MINERAL FERTILIZATION INFLUENCE ON SOIL pH, CATIONIC EXCHANGE CAPACITY AND NUTRIENT CONTENT

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Abstract *Crop production capacity is greatly influenced by soil quality. Soil quality is determined by physical and chemical characteristics, some of which may or may not be economically controlled. Chemical characteristics that influenced soil quality are: soil reaction, exchange capacity, organic matter and essential plant nutrients content. In general if physical characteristics are satisfactory, chemical properties can be modify by adequate use of mineral fertilizers, manure, green manure plow downs and other organic additives. Improper fertilization contributes to soil infertility. Over-fertilization increases salinity in the soil and inhibits plant uptake for some nutrients. Under-fertilization fails to replace macro- and micro-nutrients previously removed by plants and environmental actions. A special importance should be given to the type of fertilizer to be applied. The aim of this paper is to monitories the changes of soil chemical properties like soil reaction, cationic exchange capacity, humus and N,P,K content after mineral fertilization. Researches in this area showed a significant correlations between the type and quantity of applied fertilizer and modification of main soil chemical features. Our research was made on cambic chernozem, with six fertilizer treatments (different N, P, K doses). In plots with nitrogen fertilization only nitrogen was applied as calcium ammonium nitrate, in plots with NPK fertilization complex fertilizer was used. After soil sample analysis the effect of treatments on soil pH, CEC and N,P,K content were tested using ANOVA method, and the significance of their correlations was made by Pearson correlation matrix. Results does not shows a decrease of pH value as shown by researches when nitrogen is applied as ammonium nitrate. The increase of the CEC value is not strongly influenced by soil pH and total nitrogen, being significantly influenced by phosphorus and potassium content of soil. To maintain a certain level of soil fertility is important to monitor the continuous changes that suffer its chemical properties after application of mineral fertilizers.*

Key words*: soil quality, fertility, soil chemical properties, fertilizers*

INTRODUCTION

The soil is and will be the main source of human nutrition. A fertile and productive soil is the fundamental resources for the farmer and the entire ecosystems. The farmers objectives is to maintain the productivity of his soil, that is maintaining a good physical structure, organic matter content, good aeration, an adequate moisture content, proper pH and optimal nutrient status (CRESSER, 1993).

Soil productivity is the ability of a soil to support crop production. Soil fertility is only one aspect of soil productivity but is very important one. For the farmer, the decisive property of soils is their chemical fertility and physical condition, which determines their potential to produce crops.

Chemical characteristics of soil fertility are: soil reaction (pH), nutrient content, adsorption and exchange. Although soil reaction is not a growth factor, it is a good indicator of several key determinants of growth factors, especially nutrient availability.

Probably the most important and distinctive property of soils is that they can retain ions and release them slowly to the soil solution and to plants. Cationic exchange is constantly going in soils and is of great importance. Without cationic exchange plants would be unable to obtain sufficient quantities of the essential nutrients to grow and the nutrients would be leached downward in the soil and lost. Also cationic exchange capacity determines how often and how much lime must be added to a soil (HAVLIN, 1999).

As crop yields have increased over the years, few soils are able to supply the amounts of nutrients required to obtain higher yields without external inputs. Nitrogen deficiency is widespread on almost all soils, especially where they are low in organic matter content. Widespread nitrogen deficiency is reflected in the fact that out of the 142 million tones of plant nutrients applied worldwide through mineral fertilizers, 85 million tones (60%) is N. Because the native soil phosphate was strongly adsorbed in very acid soils or precipitated as the insoluble calcium phosphate in alkaline soils, phosphorus deficiencies continue to be a major production constraint. External input through mineral fertilizers alone was 33.6 million tones P_2O_5 in 2002 (ROY et.al. 2006).

Manny researches on soil chemical properties (CAKMAK et.al., 2010, CHEN et.al., 2001) showed that long term mineral fertilization, especially nitrogen, can cause alterations in these properties. To maintain a certain level of soil fertility and to optimize the dose of fertilizer that should be applied is necessary to highlight the main changes that soil agrochemical indices will suffer.

