CHANGES IN SOIL REACTION UNDER THE INFLUENCE OF MINERAL FERTILIZATION

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Abstract: *The aim of our research was to assess the impact of some chemical fertilizers on the acidity of the soil. Soil reaction, or pH, is an important agrochemical indicator of the growth medium, since it defines the conditions of bioavailability of nutritive elements for the plants as well as nutritional relationships. Following the large use of chemical fertilizers in the agricultural practice, as well as the acidification phenomenon signalled in the scientific literature, we tested the influence of a complex fertilizer type NPK (15:15:15) and of ammonium nitrate on soil pH. Both types of fertilizers are highly used in everyday practice. The soil the research was made on is a slightly gleized cambic chernozem found in Banat area, more specifically at Timişoara Didactic Station. Complex fertilizers were applied in three doses ensuring 50, 100 and 150 kg N active substance/ha. The nitrogen in the complex fertilizers was nitric and ammonia, in proportion of 6%*$N-NO_3^-$ *and* $9\%\ N-NH_4^+$*. Ammonium nitrate was applied on its own on the three agrofonds NPK ensuring a total of 50, 100, 150 and 200 kg N active substance/ha. We observed the changes in soil reaction at a depth of 0 – 20 cm, parted in 0 – 10 cm and 10 – 20 cm, in order to note the gradual influence of the fertilizers on the pH. Chemical fertilizers, whether applied separately or together, determined an acidification in soil reaction within the limits of 0.08 – 0.34 pH units for the depth of 0 – 10 cm and 0.09 – 0.31 pH units for the depth of 10 – 20 cm. After performing a comparative analysis of the two layers of soil we found gradual pH changes in relation to the infiltration of the ions coming from fertilizers on the surface of the soil. The mean change in soil reaction for the 0 – 20 cm deep layer is 0.09 pH units for a dose of 100 kg active substance N/ha ammonium nitrate. For fertilization type* $NPK_{150}+N_{50}(AA)$*, the mean change is 0.32 pH units.*

Key words*: pH, soil, acidification, mineral fertilizers, ammonium nitrate, NPK*

INTRODUCTION

Soil reaction is an important agrochemical indicator because it has a strong influence on the growth medium of plants, on the regime and bio-availability of nutrients and on the way nutritive ions get to plant roots. It is due to this fact that soil reaction is considered to be one of the most important characteristics of the nutrition environment.

The composition and reaction of the soil solution are dynamic, reversible features. According to FLOREA 1994, the modification of these characteristics in order to reach a quasi-steady state with the environment takes between 10^{-1} and 10^{0} years.

The change in soil reaction is determined by a number of natural and anthropic factors: natural factors of genetic formation and evolution of each type of soil, the biological activity in the soil, the modification in the soluble salts content by external inputs, land improvement works, agricultural systems through land and crop technologies, PRASAD, and POWER, 1997, PLASTER 2003, HAVLIN et al. 2005, RUSU et al. 2005.

In conventional agriculture, soil acidification can be generated by certain technological deficiencies based on exclusive use of mineral fertilizers that contain nitrogen, especially ammonium, on acid soils or soils susceptible to acidification, MARINCA et al. 2009. The cycle of nitrogen in the soil has intensified because of the increase in the quantities of mineral fertilizers applied. These fertilizers have stimulated crop productivity, but at the same time they have brought their significant contribution to accelerating the phenomenon of acidification.

In the U.S., after the 1960s, following excessive mineral, nitrogen-based fertilization, the acidification of soils was accelerated in such a way that, even now, large quantities of amendments have to be added annually in order to neutralize the reaction, BRADY and WEILL, 2008.

It is relatively difficult for a constant reaction of soil solution to exist and last for a longer period of time, especially on toiled lands, where various mineral or organic substances are introduced as fertilizers and amendments.

These will result in ions, which, according to the laws of ionic exchange, will be part of the ion movement from the colloidal complex to the soil solution and vice versa, and their interactions will bring about changes in the balance of soil, JENKINSON et al. 1985, MENGEL and KIRKBY, 2001.

In our country, careless use of nitrogen-based chemical fertilizers has led to an expansion of the surface of soils which are affected by acidification, and also to intensified acidification on those soils which were not base saturated. Hence, in 1998, National Studies of Soil Monitoring revealed that almost 60% of the agricultural surface is degraded through this process, BORLAN (1998, a, b).

