SUMMARY OF PhD THESIS

Evaluation of the presence of nitrates by chemical fertilization, on the growth and development of maize plants in the climatic conditions of the Suceava Plateau

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INTRODUCTION

Nitrogen is essential for the development of maize plants and therefore for production. The use of the correct doses is crucial both for the environment and for plant health. In the doctoral thesis 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 and we performed biometric observations on maize plants, to see the influence of different doses of nitrogen and two types of fertilizers (ammonium nitrate and urea) on the evolution of fertility. the superficial horizon of the faeoziom soil, the presence of macroelements and nitrates in the maize leaves and on the morphological characters of the maize plants in order to be able to offer solutions to the farmers, from the Suceava Plateau and to the specialists in this area.

THESIS OBJECTIVES

The doctoral thesis "Evaluation of the presence of nitrates by chemical fertilization, on the growth and development of maize plants in climatic conditions in the Suceava Plateau" has as main objective the analysis and interpretation of the effect of nitrate presence on maize plant growth and development by chemical fertilization differentiated with chemical fertilizers azote.

The implementation of the general objective helps to obtain results applicable to the technology of maize cultivation in the Suceava Plateau in chemical nitrogen fertilization, with practical use in production farms in this area.

The following specific objectives were identified in this study:

1. ***Pedological and agrochemical study of the faeoziom, typical of the area of the Suceava Agricultural Development Research Station, in accordance with the productive potential of the maize crop specific to this area.***
2. ***Study of the presence of macrolelements and nitrates in maize leaves under the influence of nitrogen fertilizers.***
3. ***The influence of nitrate content on the main morphological characteristics of maize plants.***
4. ***Research on the effect of mineral nitrogen fertilization on the Suceava M maize hybrid, on the accumulation of nitrates in grains.***

PhD THESIS STRUCTURE

The thesis is structured in two main parts:

FIRST PART: THE CURRENT STATE OF KNOWLEDGE - is structured in 2 chapters:

Chapter 1. Contains 5 subchapters in which are presented the need for maize cultivation, the importance of maize cultivation for global food security, the beginnings of maize cultivation in Romania, the chemical composition of kernels, and the current state of maize crop worldwide and in Romania

Chapter 2. The actual research situation concerning the ecological and nutritional requirements for maize cultivation, comprising 4 subchapters on maize requirements for temperature, humidity, light, soil and nutrition requirements (nitrogen, phosphorus, potassium, calcium, magnesium, iron) as well as the requirements for differentiated organo-mineral fertilization on maize crop, as well as the current state of research on the action of nitrogen on maize in the Moldavian Plateau.

Chapter 3. Research objectives

Chapter 4. Environmental peculiarities of the natural environment in the area of the Suceava Plateau, ARDS Suceava

This study was carried out in the experimental field of the maize breeding laboratory within ARDS Suceava, located on the outskirts of Suceava, on a faeoziom soil, at an altitude of 331 m.

During the experimented period, the average monthly temperatures from emergence to harvest of maize plants, reached a temperature of 16.7^0C, ensured the requirements of optimal thermal maize for normal development and obtaining sustainable yields, per unit area in this crop area.

In terms of rainfall, the deviation of the amount of precipitation compared to the average of 2017-2018 was positive in 2017 and negative in 2018. In the phenophases of maize vegetation, the rainfall was sufficient for the development of maize plants, which led to high production in this crop area in both years of experimentation.

Chapter 5. Biological material and research method

The experiments were performed in the Experimental Field of the Maize Breeding Laboratory, within ARDS of Suceava, which is located on a faeoziom soil, located in the Suceava Plateau. The experiment was designed three-factorial and placed according to the method of subdivided plots with the following graduations:

Factor A: fertilization levels with 6 graduations.

Factor B: two types of nitrogen fertilizers.

Factor C: years of experimentation (2017-2018).

