THE EFFECT OF AMENDMENT AND FERTILIZATION ON SOME CHEMICAL CHARACTERISTICS OF THE SOIL

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Abstract

The paper presents the results obtained from the long-term experimental field within Agricultural Research Station Livada. The experience included 6 variants in which manure, amendments (CaCO3) and mineral fertilization with NPK were applied. The soil samples were collected at a depth of 0-20 cm after 5 years from the application of manure. By applying CaCO3 0.5t/ha/year the pH was maintained at the value of 6.0 and with 0.7 t/ha/year the pH value was maintained at 7.0. The amendment potential of the manure that was applied in a dose of 20 t/ha determined an increase in pH from 4.56 to 5.28 after 55 years of application. Long-term fertilization with 20 manure + $N_{100}P_{70}K_{60}$ increased the level of soil total nitrogen supply from low to medium. Fertilization with manure + $N_{100}P_{70}K_{60}$ led to high accumulations (highly significant compared to fertilization with manure alone) of phosphorus, accumulations stimulated in the amended varieties.

Amending acidic soils with limestone (calcium carbonate) and proper fertilization are essential for maintaining and improving soil quality.

Key words*: acidic soils, amendaments, manure, mineral fertilizers*

INTRODUCTION

The need for the continuous increase in agricultural production as a result of the rapid growth of the population and the increase in its standard of living, and the creation of hybrids with high production potential, therefore also with an increased consumption of nutrients, has led to a continuous increase in the consumption of organic and mineral fertilizers, and with it to increased losses of nutrients in the environment.

Although manure is the most valuable fertilizer, losses of nitrogen through leaching to ground water, runoff to surface waters, and air emissions in the form of NH_3 and N_2O have led to restrictions on the use of manure as a fertilizer. Excessive nitrate loads were also found in plants and animal organisms and changes in plant biodiversity where excessive doses were applied. And yet, it is necessary for the manure to be utilized in its entirety as a fertilizer because the humus in the soil can only be formed from organic matter, and it controls the physical, chemical and biological characteristics of the soil, being the most complex fertilizer.

The increase in the consumption of mineral fertilizers, the engine that led to the accelerated increase in productions, has slowed its growth rate due to the impact on the environment, the high energy needs for production, the reduction of raw material resources and the growing concern of people for a food healthy.

A current has been imposed to increase the degree of valorization through production of the nutrients applied through fertilizers in order to reduce the impact on the environment. The utilization of nutrients depends on the level of supply of the soil with them, the cultivated plant species, the cultivated hybrid, the soil moisture, the ratio between the nutrients and especially the soil reaction. Each plant has an optimal reaction environment for development. This has required amendments to be applied where the soil is too acidic or too basic.

Most cultivated plants require a weakly acid-neutral reaction medium (pH 6.2-7.2) for normal growth. The soil reaction values depend mainly on the degree of saturation in bases of the soil and the type of saturation (predominantly calcium or sodium). At the same time, the percolative water regime determined by a more abundant rainfall regime, the long-term application of large doses of fertilizers with an acid reaction, pollution with acidifying substances (sulphur oxides, nitrogen oxides, etc.), and the export of bases from soil with the help of plants, lead to soil acidification and the appearance of toxic substances: Al^{3+} and Mn^{2+}. pH values below 5.5 generally provide conditions for greater solubilization of pollutants and their translocation into plants.

Research carried out within the National Soil Quality Monitoring System showed that in Romania, soils with an extremely acidic reaction (pH below 3.6) occupy 0.74%, those with a very strongly acidic reaction (pH= 3.6-4,3) occupy 8.37%, those with a strongly acidic reaction (pH = 4.4-5.0) occupy 15.60% of the surface, those with a moderately acidic reaction (pH=5.1-5.8) occupy 23 ,25%, those with a slightly acidic reaction (pH=5.9-6.8) occupy 22.19%, those with a neutral reaction (pH=6.9-7.2) occupy 4.78%, those with weakly alkaline (pH=7.3-8.4) occupies 23.04%, those with a moderately alkaline reaction (pH=8.5-9.0) occupy 3.71% and those with a strongly alkaline reaction (pH=9 ,1-9,4) occupies 0.32% (Dumitru et al., 2000).

