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RESEARCHES INFLUENCE OF ZEOLITE ON PRODUCTIVITY ELEMENTS AND MICROBIOLOGICAL ACTIVITY ON SPRING BARLEY, SOYBEANS AND MAIZE AT ARDS TURDA

(SUMMARY OF PhD THESIS)

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Please you accept a copy of the summary of the thesis entitled: „RESEARCHES INFLUENCE OF ZEOLITE ON PRODUCTIVITY ELEMENTS AND MICROBIOLOGICAL ACTIVITY ON SPRING BARLEY, SOYBEANS AND MAIZE AT ARDS TURDA” edited by biologist Sfechiş Susana, to obtain scientific title „DOCTOR IN AGRONOMY“

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INTRODUCTION

During the sharp global economic development and exponential growth in the consumption of material resources and minerals of the last century, have attracted intense preoccupations in finding viable alternatives for increasing soil productivity together with the increase their fertility.

Agriculture the present phase of world economic development, in which synthetic industrial products have invaded the world imposes complex measures dialing to raw materials and especially environmentally friendly natural products and renewable depolluting properties.

One of the branches of economy where natural zeolite can be used is agriculture. With the increase of restrictions on the use of agrochemicals, zeolite is able to provide ecological alternatives to follow for modern farmer increasingly concerned about the consequences of his actions on the environment.

CHAPTER I
ZEOLITE AND ITS USES

The first chapter are presented the general notions about zeolite, properties of zeolite applications in various areas, and the advantage to its use in agriculture.

Zeolites, also known as the rock prodigy, or boiling rock, discovered by the Swedish scientist Alex Baron Frederik Cronstedt in 1756 (CRONSTEDT, 1756).

In the context of current agricultural practice presents one of the priorities of sustainable agriculture, where the zeolite can be used to obtain high yields but not the least to maintain or improve soil quality.

Zeolites have three main properties, which are of great interest for agricultural purposes: high cation exchange capacity; high water holding capacity in the free channels; and high adsorption capacity (MUMPTON, 1999).

Zeolites also improves the efficiency of water use by increasing the soil water holding capacity and its availability to plants (XUBIN and ZHANBIN, 2001; BERNARDI et al., 2010).
CHAPTER II
NATURAL AREA STUDIED

The experiments were placed in the experimental field of Agricultural Research and Development Station Turda, a soil type faeoziom argic very well stocked with necessary minerals plant growth and development. The thermal regime shows a warming trend, with an average annual temperature of 10.4°C in 2013 and an amount of rainfall of over 500 mm. In 2014 thermal regime was characterized by a temperature of 11.1°C, and the annual amount of rainfall over 700 mm.

CHAPTER III
TESIS OBJECTIVES

In chapter III is motivated choice of research topic and objectives.

The general objective of the thesis is to study the effect of unilateral application of zeolite and associated mineral fertilizers (urea and complex fertilizer NP20: 20) on productivity elements and in particular the microbiological activity of the soil in some species widespread in the culture of the Transylvanian Plain: spring barley, soybeans and maize.

Specific objectives:

- The effect of treatment with zeolite and mineral fertilizers on crop productivity elements studied.
- The effect of treatments with zeolite and mineral fertilizers on quality production at species studied.
- Influence of zeolite mineral fertilizer treatments on the physicochemical characteristics of the soil in the study area.
- Study of microbiological communities and soil microbiological activity.
- Elaboration of recommendations on the application of mineral fertilizers zeolite and to obtain production increases, while preserving the characteristics of trophic soils.
CHAPTER IV
MATERIAL AND METHODS

In chapter IV is presented the research methodology for the three species, the method used to spring barley randomized blocks and Latin rectangle method soybeans and maize. The variants differ in the three culture under study and may be composed of zeolite, mineral fertilizer (urea and complex fertilizer NP20: 20), and zeolite associated with mineral fertilizers.

Were used two native varieties: Romania to spring barley, Felix at soybean and hybrid Turda Star to maize.

As a methodology of research productivity elements were determined both the in the experimental field and in the laboratory.

Analysis of microbiological community profile was determined with the method MicroResp™ (CAMPBELL et al., 2003) - this method determines the response of microbiological community some carbon sources (amino sugars, amino acids, carboxylic acids and neutral sugars).

