SOIL CHEMICAL FEATURES MODIFICATION AFTER LONG AND INTENSIVE MINERAL FERTILIZATION

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Abstract

The paper presents the influence of long term chemical fertilization upon the chemical properties of soil. The used fertilizers were ammonium nitrate, complex fertilizer 15:15:15. The researches were made on weakly gleyed cambic chernozem, in the climate conditions of Banat Plain from Timisoara. The analyzed indicators were: soil pH, base cations (BC me/100 g soil), exchangeable acidity (me/100 g soil), the percent base saturation (% BS), cation exchange capacity (CEC me/100 g soil).

Key words: chemical features, chemical fertilization, soil.

INTRODUCTION

One of the most important components of soil is the pH. The pH of soil can be modified by adding different chemicals. The pH of a soil is crucial because crops grow best in a narrow pH range which can vary among crops.

Probably the most important and distinctive property of soils is that they can retains ions and release them slowly to the soil solution ant to plants. The retention prevents concentrations that are too high and too low. The soil acts similar to a magnet, attracting and retaining oppositely charge ions, and holding them against the dawnward movement of water through the soil profile [Goian, 2000]. The nutrients held by the soil in this manner are called “exchangeable cations” and can be displaced or exchanged only by other cations which take their place. The cation exchange capacity (CEC) measures the extent to which soil can hold and exchange plant nutrient cations .

Soil with high CEC not only hold more nutrients but they are better able to buffer, or avoid rapid changes in soil solution levels of this nutrients by replacing them as the solution becomes depleted. The inherit fertility, and long term productivity of a soil is greatly influenced by its CEC [Hodges, 2006].

Base saturation is the proportion of the CEC occupied by base cations (K, Ca, Mg and Na). A relatively high base saturation of CEC (70 to 80%) should be maintained for most cropping systems, since the base saturation determines in large measure the availability of base for plant uptake, and strongly influences soil pH as well. Low base saturation levels will result in very acid soils, and potentially toxic cations such as Al and Mn from the soil [Cresser et.al., 1993].

Nitrogen in soil has been studied for centuries and is still the most studied element in soil chemistry, microbiology and fertility. It is the soil element that most commonly limits plant growth. Plant available nitrogen forms are ammonium NH_4^+ and nitrate NO_3^- ions. The amounts of NH_4^+ and NO_3^- in soils are small compared to the amounts of organic nitrogen [Sala, 2008]. Because soil N contents tent toward steady states, the concentration of NO_3^- and NH_4^+ in the soil solution are rough indicators of nitrogen availability to plants [Tan, 1998].

MATERIALS AND METHODS

The researches have been made on weakly gleyed cambic chernozem with middle texture from Didactic Station Timisoara.

The experiment is of stationary and bifactorial type, with 4 variants and 5 repetition, and it is placed in subdivided lots, as it follows:

Factor A – phosphorus and potassium fertilization

- a_1 – P_0K_0 – control
- a_2 – $P_{50}K_{50}$ (50 kg P_2O_5/ha and 50 kg $K_2O \cdot ha^{-1}$)
- a_3 – $P_{100}K_{100}$ (100 kg P_2O_5/ha and 100 kg $K_2O \cdot ha^{-1}$)
- a_4 – $P_{150}K_{150}$ (150 kg P_2O_5/ha and 150 kg $K_2O \cdot ha^{-1}$)

Factor B – nitrogen fertilization

- b_1 – N_0 – control
- b_2 – N_{50} (50 kg N· ha^{-1})
- b_3 – N_{100} (100 kg ·N ha^{-1})
- b_4 – N_{150} (150 kg ·N ha^{-1})
- b_5 – N_{200} (200 kg ·N ha^{-1})

In order, to fertilize the plots, it has been used complex fertilisers 15:15:15, ammonium nitrate (35 % N), superphosphate (40 % P_2O_5) and potash salt (40% K_2O).

To determinate the present indicators, soil samples were taken from the experimental plots, on 0-20 cm depth.

Soil pH was determinated in water extract 1 : 2.5 by pH – meter Mettler Delta 340.