Experimental design at maize Hybrid Suceava M in ARDS Suceava (2017-2018) is the following:

Fertilizant level	**b1-*Amonium nitrate***		**b2-*Urea***	
	c1-2017	c2-2018	c1-2017	c2-2018
a1-Unfertilized Control	x	x	x	x
a2-N_{80}	x	x	x	x
a3-N_{120}	x	x	x	x
a4-N_{160}	*x*	*x*	*x*	*x*
a5-N_{200}	*x*	*x*	*x*	*x*
a6-N_{240}	*x*	*x*	*x*	*x*

The biological material used in the experiment was the trilinear maize hybrid Suceava M.

Agrochemically, this type of soil has a strong acid reaction in all three horizons (Ap-4.75; Bt-4.98), has a low nitrogen content, moderate phosphorus and high potassium.

Agrochemically, the analyzed faeoziom soil has a strong acid reaction in all three horizons (Ap-4.75; Bt-4.98), has a low nitrogen content, a moderate phosphorus content and a high potassium content.

It is a medium fertility soil with acidic pH, suitable only for a certain variety of plants, such is maize crop.

The statistical calculation of the data from the research topic, of the two years of experimentation (2017-2018), from the Suceava Plateau, more precisely from the maize breding field, within ARDS of Suceava, was performed by the method of analyzing correlations and regressions for the factors taken in the study, which highlighted the effects of nitrogen fertilizers on plant growth and development and the presence of nitrates both in the green leaves of maize plants and in the soil.

Chapter 6. Results and discussions regarding the agrochemical evolution of the faeoziom soil in the superficial horizon by differentiated fertilization with nitrogen, at ARDS of Suceava

When applying the 6 levels of fertilization, for both types of fertilizers (ammonium nitrate and urea), the main agrochemical components of the soil have undergone some changes, as follows:

When applying ammonium nitrate:

- pH, humus content (3.86-3.98) and nitrogen index (2.17-2.12.) had a flat evolution both at the beginning of the maize vegetation and at its end;

- The sum of the basic exchange cations (12.97; 13.87) and the hydrolytic acidity (11.38; 19.55) showed slightly higher values at maximum

nitrogen doses. The hydrolytic acidity at the end of the maize vegetation showed higher values than at the beginning of the vegetation;

- The hydrolytic acidity index (Vah%) registered lower values with the increase of fertilization levels, the decrease being more accentuated at the end of the vegetation period (56.23 -41.51).

When urea is applied:

- As with the application of ammonium nitrate, the pH, humus content and nitrogen index (IN) had a flat evolution both at the beginning of the maize vegetation and at the end of the vegetation;

- The sum of the basic exchange cations and the hydrolytic acidity had a flat evolution at the beginning of the vegetation, but they increased slightly at the end of the vegetation period, at the use of doses over 160 kg/ha (14.72).

- The hydrolytic acidity index (Vah) registered slightly higher values, at the application of doses over 200 kg/ha (46.68), and lower at the end of the vegetation period, with the increase of fertilizer doses (43.69).

Chapter 7. Results and discussions regarding the presence of nitrates and other macroelements in the soil, through differentiated nitrogen fertilization, at ARDS of Suceava

Effect of the two nitrogen fertilizers (ammonium nitrate and urea) on the content of soil chemicals (pH, total nitrogen, mobile phosphorus, mobile potassium, sum of basic cations, hydrolytic acidity, mobile aluminum, nitrates, conductivity, total salt content soluble, IN) was analyzed separately to highlight any differences that may occur in the application of the two types of fertilizers.

When ammonium nitrate was applied, it was observed that when using high doses of fertilizer, there is a strong increase in nitrate content, soluble salt content and electrical conductivity, especially in the early stages of maize plant growth. In contrast, the values of some chemical elements (mobile P, mobile K, mobile K) have undergone insignificant changes in all the situations presented.

In the case of urea administration, high doses of nitrates are recorded at high doses of fertilizer, especially in the early stages of plant vegetation. The same phenomenon is observed in the case of electrical conductivity and soluble salt content, but these components register high values at high doses of nitrogen, when maize plants are in the milk stage.