CHAPTER V
RESULTS AND DISCUSSION
SPRING BARLEY

5.1. RESULTS ON PRODUCTIVITY AND ELEMENTS OF SOIL MICROBIOLOGICAL QUALITIES

5.1.1. Production (t/ha)

Comparing the two experimental years (2013-2014) we can observe that yields variant (V1) control in 2013 differ significantly smaller with more than 1 t/ha compared to variants that were applied treatments (V2-V5) which show a production increase of up to 5.79 t/ha in 2014. The same thing can be observed in simple zeolite application (V3) in 2013, with yield this variant (4.11 t/ha) below the level all variants in 2014 (Figure 5.1).
This could be attributed to weather conditions in 2014 that made this year to obtain yields more uniform in all variants than in 2013 because this year the amount of rainfall during the vegetation period was higher, July excessively rainy; noteworthy is that the plants were more susceptible to failure which could explain all variants uniform production compared to 2013 (Figure 5.1).

In both experimental years (2013 and 2014) best production increases of more than 5 t/ha are obtained from variant were added urea to 70% mixed with zeolite to 30% (V5) and urea unilateral application of up to 150 kg/ha (V2), and variant (V4) the application of equal quantities of urea + zeolite (Figure 5.1).

IFRIM, 2010 studied the influence of fertilization on yield varieties of barley in several environmental conditions in Baragan Plain. The three year average, spring barley yields have exceeded 3000 kg/ha. The ARDS Turda, production came comparative namely over 5 t/ha in two experimental years.

### 5.1.2. Soil respiration (g/m$^2$/h)

Analysis of the results of two experimental years (2013-2014) we see that the soil respiration 2013 variant (V1) control what was recorded highest value 7.81 g/m$^2$/h, compared with this value all experimental variants were registered in 2014 significantly lower values up to 2.48 g/m$^2$/h. In all the variants that one treatment (V2-V5) were observed significant decreases from 2013 by 2014 (Figure 5.2).
Variant treated only with zeolite (V3) has a value respiration of 7.01 g/m$^2$/h to 2013 and reduced to 4.70 g/m$^2$/h to 2014, indicating a stability of the dynamic respiration due to this type of unconventional fertilizer, such as zeolite (Figure 5.2).

Thus in 2013, characterized by drought, the values of soil respiration averaged more than 6 g/m$^2$/h, and in 2014, the year that fell rainfall over the annual average, it is found that values soil respiration are average of more than 3 g/m$^2$/h. In fertile soils predominate aerobic microorganisms, such periods of excess moisture will lead to the reduction of their number because they occupy spaces in the soil will decrease, their place being taken by water (Figure 5.2).

Other studies (AMOS et al., 2005; LOU et al., 2004) also shows that the highest values of soil respiration are in summer. The authors confirm that these results are due to the high temperature and humidity conditions of the soil. The effects of fertilization on soil respiration are controversial and skinny understood (SANDOR and OPRUTA, 2012).

5.1.3. Community level physiological profiles (CLPP)

The rhizosphere, defined as the layer of soil influenced by root metabolism (BERG et al., 2005), is greatly important to plant health and soil fertility.

Community level physiological profiles (CLPP) response after analyzing the NMDS can be explained up to 88.38%. The first axis have a particular importance, explaining to
86.36% of the total variance, the rest (2.02%) is explained by axis 2 (Figure 5.3). Application of different treatments produced changes in the microbiological community profile (CPPL).

![Figure 5.3 Microbial community determined of treatments](image)

The distilled water shows the lowest values on microbiological activity in soil cultivated community with spring barley, the differences being statistically. Average basal respiration distilled water (where no source of added C) ranged from 0.72 - 1.02 µg CO$_2$-C/g/h (Figure 5.3). By applying treatments is an increase of CO$_2$ applied to all substrates with higher values α-ketoglutaric acid 4.43 µg CO$_2$-C/g/h (Figure 5.3).

The spring barley crop treatment application from variant (V5) 105 kg/ha urea + 45 kg/ha zeolite causes a positive effect on this community microbiological culture. A wide range of carbon sources were are metabolised by the microorganisms which are found in this type soil.
Changes in the activity and diversity of soil microbes may reflect changes in soil quality. The pattern of carbon sources utilization by the soil microorganisms and the change in the microbial community structure under the influence of plant is useful for better understanding of the soil functions and in the development of sustainable agroecosystems (DAS and CHAKRABARTI, 2013).

