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NEUTRALIZATION OF SOIL ACIDITY USING AN UNCONVENTIONAL AMENDMENT

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Abstract. *Soil acidity is one of the limiting factors for growth and production of most crops. Its harmful effect refers to the availability of essential nutrients to plants and also the decrease of cation exchange capacity (exchangeable bases), especially calcium and magnesium. These effects can be corrected by applying mineral amendments. The present research study is the first stage regarding the use of steel slag as a mineral amendment in agriculture. The paper presents data on the selection of acid soil, physical and chemical characteristics of the soil and the need and opportunity to apply an unconventional amendment. In order to set up experiments to study the changes occurring in an acid soil treated with steel slag, in the preliminary study it has been selected both the soil and amendment (steel slag). The soil selected for the experiment was subjected to the laboratory protocol considering that changes in soil reaction occur due to changes in soil base cation saturation ratio (BCSR %≡V%) and in the content of other chemical indicators. Soil material needed for the experiment has been sampled from a luvosoil, Albota area, Arges county. Luvosoil from Albota belongs to the group class of middle texture, medium clay subclass (LL) according to Soil Taxonomy Roumanian System (SRTS). Soil material has a moderately acidic reaction (pH=5.48) and total exchangeable acidity (SH) has a value of 6.28 me/100g soil. Due to the degree of base cation saturation ratio the soil is in an early stage of debasification. For this type of soil, both the heavy metals content and the total soluble salts content are in normal quantities. Having a very high alkaline reaction and high contents of calcium and magnesium oxides, the steel slag will be used in our experiment as mineral amendment to neutralize the acidity of luvosoil and to improve the mineralization in terms of ensuring environmental protection.*

Keywords*: soil, acidity, unconventional amendment*

INTRODUCTION

There are several types of problems regarding soil amendments such as low health of soil and problems in low functioning of ecosystem. Soil acidity is the limiting factor for growth and production of most crops.

On the other hand, its detrimental effect may be felt because of high concentrations of hydrogen and aluminium ions in the soil, causing adverse conditions for plants and microbial life. But indirectly this may be felt by the complex phenomenon which refers to the availability of essential nutrients to plants, as well as the decrease of cation exchange capacity(exchangeable bases) , especially calcium and magnesium.

MATERIAL AND METHODS

Initially, each soil type has a certain level of acidity which depends on the composition of natural vegetation, the amount of rainfall and other various factors that cause, over time, changes in soil pH (BEEGLE AND LINGENFELTER, 1995). Leaching, erosion, and absorption by the plants of the cations (Ca^{2+}, Mg^{2+}, K^{+}); deposition and decomposition of plant residues and exudates through the roots of the plants are means by which the acidity of the soil may increase.

However, a common source of acidity stands for H^+ ions which are released when aluminum ($Al^{3+)}$ ions in high content in the soil react with water molecules. Acid residues also arise from certain fertilizers.

Although the amendment provides plants with some of the nutrients (Ca^{2+} or Mg^{2+}), its greatest benefit in plant growth consists in counteracting the negative effects of soil acidity which can cause some of the following problems: the toxicity of soluble metals effects on the availability of phosphorus, on soil organisms, and so on.

Regarding the physical condition of soil, fine texture of calcareous amendments improves the structure and this involves several positive attributes including the reduced formation of crust, a better plant emergence and fewer requirements regarding the necessary operations in agricultural work (BEEGLE AND LINGENFELTER, 1995).

Soil reaction (pH) or the ability to maintain in solution a certain of hydrogen ion activity is an emanation of base saturation of the adsorptive clay-humus complex and the concentration of salts in the soil. As such, changes in reaction occur due to changes in the degree of bases saturation and also in salts content in the soil. In base unsaturated soils (without free carbonates), the decrease of pH value may be the results of either debasification (reduce the degree of base saturation) or increasing concentrations the soluble salts in the soil solution (POPESCU ET AL., 2016).

This is the preliminary soil test, in advance of plant test to provide results and observations to decide the require amount of amendment added to an acid soil.

The physical and chemical (pH, N, C, available P and K, heavy metals, exchangeable cations, etc) characteristics of the soil material taken from Albota area will be presented in this study (METODOLOGIE, 1981).

Steel slag has an alkaline reaction (pH > 11) and a very high calcium and magnesium oxides contents. Steel slag also contains some metals in concentrations higher than normal values in soil and very high soluble salts content.

RESULTS AND DISCUSSIONS

In Romania, according to official data, there are 1.8 million ha of acidic arable land representing almost 12% of the total agricultural area (POPESCU ET AL., 2016).

In order to set up experiments regarding transformations that occurred in acid soil treated with steel slag was selected both the soil and amendment material.