In order to identify possible differences, in terms of soil nitrate content, under the conditions of using two types of nitrogen fertilizers, in the 5 phases of plant development, by using 6 levels of nitrogen fertilization, we analyzed the evolution of the content of nitrates, and we found that in the case of

ammonium nitrate, the nitrate content is higher at all stages of plant development, compared to the nitrate content in the soil when urea was used. In both fertilizers the nitrate content is highest in the early stages of plant development (in stage of 5 leaves).

Chapter 8. Results and discussions regarding the presence of nitrates and other macroelements in maize plants, through differentiated nitrogen fertilization, at ARDS of Suceava

The effect of the two nitrogen fertilizers (ammonium nitrate and urea) on some chemical elements in the maize leaves (total nitrogen, phosphorus, potassium, calcium, magnesium) and on the nitrate content is analyzed separately, to highlight possible differences that may occur, when using different types of nitrogen fertilizers.

When using ammonium nitrate, we notice that when high doses of fertilizer are used (240 kg/ha), the total nitrogen content in the leaves is very high, but the phosphorus content decreases greatly in all stages of plant development, most low content, being recorded at maturity in milk. The same situation is observed in the case of potassium content. The calcium content does not differ much at the 6 levels of fertilization (from 0.2 to 0.9%). We also found that the lowest calcium content in the leaves is also found at maturity in milk. If we refer to the magnesium content, it is observed that there are small differences between the stages of plant development, from 0.2% in the 5-leaf stage to 0.1% at maturity in milk. Instead, the nitrate content doubles, when fertilizer doses are maximum, in all phases of maize plant growth.

In the case of using urea, we noticed that high doses of fertilizers (240 kg/ha), cause a high content of total nitrogen in the leaves, the phosphorus content decreases greatly in all stages of plant development, the lowest content being recorded at maturity in milk. The same situation is observed in the case of potassium and calcium content. If we refer to the magnesium content, it is observed that there are small differences between the stages of plant development, from 0.28%, at the stage of 5 leaves to 0.2% at maturity in milk. When using urea, in maximum doses, the nitrate content doubles only at maturity in milk, at the other two phenophases, the nitrate content increases but not as strongly as with the use of ammonium nitrate.

Chapter 9. Results and discussions on the influence of nitrate content on the main morphological characteristics of plants, under conditions of differentiated nitrogen fertilization, at ARDS of Suceava

To highlight the impact of the two types of fertilizers (ammonium nitrate and urea), on the different morphological characteristics of maize

plants, through the nitrate content accumulated in maize leaves, we presented the action of these two types of fertilizers in the two years of experimentation. (2017, 2018).

In the case of using ammonium nitrate, according to the resulting correlation coefficients, it was observed that there were differences between the values of correlation coefficients in the two years of experimentation, which means that the presence of nitrates in plants is conditioned by climatic conditions. If in 2017, there are statistically significant correlations, very significant negative, between nitrate content and ear length, leaf width and weight of grain/ear, in 2018 there are very significant positive correlations between nitrate content and minimum ear diameter and very significant, between the nitrate content and the number of grains / row.

And in the case of urea use, the differences between the values of the correlation coefficients in the two years of experimentation can be observed, which means that the presence of nitrates in the leaves of the plants is also conditioned by the climatic conditions. If in 2017, there are very significant negative correlations between the nitrate content and the number of the leaves up to the main ear, the minimum diameter of the ear, the width of the leaf and the weight of the kernels/ ear, and very significant positive correlations between the nitrate content, and plant height, the minimum diameter of the ear and the weight of the ears /plant.

Chapter 10. Conclusions and recommendations

The results of the research obtained in the ecopedological conditions of the Suceava Plateau, in the two years of experimentation (2017-2018), regarding the evaluation of the presence of nitrates by chemical fertilization, on the growth and development of maize plants in the climatic conditions of the Suceava Plateau, allow highlighting the following aspects :

1. The analysis of the soil profile shows the type of soil representative of the area, typical faeoziom which is defined by the presence of horizons Ap and A/B a sandy-loam structure, and in the horizon Bt a loam-sandy structure. The sandy-loamy texture denotes an aerated soil with a normal density, favorable for the normal growth and development of maize plants.