CHAPTER VI
RESULTS AND DISCUSSION
SOYBEANS

6.1. RESULTS ON PRODUCTIVITY AND ELEMENTS OF SOIL MICROBIOLOGICAL QUALITIES

6.1.1. Production (t/ha)

The production level soybean presents the large variations from year to year on average in the experimental year 2013 production was over 1 t/ha and 2014 average production exceeded 3 t/ha, being influenced positively by applying equal quantities of urea + zeolite (V4), but differences between doses have increased in more favorable climate (Figure 6.1).

Figure 6.1 Variation of production in two experimental years

Analyzing data obtained on production in two experimental years (2013-2014), we see that there is significant differences (p<0.001) in all variants. The explanation that
Soybean production has had a production increase in 2014 by more than 2 t/ha compared to 2013, may result in conditions of high temperature and because of rainfall very low in the summer months of this year (Figure 6.1). The critical period for water records phases of the reproductive organs, flowering, especially during formation and seed filling phases calendar which usually falls between June 10 to 15 and 15 to 20 August. Water scarcity in this period leads to the fall flowers and pods formation of small seeds, what in the end leads to a small production, reduced to half (Muntean et al., 2008).

These results are in agreement with findings of a study of DEAC et al., 2014 under the same climatic conditions Felix variety.

The literature confirms that the soybean plants are very sensitive to environmental conditions, such as climatic conditions: solar radiations, temperature and rainfall; as well as soil conditions: drought, excess water, pH, soil fertility, mineral nutrition (Bohlool et al., 1992).

### 6.1.2. Soil respiration (g/m²/h)

We conclude that soil respiration, the equivalent of microbiological activity was more intense in 2014 in humidity, drought affecting microbial community, so soil biological activity in 2013 (Figure 6.2). LOU et al., 2004, reported that the high temperature of the soil is positively correlated with the flow of CO₂. Another factor which is positively correlated with soil moisture soil respiration (Luo and Zhou, 2006).

![Figure 6.2 Variation of soil respiration in the two experimental years](image)

**Figure 6.2 Variation of soil respiration in the two experimental years**
A study on respiration of soil showed no significant differences between treatments, the highest value was registered in control, followed by organic and mineral treatments (SANDOR and OPRUTA, 2012).

6.1.3. Community level physiological profiles (CLPP)

Although little known of soybean plant rhizosphere can rightly be regarded as an essential functional interface between plants and soil, active interface due to the presence of microorganisms: bacteria, fungi, protozoa (ARSHAD and FRANKENBERGER, 1991). Described by Hiltner in 1904 (cit. SYLVIA, 1999) as region of soil microorganisms are exposed to specific influences of plant roots, the rhizosphere is currently defined with sufficient ambiguity. After a physiological definition, rhizosphere soil as periradicular the region is feeling the effects of substances of plant exudates, performing the so called rhizosphere effect (ZARNEA, 1994).

Figure 7.3 Microbial community determined of treatments
Community level physiological profiles (CLPP) response after analyzing the NMDS can be explained up to 90.08%. The first axis have a particular importance, explaining to 89.52% of the total variance, the rest (0.56%) is explained by axis 2 (Figure 7.3). Application of different treatments produced changes in the microbiological community profile (CPPL).

The distilled water shows the lowest values on microbiological activity in soil community at soybean, the differences being statistically significant as. Average basal respiration distilled water (where no source of added C) ranged from 0.43 - 0.82 µg CO$_2$-C/g/h. Carboxylic acids presents the the highest values of the community response microbiological almost all variants. The highest values are presented $\alpha$-ketoglutaric acid range between 2.66 - 5.28 µg CO$_2$-C/g/h. The highest value 5.28 µg CO$_2$-C/g/h registered variant (V4) to the equal quantity of urea + zeolite (Figure 6.3).

A similar result was reported soybean crop in a previous study, malic and citric acid in rhizosphere they had noticeable effects on soil microbial communities (YANG et al., 2012). A similar result was also reported in a previous study (YANG et al., 2000) suggest that citric acid and malic acid may be a factor for positive selection of certain microbes in the rhizosphere.