A correct program to amend is based on a soil test that determines the degree of acidity and other important physical and chemical indicators. It is also necessary to establish the quality of the amendment to neutralize acidity, the Calcium Carbonate Equivalent (CCE), the fineness of amendment material, etc.

The paper presents the characterization of acid soil which will be subject to experiment of soil acidity neutralization using an unconventional amendment, steel slag.

Soil material was sampled from Albota area, Arges County. The soils from this area have a strongly or moderately acidic reaction. The geographical position of Arges county, determine, in terms of relief, major differences from south to north.

In terms of parenting materials, stand two distinct situations: a) uniformity due to the presence of pleistocene clay deposits with high thickness occupying the entire plains and low hills and b) the varied character of surface deposits in the high hills and mountain (RĂUȚĂ ET AL., 1988).

Environmental conditions favored some pedogenetical processes and associated with a single or more factors caused the formation of a coating of various soils. Thus, the nature of the parent material characterized by the presence of clays swelled, has determined the formation of vertic soils on an area of about 13% of the arable land. The increased rainfall and the decreasing of temperatures from south to north has determined on the parental materials, finally, the formation of the soils with argillic horizon, largely nature vertic, rich in clay and highly compacted, represented mainly by argillic brown soils and reddish brown soils occupying about 19% of the arable land (RĂUȚĂ ET AL., 1988).

Along with the process of clay iluviation, in most soils (38% of arable land) takes place the process of debasification of adsorptive complex with important implications for soil fertility. Intensity of this process increases from south to north, from brown and reddish brown luvic soils to albic luvisoils and planosoils located in the north-central part of the county where are touched the most advanced stages of the process (RĂUȚĂ ET AL., 1988).

The main limiting factors of agricultural production determined by the local climatic conditions are fine texture and compaction, deficit of nutrients and organic matter, low permeability, moisture excess, acidity and erosion (RĂUȚĂ ET AL., 1988).

In order to increase the production capacity of the soil, taking into account their specificity, a number of measures are required to take into account the complex nature of ameliorative works among which fine maintaining an optimal ecological balance.

In general, Albota area has pseudogleic podzol soils with low humus content and poor in nutrients, with high acidity, being developed on pseudogleyed clay, while retaining the characteristics of soils both from Arges premountain hills and piedmont plateaus Cândești and Cotmeana of the southern Albota area.

Meadow soils are less spread, them being in the south of area, in the flood plains of Teleorman and Teleormănel.

High acidity of the soil at 0-65 cm depth limits the spread of cultivated plants and causes the degradation of humus and other adverse reactions of any kind.

The soil from which samples were taken for the experiment, that is albic luvosoil (according to SRTS - 2012) has the parent material - loess; the relief - is flat, it is at an altitude of about 320 m; the use - arable; the characterization of physical and chemical properties will be presented as follows.

Table 1

Particle - size distribution in the soil material taken from Albota area, Arges county (n = 3), in mm, % from mineral size (g/g)

,	Particle - size distribution (in mm) (% of the mineral part of the soil)											**Symbol - subclass texture**	Carbonates (%)
	Coarse sand				**Sand**				**Silt**	**Clay**			
	2.0-0.2mm	2-1	1-0.5	0.5-0.2	**0.2-0.02mm**	0.2-0.1	0.1-0.05	0.05-0.02	**0.02**	**<0.002mm**	<0.01mm		
Mean	**9.5**	2.0	3.2	4.3	**38.7**	2.9	0.1	35.7	**26.1**	**25.7**	40.2	**LL – Medium Clay** (Romanian Soil Taxonomy System, 2003)	-

This soil material will be a support material to set up the experiments in the following activities of the study.

Luvosoil from Albota is a soil that belongs to the class group of middle texture in the subclass of medium clay (LL) according to the indicator 23 - groups of classes, textural classes and subclasses. (VLAD ET AL., 2014), (METODOLOGIA ELABORĂRII STUDIILOR PEDOLOGICE), (SRTS, 2003) (Table 1)

As particle – size distribution (in mm, % of the mineral part of the soil), soil contains 9.5% coarse sand (2.0 to 0.2 mm), 38.7% fine sand (0.2 to 0.02 mm), 26.1% silt (0.02 mm) and 25.7% clay (0.002 mm). These values represent the average of three samples of soil material sampled from the territory. According to the indicator 23, the textural clay class, the medium clay content is 25 (in mm and % of the mineral part of the soil). (Table 1)

Chemical characteristics of the soil sampled from Albota area are presented in Table 2.