2. From an agrochemical point of view, this type of soil has a strong acid reaction in all three horizons (Ap-4.75; Bt-4.98), has a low nitrogen content, a moderate phosphorus content and a high potassium content. It is a medium fertility soil with acidic pH, suitable only for a certain variety of plants, among which are early and semi-early maize.

3. The pH of the soil in the conditions of using 6 levels of fertilization with ammonium nitrate, in the two phases of plant development (5 leaves,

full maturity) is acid with values between 4.88-4.65 in the first phases vegetation, and between 4.36-4.3 at the end of the vegetation period.

4. When applying the 6 levels of ammonium nitrate fertilization, the sum of the basic exchange cations and the hydrolytic acidity showed slightly higher values at maximum doses of nitrogen. The hydrolytic acidity at the end of the maize vegetation showed higher values than at the beginning of the vegetation.

5. Vah (%) registered lower values with the increase of ammonium nitrate fertilization levels, the decrease being more accentuated at the end of the vegetation period.

6. The pH of the soil in the conditions of using 6 levels of urea fertilization, in the two phases of plant development (5 leaves, full maturity) is acid with values between 4.79-4.95 in the first phases of vegetation, and between 4.35-4.21 at the end of the growing season.

7. When applying the 6 levels of urea fertilization, the sum of the basic exchange cations and the hydrolytic acidity had a flat evolution at the beginning of vegetation, but increased slightly at the end of the growing season, when using doses over 160 kg/ha.

8. Vah (%) recorded slightly higher values, when applying doses over 160 kg/ha urea, and lower at the end of the vegetation period, with the increase of fertilizer doses.

9. Regarding the presence of nitrates in the soil, there was an upward evolution of nitrate content when ammonium nitrate was applied, the highest values were recorded when the plants were in the 5-leaf stage (267.7 ppm), in while the content of total nitrogen and mobile phosphorus is the same, do not depend by the stage of development of the plants or the dose of fertilizer used.

10. In the case of mobile potassium content there are very small fluctuations when applying the 6 levels of ammonium nitrate fertilization, instead the electrical conductivity increases when doses of 200 kg/ha are administered, after which the values decrease slightly at doses of 240 kg/ha has ammonium nitrogen.

11. As the doses of ammonium nitrate increase, there is a reduced fluctuation of the mobile Al content, while the soluble salt content increases, maximum values being registered in the first phases of maize vegetation.

12. The existence of distinctly significant positive correlations between nitrate content, electrical conductivity and soluble salt content shows a strong link between soil nitrate content and electrical conductivity on the one hand and soluble salt content on the other, the links being

identical, in the case of these two soil components, when ammonium nitrate is administered.

13. Regarding the presence of nitrates in the soil, there is a strong increase in nitrate content, when 240 kg/ha of urea was used, especially in the early stages of vegetation. Not the same can be said about the total nitrogen content and P-mobile. The content of these two soil components is not influenced by the level of nitrogen fertilization.

14. There was a downward evolution of the K-mobile content and a flat one in the case of Al-mobile, there being very small differences between the non-fertilized and the fertilized variants with 240 kg/ha urea.

15. When urea was used, the soluble salt content increased to a lesser extent, but an upward curve of this agrochemical components, was noted, the highest values being recorded at maximum doses of nitrogen, at milk maturity.

16. The existence of distinctly significant positive correlations between the nitrate content of the soil and the total nitrogen content, when urea was administered, indicates the strong link between the two agrochemical components.

17. It was found that in the case of ammonium nitrate, the nitrate content in the soil is higher at all stages of plant development, compared to the nitrate content recorded in the soil when applying urea. In both fertilizers the nitrate content is highest in the early stages of plant development (5-leaf stage).

18. By fertilizing with ammonium nitrate, it is observed that when high doses of fertilizer (240 kg/ha) are used, the total nitrogen content in the leaves is very high.