CHAPTER VII
RESULTS AND DISCUSSION
MAIZE

7.1. RESULTS ON PRODUCTIVITY AND ELEMENTS OF SOIL MICROBIOLOGICAL QUALITIES

7.1.1. Production (t/ha)

From studies it is found that the highest production increases during the two experimental years (2013-2014) obtained from variant (V4) the application of an equal amount of 100 kg/ha urea + 100 kg/ha zeolite with a increase of 4.71 t/ha in 2013, ie 8.31 t/ha in 2014 (Figure 7.1).

In the two years of experimentation (2013-2014), climatic conditions of 2014 caused the this year to obtain the highest yields. General trend in temperature during the growing
season of 2013, closely followed annual average, but July and August have been characterized as dry with temperatures often exceeded the normal average temperature. Also, the total precipitation especially in the second half of the growing season were strong deviations from the average of July and August. The explanation that maize production had a production increase in 2014 by more than 2-4 t/ha compared to 2013 can be related to conditions of high temperature and very low rainfall in the summer months this year.

Figure 7.1 Variation of production in two experimental years

Meteorological conditions such as temperature and precipitation development are the main factors that influence agricultural production variability from year to year (COCIU, 2012). The large differences production from year to year and production increases per unit active influence attest years (with climate effects) on the efficiency of mineral fertilizers + zeolite application at maize. From this point of view can only be conclusive results of 2014 technical and economic analysis correct.

The results are consistent with previous results obtained PORUTIU 2014, production recorded a differentiation between 2011-2013. Year most favorable climatic point of view was 2011, and in 2012 (first) and 2013, led by lower results excess heat.

7.1.2. Soil respiration (g/m²/h)

Comparing the results recorded in two experimental years (2013-2014) by applying treatments can notice that the soil respiration recorded the highest values up to 8.51 g/m²/h
of soil respiration in 2013, with significant results when applying the quantity equal urea + zeolite (V4) with significant differences from some variants (V2) 4.64 g/m²/h; (V4) 5.53 g/m²/h; (V6) 5.69 g/m²/h; (V8) 5.05 g/m²/h in 2014 (Figure 7.2).

Figure 7.2 Variation of soil respiration in the two experimental years

Soil respiration intensity is the measurement of biological activity in the soil and soil microbial community profile. Treatments with zeolite, especially zeolite + urea, where soil microbial communities in maize can cause some significant differences, being evidently influenced by climatic conditions.

7.1.3. Community level physiological profiles (CLPP)

Soil microorganisms play a crucial role in one of the most important ecological processes – the turnover of chemical elements in an ecosystem. Soil microbes break down complex organic molecules and release inorganic nutrients which then can be used by plants. The rate of dead organic matter decay depends on the biomass and metabolic activity of microorganisms. These parameters are in turn controlled by numerous natural factors such as temperature and humidity (AERTS, 1997), chemical composition of organic matter (AERTS, 1997; COUTEAUX et al., 1955), vegetation type (WARDLE et al., 2000) and soil properties (PRESCOTT, 1996).

Community level physiological profiles (CLPP) response after analyzing the NMDS can be explained up to 94%. The first axis have a particular importance, explaining to
78.04% of the total variance, the rest (15.96%) is explained by axis 2 (Figure 7.3). Application of different treatments produced changes in the microbiological community profile (CPPL).

![Figure 7.2 Microbial community determined of treatments](image.png)

Distilled water and γ-aminobutyric acid do not change the microbiological community activity. Average basal respiration (where no source of added C) CO$_2$ ranged from 0.46 - 0.66 $\mu$g CO$_2$-C/g/h. Carboxylic acids are metabolised best by microbiological communities who prefer urea (V2). The citric acid treatment application determines the highest increases 3.94 $\mu$g CO$_2$-C/g/h variant (V2).

Citric acid production is directly influenced by the nitrogen source, physiologically, ammonium salts are preferred, e.g., urea. The literature states that a large number of organisms, including bacteria, fungi and yeasts have the ability to produce (extensive metabolisers) citric acid. Fungi such as: Aspergillus niger, A. aculeatus, Penicillium janthinellum; yeasts: Saccharomiceslipolytica, Candida tropicalis, C. oleophila, C. guillermondii, C. parapsilosis also bacteria: Bacillus licheniformis, Arthrobacter paraffinens, Corynebacterium sp. (VANDENBERGHE et al., 1999).
It has also been shown that introduction of leguminous crops for a season into a conventional system of continuous cultivation of maize (*Zea mays* L.) increased microbial diversity (BUNEMANN et al., 2004; BOSSIO et al., 2005).