MATERIAL AND METHODS

The researches were made at USAMVB experimental station in Timisoara. Soil type is *cambic chernozem*. Different doses of nitrogen, phosphorus and potassium fertilization was applied on maize crop. Soil were sampled from each of four replicates that were designed as 3 x 10 m plots in a randomized complete block experiment, including the control treatment that didn`t receive any fertilizers. Experimental variants were:

1. control,
2. 54.0.0 (54 $kgN \cdot ha^{-1}$),
3. 81.0.0 (81 $kgN \cdot ha^{-1}$),
4. 81.15.0 (81 $kgN \cdot ha^{-1}$ and 15 $kgP_2O_5 \cdot ha^{-1}$),
5. 81.20.40 (81 $kgN \cdot ha^{-1}$, 20 $kgP_2O_5 \cdot ha^{-1}$ and 40 $kgK_2O \cdot ha^{-1}$),
6. 81.27.27 (81 $kgN \cdot ha^{-1}$, 27 $kgP_2O_5 \cdot ha^{-1}$ and 27 $kgK_2O \cdot ha^{-1}$),
7. 122.30.60 (122 $kgN \cdot ha^{-1}$, 30 $kgP_2O_5 \cdot ha^{-1}$ and 60 $kgK_2O \cdot ha^{-1}$).

Nitrogen was applied as calcium ammonium carbonate. Complex fertilizer types that we used were 20.20.0, 15.15.15 and 14.10.20. From each experimental plot soil samples were taken from 0-20 cm depth and prepared for analysis. Soil pH was determined in water by potentiometric method, total nitrogen by Kjeldahl method, and humus by Tyurin method. Cationic exchange capacity was analyzed by the $BaCl_2$ compulsive exchange method (SUMNER AND MILLER, 1996) After extraction by Egner – Rhiem – Domingo method phosphorus was determined by UV-VIS spectroscopy and potassium by atomic absorption spectroscopy. Statistical analysis was made by SPSS 17 software program. Fertilization effect on soil properties was tested using an ANOVA method and correlation between variables was analyzed using Pearson correlation matrix.

RESULTS AND DISCUSSIONS

After fertilization treatments soil pH rises in all experimental plots, exception plot fertilized with nitrogen and phosphorus only. Many fertilization field experiments made on soil pH showed the decreasing trend of soil pH with nitrogen fertilizer dose rise, in almost all cases nitrogen fertilizer was ammonium nitrate.

Table 1

Fertilization influence upon main soil chemical propeties

Fertilization	pH	CEC meq/100g	Humus %	Total nitrogen %	P ppm	K Ppm
Control	6,50	26,3	3,18	0,210	14	170
54.0.0	6,52	28,1	3,38	0,220	12	171
81.0.0	6,51	28,5	3,37	0,230	16	176
81.15.0	6,49	27,0	3,40	0,227	15	149
81.20.40	6,71	28,8	3,44	0,239	21	176
81.27.27	6,70	29,8	3,43	0,236	18	174
122.30.60	6,80	29,5	3,66	0,243	17	188

Is well known that during nitrification process, NH_4^+ releases H^+ ions which determine soil acidification. In our experiment nitrogen was applied as calcium ammonium nitrate fertilizer, which contains lime used to ameliorate soil acidity. Highest pH values were determined in plots fertilized with NPK complex fertilizers. There is no significance between fertilizer treatments, significance being more than .05 (.092)

Table 2

ANOVA Test for soil pH and cationic exchange capacity

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,197	6	,033	2,941	,092
Within Groups	,078	7	,011		
Total	,275	13			

CEC

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19,550	6	3,258	3,932	,048
Within Groups	5,800	7	,829		
Total	25,350	13			

Nitrogen application as calcium ammonium nitrate only or in combination with NPK complex fertilizer rises the soil CEC value. This can be explained by soil colloid retention of applied Ca^{2+}, NH_4^+ and K^+ ions. In case of ammonium phosphate application (81.15.0 variant), who has an acidifying effect, the rise of CEC can be explained through retention by soil adsorptive complex of H^+ ions resulted after ammonium oxidation process. There is a significant difference between fertilization plots (the significant is less than .05).