Stationary studies on soil reaction have outlined the dynamic character of this feature. The periodic pH variation can grow to one unit, being more significant on soils with low buffering capacity, FILIPOV (2005).

Mineral fertilizers, through their chemical formulation, can modify the pH of the soil. Generally, fertilizers with high nitrogen content of ammonium origin (urea, ammonium sulphate, ammonium phosphate, ammonium nitrate) can acidify soils when they are applied repeatedly. The microorganisms in the soil convert the nitrogen from ammonium (NH_4^+) to nitric (NO_3^-), thus releasing ions H^+ which acidify the soil.

The current acidification caused by fertilizers is influenced by the soil conditions which affect the transformation of ammonium into nitrate and at the same time determines how much ammonium will be assimilated by plants before the transformation, (15).

A lot of studies and research made in various pedoclimatic conditions and different crops have emphasized the fact that the soils is acidified under the influence of certain types of mineral fertilizers, BOLTON (1971), RUSU et al. 2005, HAVLIN et al. 2005.

The research made for the purpose of this paper focused on assessing the acidification capacity of some types of NPK complex chemical fertilizers and of ammonium nitrate when they are applied on a certain type of soil, namely slightly gleized cambic chernozem, in the area specific for The West plain.

MATERIAL AND METHODS

The object for our research consisted in assessing the impact of mineral fertilization in a field rotation on soil reaction, as the main indicator of the plant nutrient medium. Fertilization was based on complex fertilizers of the type NPK (S) zinc fertilizers [15/15/15(+3+Zn)] and ammonium nitrate (35:0:0).

The general frame of the experiment is given by the pedoclimatic conditions that are specific for Banat Plain. The research was conducted at Timişoara Didactic Station, on slightly gleized cambic chernozem with neutral reaction (*p*H = 6.95-7.1), good humus supply (H = 3.2), nitrogen index IN = 3.09, elevated base saturation degree (over 85-87%), scarce mobile phosphorus supply (P_{AL} = 17.4 ppm) and medium potassium supply (K = 128 ppm).

The climatic conditions can be described by multiannual average values of 603.3 mm precipitations and temperatures of 10.9°C. In the period the experiment took place, 2010 – 2011, the rainfall regime generally fit into the multiannual average, but it lacked uniformity at times. Great rainfall deficit was registered between August and November 2011.

Mineral fertilizers were represented by complex fertilizers of the type (S) zinc fertilizers [15/15/15(+3+Zn)] and ammonium nitrate.

Complex fertilizers are characterized from the point of view of their active element content as follows: 15% total N (6% nitric N, 9% ammonium N); 15% P_2O_5 phosphates soluble in ammonium citrate and water (12% P_2O_5 water-soluble nitrates; 15% K_2O, water soluble potassium oxide; 3% S, total sulphur (2.7% water-soluble sulphur); 0.01% Zn.

Ammonium nitrate had a content of 33.5% total N, of which 16.75% NO_3^- and 16.75% NH_4^+.

The biological component was represented by wheat crops, maize crops and crops of sunflower; the determinations were made on the plot cultivated with winter wheat, *Alex* variety.

The experiments were organized in randomized blocks, with the surface of an experimental variant of 30 mp.

The fertilization was hand-made: the fertilizers were applied manually in two stages, namely in autumn and in spring. Sampling was done in the third decade of March.

The samples were harvested for two depths, 0 – 10 cm and 10 - 20 cm, in order to record the changes in pH both on experimental variants and on the soil profile, in relation to the infiltration of nutritive ions.

In order to discover the acidifying influence of chemical fertilizers, we determined the following indicators: soil *p*H, the degree in base saturation (V), the degree of correlation between the independent variant - fertilizer doses and dependent variant - soil reaction.

RESULTS AND DISCUSSIONS

The results of our research on the influence of complex NPK fertilizers (S) zinc fertilizers [15/15/15(+3+Zn)] and ammonium nitrate (35:0:0) on soil reaction when applied on cambic chernozem are presented in Table 1 and Figure 1.