**CONCLUSIONS**

The results confirm the suitability of using natural zeolite (clinoptilolite) in agriculture, having a positive role in plant nutrition and microbial community stability, as evidenced subject experimentation crops: spring barley, soybeans and maize.

1. **Spring barley**
   1.1. Treatment of with urea + zeolite (V4, V5) is highly effective, ensuring production increases of more than 5 t/ha in two experimental years (2013 and 2014).
   1.2. Regardless of weather conditions, applying 150 kg/ha urea (V2), provides significant production increases of more than 5 t/ha.
   1.3. Microbiological characteristics and the spring barley crop soil respiration under the influence variability present study, however it is noted that zeolite applied unilaterally maintain the balance of the microbial community and applied to 70% urea has the effect of diminishing the soil respiration.
   1.4. Test analysis of carbon substrates (Microresp™) allowed detecting changes in functional diversity of microbial application in a mixture of zeolite mineral fertilizers (urea).
   1.5. The treatment with 30% zeolite + 70% urea (V5) of spring barley crop causes a positive effect on microbiological community. A wide range of carbon sources were metabolised by the microorganisms found in the soil type (amino sugar, amino acids except L-arginine, all the carboxylic acid and the neutral sugars).

2. **Soybean**
   2.1. Variety Felix is characterized by a high yield potential for the group of maturity falling; this proved in the second year of experimentation (2014), reaching a maximum potential production of 3.44 t/ha the application of equal proportion zeolite + urea (V4), and a significant difference of more than 2 t/ha compared to experimental results obtained in the first year (2013).
2.2. In 2013 the largest production increase was registered variant (V4) the application of equal proportion zeolite + urea and urea (V2) production was 1.39 t/ha.

2.3. In 2013, none of the the experimental variants there has been increases in soil respiration. But in 2014 the application of 175 kg/ha zeolite + 25 kg/ha NP20: 20 (V8) was an increase of soil respiration of 15.49 g/m²/h.

2.4. Profile microbiological community soybean differ between treatments applied; carboxylic acids present the highest values in response to community microbiological almost all cases, the highest values are where acid $\alpha$-ketoglutaric (5.28 µg CO$_2$-C/g/h) and citric acid (4.18 µg CO$_2$-C/g/h) the application of urea + zeolite.

2.5. Actinomycetes (acid $\alpha$-ketoglutaric) are the dominant group rhizosphere of soybean plants fertilized with urea and zeolite, zeolite occurring at low values of actinomycetes-cyanobacteria dominance ($\alpha$-ketoglutaric acid - citric acid).

3. Maize

3.1. Productions highest achieved in the two years fertilization experiments are related to efficient economically and ecologically. This is mixed, based on moderate amounts of urea and zeolite (V4) in 2013 yielding a production of 4.71 t/ha, and in 2014 a larger production by almost half 8.31 t/ha.

3.2. The intensity of soil biological activity expressed by values of soil respiration is positively influenced by equal application of zeolite and urea in V4 (50 kg/ha zeolite +50 kg/ha urea).

3.3. Community profile microbiological led to changes in terms of diversity of treatments applied, all carboxylic acids are metabolised best by the communities microbiological prefer urea (V2) with a maximum oxalic acid (5.09 µg CO$_2$-C/g/h).

3.4. For maize, the best option fertilizing include equal amounts of zeolite and urea (100 kg/ha + 100 kg/ha) with the capability to maintain the microbial community at a high level of efficiency with the balancing processes of nitrogen fixation in nesimbiotic mode and denitrifying.

3.5. Test analysis of carbon substrates (Microresp$^{TM}$) allowed detecting changes in functional diversity of microbial application in a mixture of zeolite mineral fertilizers (urea and complex fertilizers NP20:20).
SELECTIVE BIBLIOGRAPHY


7. CRONSTEDT B.A.F., 1756. Observation and description of an unknown kind of rock to be named zeolites, Stockholm, Sweden: Kongl Vetenskaps Academiens Handlingar, 120-123.


