogen fertilizers on soil soluble salts content, in different stages of maize plants

2. Maize plants leaves, macro elements and nitrate contents

The role of two nitrogen fertilizers (Ammonium nitrate and Urea) on certain chemical contents (tN, P, K, Calcium, Magnesium and Nitrates) in maize leaves at three development plant stages are presented in the bellow figures.

The content of total nitrogen (tN) is higher during first vegetation period when the plants had 5 leaves, for both fertilizers, but the biggest value (6.08 ppm) was registered when it used 240 kg/ha Urea (Figure 9). The lowest tN was noticed at maturity in milk (1.11 ppm) at treatment with urea (80 kg/ha).

The phosphorus pentoxide content was low in all three stages development of maize plants, but the lowest content is registered at maturity in milk (0.16 % d.m.) with addition of maximum quantities to both fertilizers (240 kg/ha) (Figure 10). Also, the potassium content in maize leaves was very low in all three stages of maize development, the smallest values, being noticed, at maximum quantities used to both fertilizers (Figure 11). The similar situation, was noticed to calcium content, the smallest values (0.21 ppm) was registered at maturity in milk when used ammonium nitrate in maximum doses (240 kg/ha) (Figure 12).

The magnesium content decreased with increasing doses of fertilizers, reaching the lowest values (0.1 ppm), to the milk maturity of maize plants, when applying the maximum doses of ammonium nitrate (Figure 13).

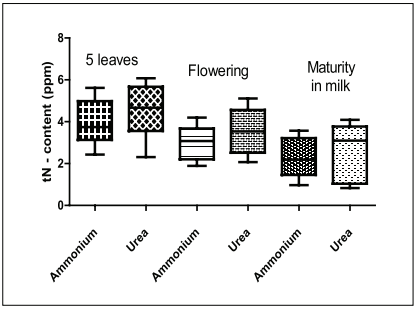

Fig. 9. Effects of two nitrogen fertilizers on tN content of the leaves, in different growth stages of maize plants

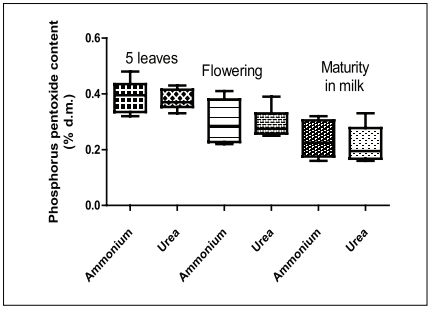

Fig. 10. Effects of two nitrogen fertilizers on phosphorus pentoxide content of the leaves, in different growth stages of maize plants

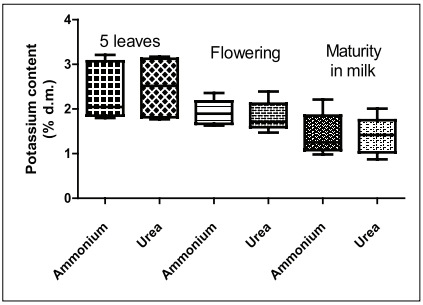

Fig. 11. Effects of two nitrogen fertilizers on potassium content of the leaves, in different growth stages of maize plants

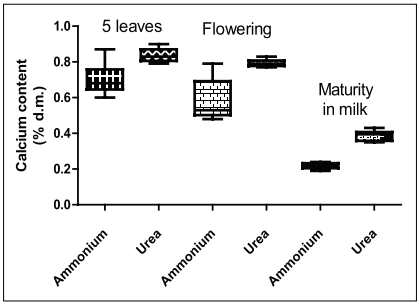

Fig. 12. Effects of two nitrogen fertilizers on calcium content of the leaves, in different growth stages of maize plants

The use of high doses of ammonium nitrate led to an increase in the nitrates content of plants in the three stages of plant development, the highest nitrates content was recorded in the 5-leaf stage (877.9 % d.m) when applied 240 kg/ha ammonium nitrate (Figure 14)

2. Distribution of fertilizer N in plant soil — system

From the table 1 it is observed that in the first vegetation stage (5 leaves) there are very significant correlations between the content of the four chemical elements (N, P, K and N-NO3) in the soil and in the green leaves both when applying the doses of ammonium nitrate and urea.

During the flowering there is a distinctly significant correlation between the nitrogen content of the soil and the green leaves when urea is used. In the case of other chemical elements the correlations are very significant.

