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SOIL ACIDITY AND EXCHANGEABLE ALUMINIUM IN SOIL OF THE HIGH PITEȘTI PLAIN, ARGEȘ COUNTY, ROMANIA

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Abstract

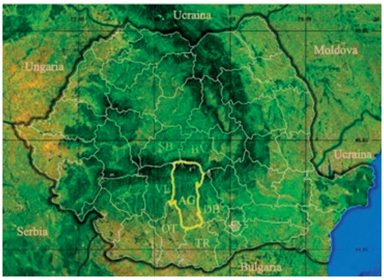
In Romania 49.5% of the total soil surface have pH below 5.8 which represents a risk for aluminum toxicity and plants growth. Research carried out in the High Pitești Plain aimed to study exchangeable aluminum presence in cultivated soils in order to issue recommendations for acid soils liming. Soil samples collected from the first soil layer, down to 25 cm depth, were analysed in the laboratory and the reaction, humus and available phosphorus and potassium contents, and cation exchange properties were determined. Out of 120 analysed samples 38 showed contents below the method's detection limit. Relationships were drawn for the rest 82 of them between humus and available phosphorus and potassium on one hand and soil reaction and aluminum contents on the other to assess aluminum variability and its possible toxicity for plants. Low, very low, and extremely low aluminum quantities were found which means there is no immediate risk of soil acidification in the studied area from this point of view. Researches must be carried on though in other Romania agricultural land on acid soils.

Key words*: exchangeable aluminum, soil analysis, slightly acid soils, CS Region, Romania.*

INTRODUCTION

This research is expected to determine the maximum aluminum concentration which exists in three different places in the Pitesti High Plain. The goal is that after determining the quantities of aluminum, concrete measures can be taken to increase agricultural productivity in this area.

Aluminium is an element commonly occurring in nature, the third most abundant in the earth's crust after oxygen and silicon. It forms numerous mineral and organic complexes, characterised by different degrees of hydration. In soil, aluminum is mainly found in the mineral form as aluminosilicates and aluminum oxides and this aluminium is in stable inactive form. Al can be found as precipitates or in very minute quantities appearing in soluble forms such as conjugated organic and inorganic, and molecular ions (Al^{3+}, $AlOH^{2+}$, $Al(OH)^{2+}$ and $Al(OH)^{4-}$). Aqueous Al also forms inorganic complexes with F^- and SO_4^{2-}, the formation of which also varies with pH, the concentration of the inorganic ligands, ionic strength and temperature. It's easy transition from solid to liquid phase and high solubility in the acid environment are decisive factors for its important function in the environment (May & Nordstrom, 1991). Fragmentation and inhomogeneous territorial dispersion are the general characteristics of the agri-food sector in Argeș County. Integration into agri-food chains is difficult for small and medium-sized farmers looking for alternative solutions to increase land capacity.



Map 1. Location of Argeș County in Romania (Tudor M. et al)

We found in the area of Argeș County in the High Plains of Pitestilor, by analysing two areas near to Costești and one near Căldăraru, see Map 1, small amounts of aluminum in soils. Comparing the results with the general ones from Table 1, the amount of exchangeable aluminum found is at a maximum of 1.09, so it is in the area of 0.9-2.0, that is, a small amount of aluminum. The present study demonstrated that differing in Al tolerance differed markedly in response to subsurface soil acidity. The results imply that Al toxicity was the major growth-limiting factor in the acidic subsurface soil. It was also evident that the effect of subsurface soil acidity was greater on root growth than on the above-ground growth. Therefore, decreased shoot growth and grain yield of Al-sensitive wheat in response to subsurface soil acidity had mainly resulted from the poor root growth. In the field the growth of wheat plants relies largely on water and nutrients in deep soil layers at the later growing stages in regions where rainfall is low and terminal drought is endemic. The poor root growth may exacerbate the subsurface soil acidity problem in these regions. Subsurface soil acidity with high levels of toxic aluminium (Al) restricts the yield of many crops throughout the world (Sumner et al., 1986) and is a major limiting factor in wheat production (Carr et al., 1994). Subsurface soil acidity impairs root growth of sensitive crops and hence may reduce nutrient acquisition and plant access to water reserves in the subsurface soil layer (e.g. lucerne, Simpson & Lipsett, 1973; cotton, Doss & Lund, 1975; wheat and oats, Pinkerton & Simpson, 1986; Jayawardane et al., 1995), especially when the topsoil dries out. The deleterious effect of subsurface soil acidity on crop growth will thus be influenced by the extent that a plant depends on the subsurface soil for supply of water and nutrients. However, later in the growing season when temperature and plant growth rates increase considerably, and the frequency of rainfall decreases, moisture in the topsoil is depleted. Moreover, drying of topsoil decreases root capacity to utilise the nutrients in that layer (Nambiar, 1977; Simpson & Pinkerton, 1989). Therefore, plants are forced to rely on supply of water and nutrients from the subsurface soil.