Table 2

Chemical characteristics of Luvosoil from Albota area (n=3)

Characteristics	**U.M.**	**Mean value**
pH_{H2O}	-	5.48
Total nitrogen content	%	0.132
Organic carbon content	%	2.52
Humus content	%	4.35
Soluble phosphorous content	$mg \cdot kg^{-1}$	75
Soluble potassium content	$mg \cdot kg^{-1}$	343
Conductometric residue	mg/100 g sol	19

Soil material analyzed has a *moderately acidic reaction* (pH = 5.48) according to Indicator 63 - Classes of soil reaction; a *medium humus* content (4.35%) - according to Indicator 70 - Classes of organic matter (humus) content; a *low content in total nitrogen* (0.132%) – according to Indicator 71 - Classes of total nitrogen content; with a very high content of soluble phosphorus (P_{AL} = 75 mg • kg-1) – according to Indicator 72 - Classes of soluble phosphorus content, and high soluble potassium content(K_{AL} = 343 mg • kg-1) - according to Indicator 73 – classes of mobile potassium content (METODOLOGIA ELABORĂRII STUDIILOR PEDOLOGICE).

Soil sampled for the experiment with steel slag is falling within *mesobasic class*. Soil is in an early stage of debasification having a Base Cation Saturation Ratio (BCSR% ≡ V % = 71.9 % of T), according to Indicator 69 – class of base saturation (Indicatori METODOLOGIA ELABORĂRII STUDIILOR PEDOLOGICE).

The cation exchange properties of luvosoil from Albota area are presented in Table 3.

Table 3

The cation exchange properties of Luvosoil from Albota area (n=3)

Cation exchange properties - **Indicators**	**U.M.**	**Mean value**
Ca^{2+} exchangeable	me/100 g soil	11.66
Mg^{2+}exchangeable	me/100 g soil	3.60
Na^{+}exchangeable	me/100 g soil	0.11
K^{+}exchangeable	me/100 g soil	0.67
Base Saturation (BS)	me/100 g soil	16.04
Total Exchangeable Acidity (SH)	me/100 g soil	6.28
T=BS+SH (CEC)	me/100 g soil	22.32
V_{Ca2+}	% from T	52.2
V_{Mg2+}	% from T	16.2
V_{Na+}	% from T	0.5
V_{K+}	% from T	3.0
SH	% from T	28.1
V (BCSR)	% from T	71.9

The total Cation Exchange Capacity (CEC=T=BS+SH) falls into the middle class, with an average of 22.32 me / 100 g soil (Table 3).

Base Saturation (BS, sum of the exchangeable bases) is the sum of the exchangeable cations content of alkali and alkaline earth metals (K^{+}, Na^{+}, Ca^{2+}, Mg^{2+}) expressed as me/100 g soil. Fall into the middle class with a value of 16.04me/100 g soil.

The degree of Base Cations Saturation Ratio (BCSR=V) is the percentage with which the sum of exchangeable cations participate in the Cation Exchange Capacity. The degree of Base Cations Saturation Ratio at luvosoil from Albota area is 71.9 (% of T).

The saturation degree in each cation of alkali and alkaline earth metals is the percentage of the total cation exchange capacity of the cation part, respectively. This proportion of each cation is determined by the nature of the colloids in the soil, the adsorption power of the cation, the ionic composition of the solution with which the soil is in equilibrium.

Total Exchangeable Acidity (SH) is framed in small class with a value by 6.28me/100 g soil.

Conductometric residue represents the salts content in the soil and it is low, by 19 mg/100 g soil.

It is considered necessary to determine these parameters for correct estimation of the degree of base saturation of debazificated soil, prevention and correction of deficiencies and imbalances nutrition and to follow the development of various technologies of soil properties under the influence of crop tehnologies.

As a result of the chemical analysis to identify the presence of *heavy metals* in the material sampled from the Albota area was found to be present in quantities normal for this type of soil. Determinations were carried out for Cd, Cu, Cr, Ni, Pb, Mn, Co, Zn (Table 4).

Table 4

The content of heavy metals in luvosoil from Albota area (n=3)

Heavy metals content	**U.M.**	**Mean value**
Cadmium	$mg \cdot kg^{-1}$	slq
Copper	$mg \cdot kg^{-1}$	19.3
Chromium	$mg \cdot kg^{-1}$	15.4
Nickel	$mg \cdot kg^{-1}$	15.7
Lead	$mg \cdot kg^{-1}$	19.9
Manganese	$mg \cdot kg^{-1}$	859
Cobalt	$mg \cdot kg^{-1}$	13.7
Zinc	$mg \cdot kg^{-1}$	65.2

CONCLUSIONS

- Soil material (luvosoil) has a moderately acidic reaction. The soil is in an early stage of debasification;
- For this type of soil, both the heavy metals content (total form) and the total soluble salts content are in normal quantities;
- The neutralizing of luvosoil acidity and improving its negative effects are phenomena that address the need of using soil amendments, steel slag being framed and considered unconventional mineral amendment that could be used in agriculture in terms of ensuring environmental protection.

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