CEC is determined when 5 g of air dried soil is leached with 60 mL 1M NH_4Oac, pH 7, to saturate exchange sites with ammonium ions. Excess free ammonium ions are rinsed from the soil with isopropyl alcohol. The remaining ammonium ions held on cation exchange sites are replaced by leaching the soil with succesive aliquotes of a solution of 10% KCl acidified to 0,005 N HCl. Ammonium is determined on the KCl leachate by distillation and titration [Rhoades, 1998].

Base cations are extracted by leaching 3 g air dried soil with succesive aliquotes of 1 M NH_4Oac, pH 7, to total 60 mL. The concentrations of the base cations in the leachate are determinated by AAS.

Hydrolitic acidity is leached from 5 g of air dried soil with first, 20 mL of 0.2 M triethanolamine and 0.25 M barium chloride buffer solution (pH 8.1), them by 20 mL of 0.25 M barium chloride solution. The concentration of hydrolitic acidity is calculated from the amount of standard acid needed to back titrate the leachate to the methyl red and bromcresol green endpoint [Sparks, 1996].

Nitrate nitrogen is determined when 20 g of soil is mixed with 50 mL of distilled water and shaked for 5 minutes in a reciprocal shaker. The N-NO_3^- concentration wad read directly from a pH/ion meter.

Ammonium nitrogen is determined when 30 g of fresh soil is extracted in 90 mL 0.1 N K_2SO_4 for 24 hours and a 20 mL aliquote part is treated with 3 mL Seignette salt and 1 mL Nessler reagent at 50 mL. The yellow colour intensity is measured at 525 nm on a Cintra 530 spectrophotometer.

% base saturation was calculated with the following formula [Bohn et.al., 2001]:

$$\%\ base\ saturation = \sum (exchangeable\ Ca, Mg, Na, K) \cdot \frac{100}{CEC}$$

RESULTS AND DISCUSSIONS

In figure 1 is presented the influence of intensive mineral fertilization upon the base cations and exchangeable acidity of weakly gleyed cambic chernozem.

Long term intensive nitrogen fertilization, produce the decreasing of base cations and the increasing of exchangeable acidity, fact confirm by the decreasing of soil pH too [Mengel, 1995].

The increasing of phosphorus and potassium fertilizers quantities, on the same level of nitrogen fertilization, produce the increasing of base cations, the maxim being 28.90 me/100 g soil in variant $N_0P_{150}K_{150}$.

Once with the increasing of nitrogen dose, on the same level of phosphorus and potassium, the values of percent base saturation are decreasing; soil pH is changed in acid domain. The decreasing of soil pH is due to the consecutive application of NH_4NO_3, fact confirm by the specialty literature too. (Figure 2)

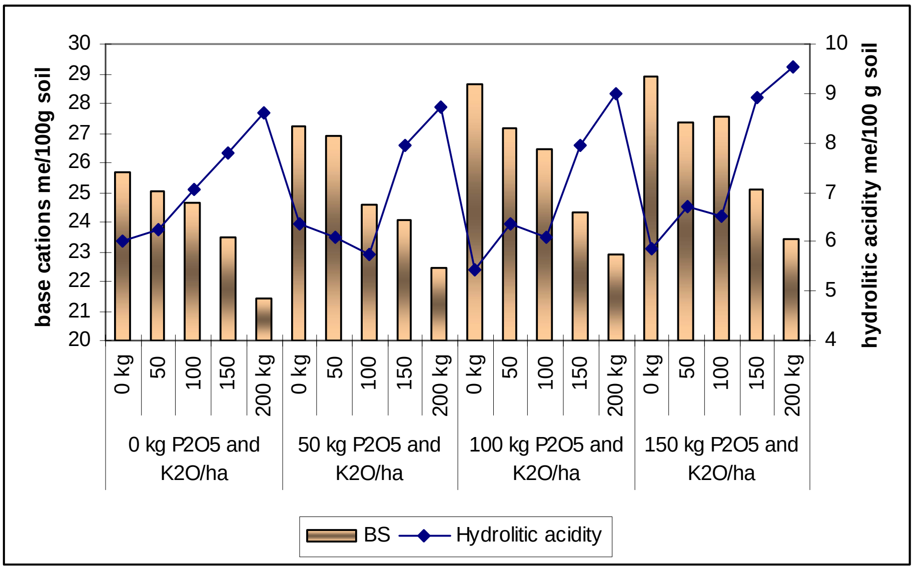

Fig. 1 Intensive mineral fertilization influence upon the base cations and hydrolitic acidity