Plant species and genotypes differ greatly in their susceptibility to Al toxicity in acid soils and some of these differences are genetically controlled (e.g. wheat, Tang et al., 2001; Rajaram et al., 1991; Scott et al., 1992).

Plant assemblages respond sensitively to changing soil acidity (Ellenberg et al., 1992; Schaffers & Sýkora, 2000; Wamelink et al., 2005). Soil reaction alone (pH) and various related soil properties, comprising available calcium and aluminium (Al), carbonates, base saturation or nitrates have been used to explain such responses in plant community data (e.g., Schaffers & Sýkora, 2000). Among different soil properties, high Al concentration has been recognized as a relevant factor driving plant growth and species transitions along the soil pH gradient (e.g., Abedi et al., 2013; Peppler-Lisbach & Kleyer, 2009). In neutral soils, aluminium occurs predominantly in an undissolved form and does not affect plants in any significant way. However, it is increasingly solubilised when soils turn more acidic and aqueous Al^{3+} then becomes a crucial growth-limiting factor for plants (Foy, 1992; Poschenrieder et al., 2008). Besides toxicity of monomeric aluminium, it reduces phosphorus, molybdenum and sulphur availability, and by occupying a major share of ion-exchange sites aluminium becomes a driving competitor for other cation nutrients, including calcium and magnesium (e.g., McLean, 1976). Therefore, soil aluminium has repeatedly been used to explain vegetational patterns on acidic soils in numerous studies (e.g., Neave et al., 1995; Abedi et al., 2013). However, so far, a little attention has been paid to the aluminium solubility, which represents a major forcing mechanism for Al availability in acidic soils (Ulrich, 1983; Wesselink et al., 1996). In fact, bioavailability of Al may vary considerably depending on the solubility of Al solids present in soils. Recent studies have indicated that a pH decrease of one unit may result in Al dissolution varying by almost three orders of magnitude, dependent on which aluminium solids are present (Mulder & Stein, 1994; Wesselink et al., 1996; Dlapa, 2002), thus resulting in different growing conditions for plants.

MATERIALS AND METHODS

Determination of exchangeable acidity extractable in solutions of neutral salts, not buffered from soils (exchangeable aluminum) after A.V. Sokolov. The described procedure is applicable to soil samples from group A, soils unsaturated in basic cations, which contain exchange acidity and which have a pH (in aqueous suspension) lower than 5.8 (STAS 7184/12-88, Annex A4). The extractable acidity in solutions of neutral, unbuffered salts (As) is the acidity due to exchangeable H^+ ions from strong acids and acidoids and H^+ ions resulting from the hydrolysis of exchangeable Al^{3+} ions (STAS 7184/12-88, point 1.1.6)

From the soil profiles described above, disturbed soil samples were taken from various parts of the soil horizons to collect average horizon samples in order to determine particle-size distribution and some chemical analyses (pH-in 1:2.5 water suspension using SR 7184-13:2001 PTL04 method, mobile forms of phosphorus (P_{AL}) and potassium (K_{AL}) as plant available extracted in ammonium acetate lactate using STAS 7184/19-82 PTL19 and STAS 7184/18-80 PTL 22 methods), respectively, and other current analyses described by Florea et al. (1987). Methods for unsaturated soils in basic cations, which also contain exchange acidity (STAS 7184/12-88, PTL-15) and unsaturated soils in basic cations that also contain exchange acidity (STAS 7184/12-88, PTL13).