19. When large amounts of ammonium nitrate fertilizers are used, the phosphorus content decreases greatly at all stages of plant development, with the lowest content being recorded at maturity in milk. The same situation is observed in the case of potassium content.

20. The calcium content does not differ much at the 6 levels of fertilization (from 0.2 to 0.9%), the lowest calcium content in the leaves was obtained at maturity in milk, when ammonium nitrate was administered.

21. Regarding the magnesium content, when using doses of ammonium nitrate, it is observed that there are small differences between the developmental stages of plants, from 0.2% in the 5-leaf stage to 0.1% at maturity in milk. .

22. In all phases of maize plant growth, the nitrate content is doubled when the doses of ammonium nitrate are maximum.

23. The existence of a very significant correlation between nitrate content and nitrogen content and a significant correlation between nitrate content and calcium content indicates the strong links between nitrate content and the two chemicals (nitrogen content and calcium content), in the case of fertilization with ammonium nitrate.

24. By fertilizing with urea, it is observed that when high doses of fertilizer are used (240 kg/ha), the total nitrogen content in the leaves in the first phases of vegetation is very high (6.08% su).

25. At high doses of urea (240 kg/ha), the content of phosphorus, and potassium decreases greatly in all stages of plant development, the lowest content being recorded at maturity in milk.

26. If we refer to the magnesium content, it is observed that at high doses of urea (240 kg/ha) there are small differences between the stages of plant development, from 0.28% at the stage of 5 leaves to 0.2% at maturity in milk.

27. In the case of the use of urea, in maximum doses, the nitrate content doubles only at maturity in milk, in the other two phenophases, the nitrate content increases but not as strongly as in the case of the utilization of ammonium nitrate.

28. When I administered urea, a very significant correlation was observed between the nitrate content and the nitrogen content, distinctly significant with the calcium content and significant with the phosphorus content.

29. The nitrate content is higher (877.9 ppm) when ammonium nitrate was administered. It was also found that the nitrate content is very high in the early stages of plant development, especially when ammonium nitrate is used.

30. In the case of fertilization with ammonium nitrate, it is observed that the presence of nitrates in plants is also conditioned by climatic conditions. If in 2017, there are statistically assured correlations, very significant negative, between the nitrate content and the ear length, the leaf width and the weight of the kernels/ear, in 2018 there are very significant positive correlations between the nitrate content and the minimum diameter of the ear and very significant, negative correlation between the nitrate content and the number of grains / row.

31. By fertilization with urea, in 2017, on the one hand, there are positive relationships between the nitrate content and the width of the leaf, the total number of leaves and the number of leaves up to the main ear, and on the other hand a relationship strongly negative with the minimum

diameter of the ear. Instead, in 2018, only negative correlations are observed with both the height of the plant and the minimum diameter of the ear and the weight of the ears/plant.

32. The increase of nitrogen doses and nitrate content causes a decrease in the weight of the ears and, implicitly, in other morphological features (leaf width, total number of leaves, etc.) which of course lead to a decrease in the values of productivity traits.

Chapter 11. The originality and the innovative contributions of the thesis

The originality, importance and novelty of these experiments in the Suceava Plateau area, more precisely at ARDS of Suceava, are due to problems not yet addressed, namely the accumulation of nitrates in soil and plants depending on the amount of nitrogen and the type of fertilizer used on maize.

This study tried to highlight the side effects of applying nitrogen fertilizers, by accumulating nitrates in both soil and maize plants. It was also highlighted how some morphological properties of plants change when nitrogen fertilizers are administered.

The originality of the thesis, in addition to the mentioned aspects, consists in the experimentation of a trilinear hybrid which recently approved, creation of the breeding laboratory from ARDS of Suceava.

In Romania, maize has a special importance, a situation that is also reflected in the large covered areas, around 3 million hectares per year, which represents 30% of the arable land of the country.

Nitrogen is essential for plant development and therefore for production. Using the right doses is crucial for both the environment and plant health.

The results of the research of this doctoral thesis can be used as a guide for farmers, students in agronomy and all specialists who want to know about the presence of nitrates in soil and plants, depending on the doses of nitrogen used.