At the same level of nitrogen fertilization, we observe an increasing of soil pH and percent of base saturation, once with the increasing of phosphorus and potassium dose. The most high values of pH and % BS: pH= 6.30 and % BS = 84.05 are determine in $N_0K_{100}P_{100}$ variant. In all variants of nitrogen fertilization at maxim potassium and phosphorus dose, we observe a decreasing of soil pH and of the base cations. High doses of potassium and phosphorus fertilizers can modify soil pH; their application on moderate acid soils must be associated by fertilizers who have potential alkaline reaction [Radulov, 2007].

On plots fertilized with 200 kg/ha nitrogen we observe a decrease of soil pH and of % of base saturation once with the increasing of phosphorus and potassium dose. On moderate acid soils and on acid ones, after the application of the potassium fertilizers, potassium ion K^+ replace the hydrogen ion H^+ in the colloidal complex, increasing its activity [3]. The application of high doses of nitrogen together with high doses of potassium reduces the quantity of cations adsorbed in soil. Similar results are presented in specialty literature by Prokoshev and Sokolova (1990).

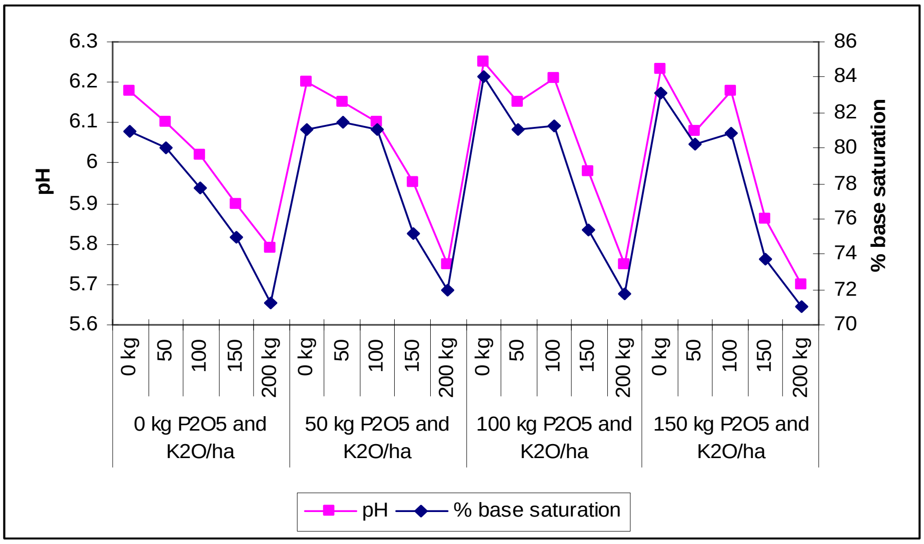

Fig. 2 Intensive mineral fertilization influence upon the soil pH and the % of base saturation

Table 1

The influence of mineral intensive fertilization upon the total exchange cation capacity

kg P_2O_5 şi K_2O/ha	kg N/ha	CEC (me/100g soil)
0	0	$31,69^{-}$
	50	$31,29^{-}$
	100	$31,72^{-}$
	150	$31,31^{-}$
	200	$30,05^{000}$
50	0	$33,60^{***}$
	50	$32,96^{*}$
	100	$30,30^{00}$
	150	$32,03^{-}$
	200	$31,15^{-}$
100	0	$34,05^{***}$
	50	$33,55^{**}$
	100	$32,51^{-}$
	150	$32,26^{-}$
	200	$31,90^{-}$
150	0	$34,75^{***}$
	50	$34,05^{***}$
	100	$34,05^{***}$
	150	$34,04^{***}$
	200	$33,00^{**}$

LSD 5% 0,938735
LSD 1% 1,254744
LSD 0,1% 1,649756

Weakly gleyed cambic chernozem is characterized by a high cationic exchangeable capacity. In table 1 is presented the value of cation exchange capacity (CEC) after long term application of mineral fertilizers with nitrogen, phosphorus and potassium.