The experiments carried out in 2020 aimed at knowing the chemical particularities of the soils.

RESULTS AND DISCUSSIONS

In the root system Al^{3+} is accumulated mainly in the cell wall (apoplastic site) (Rengel & Reid, 1997), in particular in its pectic part (Chang et al., 1999). Thus, a possible mechanism of Al toxicity could involve interactions between the metal and pectates present at the soil-root interface. Gessa and Deiana (1992) validated a synthetic Ca-PG network as a soil-root interface model, useful to study ionic interactions (Deiana et al., 2001). Blamey et al. (1993) used a similar Ca-PG network and showed that Al induced a reduction of the water flux through the interface model. Due to extreme complexity of aluminium chemistry in soils (Lindsay, 2001; Poschenrieder et al., 2008), we did not investigate the soil mechanisms responsible for this discontinuity. Some methodological considerations on the analytical Al values used in this study need to be discussed. Quite a few soil Al indices have been used in plant and vegetational studies, including monomeric Al, exchangeable Al, Al/Ca ratio and Al toxicity index (e.g., Grauer & Horst, 1991; Peppler-Lisbach & Kleyer, 2009). The conclusion from literature is that Al concentration in soils corresponds with complex mechanisms responsible for Al solubility, and that these mechanisms vary under different soil environments (Dlapa, 2002). Consequently, Al concentrations demonstrate discontinuities as different mechanisms take control over its solubility across different soils, thus forcing distinct edaphic conditions for vegetation.

Also aluminium as a growth limiting factor has been recognized for many years (Miyake, 1916). At high concentrations, Al ions reduce nutrient availability in soils, harm plant cells and inhibit plant growth (Poschenrieder et al., 2008).

High Al resistance is therefore an important trait of plant species occupying acidic soils. Although aluminium impacts on wild plants received considerable less attention than crop plants, there are numerous studies identifying aluminium as a major factor filtering species composition in favour of Al-resistant plants (Abedi et al., 2013 and literature cited therein). Because Al also forms inorganic complexes with F^- and SO_4^{2-}, so the formation of which also varies with pH, the concentration of the inorganic ligands, ionic strength and temperature. Its easy transition from solid to liquid phase and high solubility in the acid environment are decisive factors for its important function in the environment. The total aluminium content in soil showed insignificant variations in the plants grown on irrigated land. First, after analysing the pH, it can be taken into account if the pH is lower than 5.8 to analyse the amount of aluminium in the soil samples. The results can be seen in Figures 1, 2 and 3. After this analysis was carried out in the laboratory, it was observed that the exchangeable aluminium values varied from 0.05 to 1.09 for all samples in which exchangeable aluminium content appeared. From the 242 samples taken from the third place 45 samples were content in exchangeable aluminium with values that vary from 0.05 till 0.64. The results can be seen in Figures 1, 2 and 3. So the quantities of exchangeable aluminium fall under the low aluminium content in the soil. As can be seen in the number three figures, the pH value vary from a minimum of 4.80 to a maximum of 5.42.

Table 1. Changeable Al content classes (from Florea et al. (ed.), 1987 - in Lacatusu et al., 2017)

Al^{3+} value changeable, me/100 g	Appreciation of content
≤ 0.3	extremely small
0.4-0.8	very small
0.9-2.0	little
2.1-4.0	middle
4.1-6.5	big
6.6-10.0	very big
≥ 10.1	extremely big

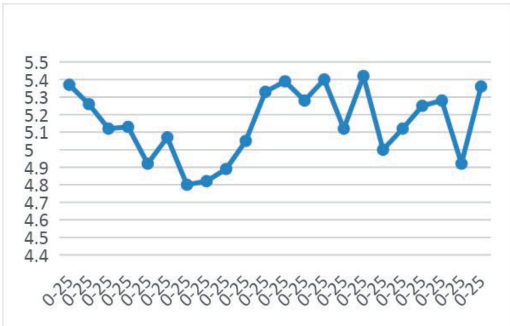


Figure 1. The pH values in the first sampling

In this chart we can see that the values of the pH vary from 4.8 till 5.5 maximum. Yet the more values of the pH are more the 5. Having this low pH the soil keeps a very small quantity of aluminium in.