At maturity in milk there are distinctly significant correlations between

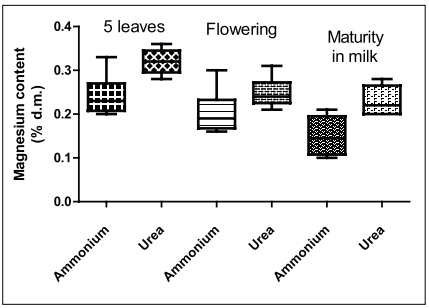

Fig. 13. Effects of two nitrogen fertilizers on magnesium content of the leaves, in different growth stages of maize plants

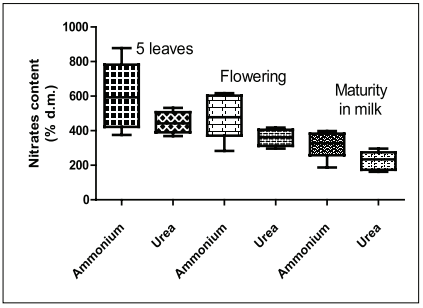

Fig. 14. Effects of two nitrogen fertilizers on nitrates content of the leaves, in different growth stages of maize plants

Table 1. The effect of nitrogen fertilizers on N, P, K and nitrates contents, in maize plants and in the soil, in three development stages

Stages/Sources of variation	Control		Ammonium Nitrate		Urea	
5 leaves	**F***	**P****	**F***	**P****	**F***	**P****
N	5.8		92.61	***	170.9	***
P	181.3	*	3191	***	1570	***
K	1346	*	4080	***	504	***
N-NO_3	8212	**	79.16	***	3722	***
Flowering	**F**	**P**	**F**	**P**	**F**	**P**
N	414.4	*	969.3	***	73.67	**
P	346.2	*	695.8	***	2397	***
K	158.8		1014	***	4013	***
N-NO_3	3196	*	111.8	***	1412	***
Maturity in milk	**F**	**P**	**F**	**P**	**F**	**P**
N	128.4		43.72	**	30.78	**
P	103.2		641.1	***	562.8	***
K	421.1	*	580.3	***	2750	***
N-NO_3	209.8	*	348.8	***	194.4	***

F* — variance between the means of used fertilizers doses;
P**— Significant differences between chemical elements from plants and soil.

the nitrogen content of the soil and from plants, when both types of fertilizers are used. For the other three chemical elements the correlations are very significant.

CONCLUZIONS

From these investigations, it could be concluded that the fertilization levels and type of fertilizers have big influences on chemical contents of soil and maize leaves in analyzed development stages.

In the soil, in all phases of vegetation the nitrate content was higher, when ammonium nitrate was used. The type of fertilizer affected the N, P, K and Al concentration in soil during vegetation period of the maize plants. Also, the content of soluble salts have been the biggest values, when high doses of urea was used, especially at maturity in milk and full maturity of maize plants.

In the maize green leaves, the content of total nitrogen (tN) was higher during first vegetation period when the plants had 5 leaves, for both fertilizers, The lowest tN was noticed at maturity in milk. The phosphorus pentoxide content was low in all three stages development of maize plants. Also, the similar situation, was noticed to calcium content, the smallest values was registered at maturity in milk when used ammonium nitrate in maximum doses.

High doses of nitrogen lead to increased nitrate content in plants in all stages of maize plant development, the highest nitrates content was recorded in the 5-leaf stage, when applied 240 kg/ha ammonium nitrate.

In the first vegetation stages there are very significant correlations between the content of the four chemical elements (N, P, K and N-NO3) in the soil and in the green leaves both when applying the doses of ammonium nitrate and urea. In the other two stages (flowering and maturity in milk), there are distinctly significant correlations between the nitrogen content of the soil and the maize leaves, when urea applied, respectively both types of fertilizers are used. For the other three chemical elements (N, P, K and N-NO3) the correlations are very significant.

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[1]Мурару Д., [1]Плачінта Д., [1]Батір Руссу Д., [2]Хатнен К.
[1]Генетичний банк Сучави, вул. 1 Травня, №17, Сучава, 720264, Румунія
[2]Станція сільськогосподарських досліджень і розвитку Сучави,
вул. 1 грудня 1918, №15, Сучава, Румунія
e-mail: danela.murariu@svgenebank.ro, domnica_p@yahoo.com; dia_sv@yahoo.com; cezarhatnean84@gmail.com

Оцінка наявності нітратів та інших хімічних речовин у ґрунті та в рослинах кукурудзи при внесенні азотних добрив

Основною метою цього дослідження було оцінити вплив азотного удобрення за різних рівнів та видів добрив на агрохімічну еволюцію поверхневого горизонту ґрунту та вміст нітратів у листках кукурудзи на різних фазах росту (5 листків, цвітіння та молочна стиглість). На дослідних ділянках вносили два види азотних добрив (аміачну селітру та карбамід) та п'ять рівнів азоту (80 кг/га; 120 кг/га; 200 кг/га та 240 кг/га). Закладені експерименти проводилися на сільськогосподарській дослідницькій станції (ARDS) м. Сучава, Румунія, протягом 2021 та 2022 років. pH ґрунту за умов внесення аміачної селітри був кислим зі значеннями між 4,88—4,65 на перших стадіях вегетації та між 4,36—4,3 — наприкінці вегетації. Реакція рослин кукурудзи на рівень удобрення та тип добрив показала певний вплив на хімічний склад листків кукурудзи на різних фазах росту. Щодо наявності нітратів у рослинах кукурудзи, то дослідження показало, що вміст нітратів був найвищим на першій стадії росту рослин кукурудзи, особливо при застосуванні аміачної селітри.

аміачна селітра; сечовина; хімічне добриво; листя кукурудзи

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