The sum of exchangeable Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}, for practical purposes, represents the soil`s cation exchange capacity. Potassium fertilizer application on weakly gleyed cambic chernozem, soil developed on loess deposits, leads to decrease of potassium fixation capacity in upper part of soil, inducing increase of exchangeable potassium. As a cosequence, application of potassium fertilizer determines increase of soil`s cation exchange capacity as the K dose rise. The highest value of CEC =34.75 me/100 g soil was determined in $N_0P_{150}K_{150}$ plot.

Table 2

The influence of intensive mineral fertilization upon the content in nitrate and ammonium of soil

Variant		$N\text{-}NO_3^-$ (ppm)	$N\text{-}NH_4^+$ (ppm)
P_0K_0	N_0	$2{,}87^-$	$0{,}95^-$
	N_{50}	$6{,}90^{***}$	$2{,}75^{***}$
	N_{100}	$8{,}55^{***}$	$4{,}90^{***}$
	N_{150}	$13{,}52^{***}$	$5{,}97^{***}$
	N_{200}	$15{,}47^{***}$	$7{,}57^{***}$
$P_{50}K_{50}$	N_0	$2{,}85^-$	$0{,}92^-$
	N_{50}	$6{,}62^{***}$	$2{,}87^{***}$
	N_{100}	$8{,}75^{***}$	$4{,}72^{***}$
	N_{150}	$13{,}40^{***}$	$5{,}85^{***}$
	N_{200}	$15{,}47^{***}$	$7{,}25^{***}$
$P_{100}K_{100}$	N_0	$2{,}82^-$	$0{,}82^-$
	N_{50}	$6{,}62^{***}$	$2{,}57^{***}$
	N_{100}	$9{,}10^{***}$	$4{,}17^{***}$
	N_{150}	$13{,}55^{***}$	$5{,}55^{***}$
	N_{200}	$16{,}20^{***}$	$7{,}47^{***}$
$P_{150}K_{150}$	N_0	$2{,}7^-$	$0{,}80^-$
	N_{50}	$6{,}65^{***}$	$2{,}30^{**}$
	N_{100}	$9{,}12^{***}$	$4{,}05^{***}$
	N_{150}	$13{,}15^{***}$	$5{,}22^{***}$
	N_{200}	$16{,}22^{***}$	$6{,}87^{***}$

LSD 5%	0,934536	LSD 5%	0,898751
LSD 1%	1,249132	LSD 1%	1,201301
LSD 0,5%	1,642377	LSD 0,5%	1,579489

Long time application of nitrogen fertilizers determines soil pH decrease and therefore CEC decrease [Bohn et.al., 2001]. Because of soil low nitrogen content, ammonium from fertilizer will be consumed by plants and soil microorganisms and only a small amount will remain in soil in exchangeable form. As a result on the same level of phosphorus and potassium fertilization, CEC values decreases as the nitrogen dose rise.

Nitrate values rises as the nitrogen fertilizer dose increase, whitout influence from phosphorus and potassium application. Intensive mineral fertilization, especially with nitrogen, lead to increased nitrate values, from 2.87 ppm to 16.22 ppm. Through the 5 years of experiment, the highest levels of nitrate in soil was determined at application of 200 kg N/ha. (table 2).

In the case of long term mineral fertilization ammonium values are increased in connection with increasing dose of nitrogen. The level of ammonium goes down proportionally to the increasing doses of phosphorus and potassium.

CONCLUSIONS

1. After plural-annual fertilization with nitrogen on the same agricultural background with potassium and phosphorus we observe a decrease of the cationic exchangeable capacity, of the % of base saturation and of the base cations.
2. The applications of increasing nitrogen doses determine an increasing of exchangeable acidity of the cambic chernozem weakly gleyed.
3. Long fertilization with nitrogen, as ammonium nitrate, determines soil acidification.

4. The application of potassium and phosphorus fertilizers determine an increasing of cationic exchangeable capacity, % of base saturation, base cations, soil pH and a decreasing of exchangeable acidity.

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