It has been experimentally proved that nitrogen fertilizer act with the highest efficiency on soils with low humus content. Humus content of all fertilization plots increases as the nitrogen dose rise. Positive changes in humus content due to application of mineral fertilizers significantly influence the increase of total nitrogen in soils. Long-term field experiments in Rothamstead, England and Askov – Denmark (RUSU et.al., 2005), argue that nitrogen fertilizers maintain a positive balance of long-term humus.

Table 3

ANOVA Test for soil humus, total nitrogen, phosphorus and potassium content

H

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,244	6	,041	3,832	,051
Within Groups	,074	7	,011		
Total	,318	13			

Nt

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,002	6	,000	,987	,498
Within Groups	,002	7	,000		
Total	,003	13			

P

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	91,354	6	15,226	3,569	,060
Within Groups	29,860	7	4,266		
Total	121,214	13			

K

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1719,000	6	286,500	1,310	,363
Within Groups	1531,000	7	218,714		
Total	3250,000	13			

Total nitrogen content of soil increases with the increase of nitrogen fertilizer dose. This may be explained by retaining the ammonium ion by adsorptive complex or by clay minerals in the soil. It can also take place intensification of humus mineralization process and release of ammonium ions. The highest nitrogen contents were determined in plots fertilized with complex fertilizer in different doses unlike the variants fertilized with calcium ammonium nitrate only. Calcium ions from calcium ammonium nitrate can compete with ammonium ions causing a reduction in the amount of ammonium retained in soil. Similar results were obtained by BEDNAREK, 2008.

After applied treatments increase soil phosphorus content take place, except variant fertilized with 54 kg N ha^{-1}, where it has been a reduction. Application of nitrogen fertilizer improves the current and potentially state of the phosphorus system in the soil. Potassium content, like phosphorus, rises as the nitrogen and potassium fertilizer dose rise. Ammonium ion and potassium ion compete for positions of attachment of the expandable clay minerals. Following the application of high amounts of nitrogen, potassium may be released causing increase of the potassium content in soil.

Table 4

Pearson Correlations Coefficients for main soil chemical properties after mineral fertilization

		pH	CEC	Nt	P	K	Humus
pH	Pearson Correlation	1					
CEC	Pearson Correlation	,116	1				
Nt	Pearson Correlation	,451	,170	1			
P	Pearson Correlation	,164	,673**	,365	1		
K	Pearson Correlation	,230	,555*	,151	,335	1	
Humus	Pearson Correlation	,499	-,040	,587*	,382	,326	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

CONCLUSIONS

Improper fertilization contributes to soil infertility. Over-fertilization increases salinity in the soil and inhibits plant uptake for some nutrients. Under-fertilization fails to replace macro- and micro-nutrients previously removed by plants and environmental actions. A special importance should be given to the type of fertilizer to be applied. Application of calcium ammonium nitrate unlike other nitrogen fertilizer doesn`t determined soil acidification, although the increase compared with control is not significant. The increase of the CEC value is not strongly influenced by soil pH and total nitrogen, being significantly influenced by phosphorus and potassium content of soil. Total nitrogen content is significantly influenced by humus. Both total nitrogen and humus content are dependent to a certain extent on soil pH, because of his influence on soil microbial activity and soil nitrogen transformations.

To maintain a certain level of soil fertility is important to monitor the continuous changes that suffer its chemical properties after application of mineral fertilizers. Having a complete picture of the soil chemical properties changing trend we can adjust the dosage and type of fertilizer applied to meet biological requirements of plants and ensure the maintenance of soil quality.

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