Table 1

pH values in relation to the types and doses of mineral fertilizers

Variant / Depth		PK_0N_0	PK_0N_{100} (AA)	PK_0N_{200} (AA)	$PK_{50}N_{50}$ (NPK + AA)	$PK_{50}N_{100}$ (NPK + AA)	$PK_{50}N_{200}$ (NPK + AA)	$PK_{100}N_{100}$ (NPK)	$PK_{100}N_{150}$ (NPK + AA)	$PK_{100}N_{200}$ (NPK + AA)	$PK_{150}N_{150}$ (NPK)	$PK_{150}N_{200}$ (NPK + AA)
pH values	0 – 10 cm	6.91±0.03	683±0.03	7.83±0.03	6.82±0.03	6.76±0.03	6.67±0.03	6.7±0.03	6.64±0.03	6.57±0.03	6.6±0.03	6.58±0.03
pH units modified		-	0.08	0.18	0.09	0.15	0.24	0.21	0.27	0.34	0.31	0.33
pH value	10 – 20 cm	6.98±0.02	6.87±0.02	6.79±0.02	6.89±0.02	6.8±0.02	6.75±0.02	6.79±0.02	6.73±0.02	6.69±0.02	6.71±0.02	6.67±0.02
pH units modified		-	0.11	0.19	0.09	0.18	0.23	0.19	0.25	0.29	0.27	0.31

The assessment of the change in soil reaction was made for the depth of 0 – 20 cm, separated into layers 0 – 10 and 10 – 20 cm in order to record the gradual progressive action of fertilizers on the current acidity (pH) in relation to the area they were applied on.

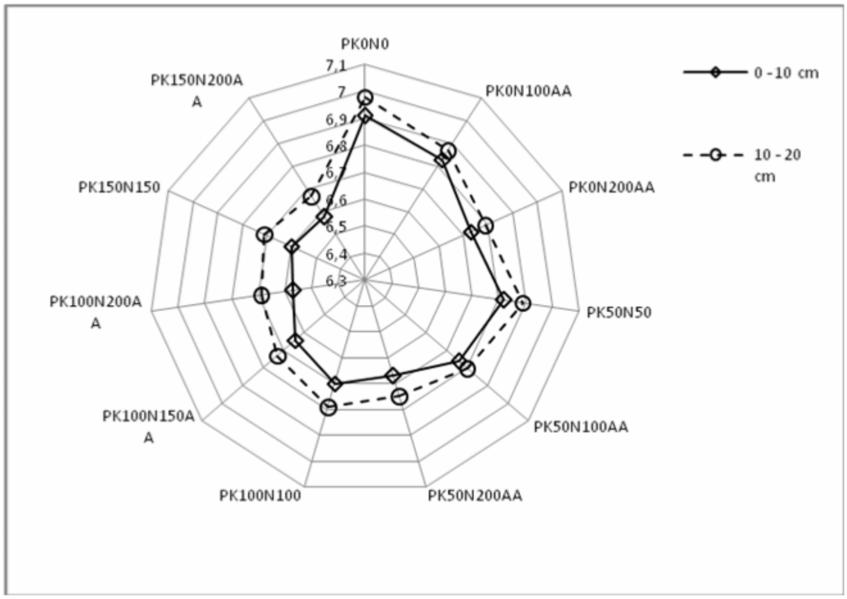

Figure 1. The distribution of pH values under the influence of mineral fertilization

For the soil layer 0 – 10 cm, complex fertilizers led to acidification of the soil reaction by 0.15 – 0.31 pH units as compared to the control variant. For the same depth, ammonium nitrate determined a change in soil reaction by 0.08 – 0.18 pH units when used by itself. When associated with complex fertilizers, it determined a change in soil reaction by 0.15 – 0.24 pH units on the agrofond $NPK_{50}(AA_{50-150})$, 0.27 – 0.34 pH units on agrofond $NPK_{100}(AA_{50-100})$ and 0.33 pH units on agrofond $NPK_{150}(AA_{50})$.

After analysing the change in soil reaction for the layer 10 – 20 cm, we found that complex fertilizers brought about acidification by 0.09 – 0.27 pH units. Ammonium nitrate determines a change in reaction for that depth by 0.11 – 0.19 pH units when applied on its own. When it is applied together with complex fertilizers, it leads to an increase of the current acidity by 0.18 - 0.23 pH units on agrofond NPK_{50} (AA_{50-150}), 0.25 – 0.29 pH units on agrofond NPK_{100} (AA_{50-100}) and 0.31 pH units on agrofond $NPK_{150}(AA_{50})$.