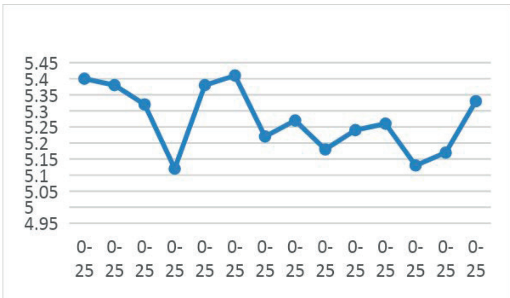


Figure 2. The pH values in the second sampling

In this area also the pH is lower than 5.8 but can be seen that the values are all more than 5.1 till 5.4 so the quantities of aluminium will be also very small correlating with the depth of the sampling.

In this case even if we took a bigger number of samples of soil it is clearly seen that the pH of all of them is like in case two is bigger than 5 so the quantity of the aluminium is also of a very small appreciation of content.

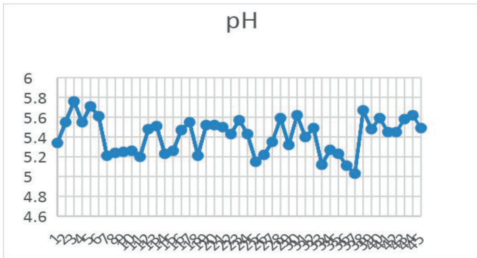


Figure 3. The pH values in the third sampling

After this in the next Figures 4 and 5 can be seen the changeable Al from these soil samples where we can see that in the first case the quantity of aluminium is the most big compared with the other two analyses from Figures 5 and 6 where the pH was bigger than 5.

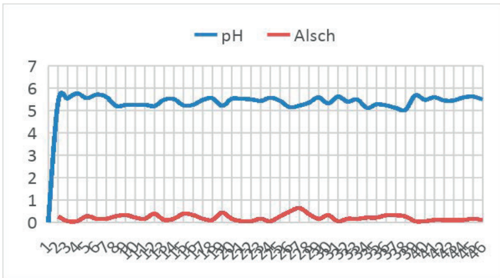


Figure 4. Changeable Al content in Căldăraru (me/100 g)

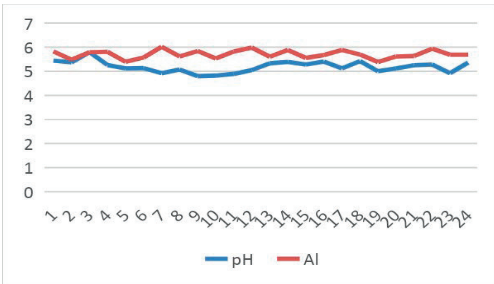


Figure 5. Changeable Al content in Costești (me/100 g)

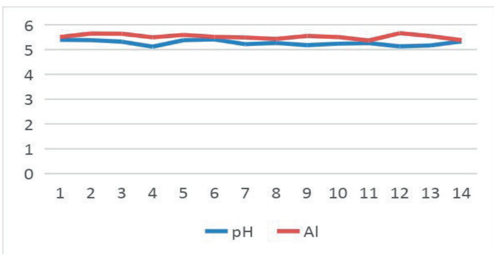


Figure 6. Changeable Al content in Costești (me/100 g)

Starting from the year 2020 this test for soil samples was selected and the conclusions were taken.

CONCLUSIONS

These results of the laboratory analyses made for the soil in the area Costești and one near Căldăraru shown very clear the need to correct calcium deficiencies in the soil. Is essential and to correct the acidity of the soil. Farmers in the area must use fertilisers according to a clear plan so that productive areas of the country do not become agriculturally inactive due to changes in properties over time. Soils become acidic due to the excessive use of fertilisers and other chemical solutions that have the effect of lowering the pH. However the release of the Aluminium from soil due to soil acidity or salinity can affect the content of mobile Aluminium in groundwater and this can cause health problems to humans, plants and animals.

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