On the plots cultivated with field crops, land works affect the 0-20 cm horizon in the conventional system, which leads to soil uniformity for that depth. Therefore, we calculated the average values of pH changes, and we found that they range between 0.09 pH units for a dose of ammonium nitrate of 100 kg active substance N applied on its own and 0.32 pH units in the case of fertilization $NPK_{150}+N_{50}(AA)$.

Previous studies, carried out in different pedoclimatic conditions, BORLAN et al. 1967, LUNGU et al. 1967, BOERIU 1969, quoted by RUSU et al. 2005, revealed similar results, which confirms our results on the acidifying influence of mineral fertilizers that contain nitrogen in the form of ammonium and especially ammonium nitrate.

JANZEN presented in 1987 the results of his research; according to these, soil pH is reduced from 7.2 to 6.9 following annual fertilization with nitrogen-based fertilizers.

HAVLIN et al. 2005, announces soil acidification by 2 pH units (from 6.5 to 4.1) over a period of 40 years, in the conditions of annually applying quantities of 200 lb N/a ammonium nitrate (90.718 kilos N active substance).

Another index we measured was the degree of interdependence among the doses of fertilizers, as an independent variable, and the change in pH as dependent variable, through the correlation expressed as a linear regression line, through the regression function that defines/describes the values of the line and through the correlation coefficient R^2.

The functions that define the correlation lines between fertilizers and soil reaction for the two depths mentioned above are of the following type:

$$y_{0-10\ cm} = -0{,}0315x + 6{,}8993\ ;\ R^2 = 0{,}8785 \quad (1)$$

and

$$y_{10-20\ cm} = -0{,}0256x + 6{,}942\ ;\ R^2 = 0{,}8163 \quad (2)$$

According to the functions that describe regression lines and their graphic representation, Figure 2, the line slope is negative, which expresses a decrease in pH values in relation to the doses of mineral fertilizers and to the quantity of ammonium nitrate applied. The values of the correlation ratio (relations 1 and 2) describe strong correlation between the two variables, with a high correlation degree.

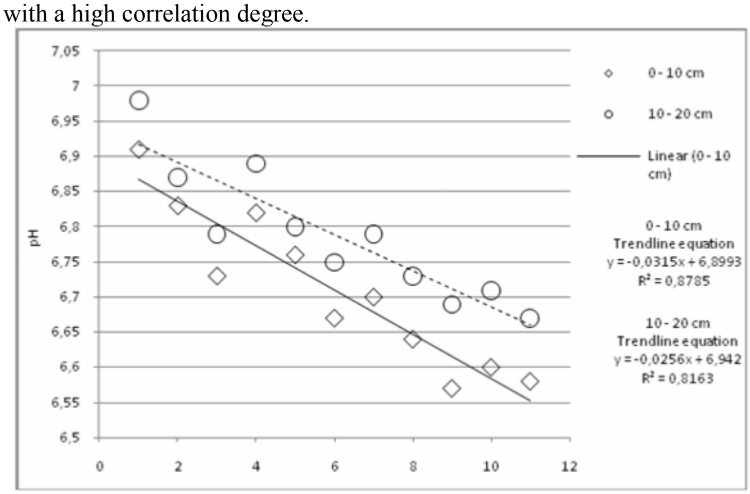

Figure 2. The correlation between doses of fertilizers and acidification of soil reaction

Corresponding to the pH variation, the degree of supply with base cations was also changed. Thus, the saturation degree, being proportional to the values of pH, is reduced to 92.7% in the control variant and to 82.03% in variant $PK_{100}N_{200}$.

CONCLUSIONS

Mineral fertilizers of type NPK (S) zinc fertilizers [15/15/15(+3+Zn)] and ammonium nitrate (35:0:0) applied singularly or in association, on cambic chernozem, determines a change in soil pH by 0.09 – 0.32 pH units.

Ammonium nitrate determines soil acidification by 0.08 – 0.18 pH units when applied on its own and 0.15 – 0.33 pH units when it is associated with complex fertilizers NPK (S).

The degree of saturation in base cations finds again balance under the new pH conditions, dropping from 92.7% in the control variant to 82.03% in variant $PK_{100}N_{200}$.

In the pedoclimatic conditions of the experiment and for crop structures where no legumes are grown, for which nitrogen is supplied only by mineral fertilization, chemical fertilizers can lead to acidification of soil reaction, with adverse effects on the regime and bioavailability of nutritive elements.

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