Amending acid soils with calcium carbonate is an old practice in agriculture. Fageria (2009) showed that the removal of toxic amounts of Al3+ and Mn2+ and the application of adequate amounts of Ca2+ and Mg2+ are the targets of lime amendment, especially on highly leached soils. In the soybean crop, the increase in pH following amendment increased from 5.3 to 6.7 and the production from 2270 kg/ha to 3330 kg/ha (4.7%).

MATERIALS AND METHODS

The soil samples were collected at the depth of 0-20 cm from the long-term experimental field (1967-2022) from S.C.D.A. Orchard, located on whitish luvisol. The climate in the area is moderate temperate-continental, with a 60-year multiannual average temperature of 9.9^0C and a total precipitation of 753.2 mm. The year 2022 was characterized as a very dry year, which strongly influenced the maize crop.

The amendments applied sought to maintain the pH at values above 5.8 to avoid the toxic effect of mobile aluminum. In the experiment the soil pH was maintained around 6.0 by amending with 0.5 t limestone/ha/year and 0.7 t/ha/year to maintain the pH at 7.0.

The manure came from the unit's cattle complex and was applied at a dose of 20 t/ha. The mineral fertilizer was applied in a dose of $N_{100}P_{70}K_{60}$. Fertilization was carried out with ammonium nitrate, simple superphosphate until 1983 and then with concentrated superphosphate, potassium salt 40% and semi-fermented cattle manure.

The experimental scheme consisted of 6 variants:

V1 – Manure

V2 – NPK+manure

V3 - CaCO3+manure 20 t pH=6

V4 - CaCO3+NPK+manure 20 t pH=6

V5 – CaCO3+manure 20 t pH=7

V6 - CaCO3+NPK+manure 20 t pH=7

RESULTS AND DISCUSSIONS

Due to the excessive drought, the level of corn productions in all fertilization and amendment variants had low values and no statistically assured differences were obtained between the variants. The highest production was obtained in variant 4 following the amendment to maintain the pH at values of 6.0 and fertilization with 20 t/ha of manure + $N_{100}P_{70}K_{60}$. The lowest production was obtained in variant three, where 20 t/ha of manure was applied on an amendment background at pH 6. It can be seen that the amendment (variant 3) did not lead to increases in production compared to the variant in which applied only to manure (option 1). A similar situation is observed between variants 2 and 6, which were fertilized with 20 t/ha of manure + $N_{100}P_{70}K_{60}$ (Figure 1).

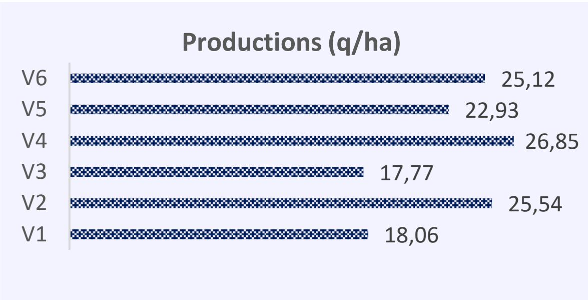

Figure 1. Maize yield obtained

Rusu et al. (2005) citing the results of older research carried out at Agricultural Research Station Livada shows that their productions were very different, corn being cited with a 32.8% increase in production. It is appreciated that, in general, the more resistant the plants are to acidity (they tolerate it more easily or prefer an acidic environment), the weaker their reaction to calcification (lupine, oats, potato) and the most sensitive to acidity react best to application of CaCO3.

It is known that the acidic environment favors the absorption of nitric nitrogen and the alkaline environment favors the absorption of ammoniacal nitrogen. At pH 6.8 root uptake is achieved in equal proportions for both ion species. As amendment leads to pH values above 6.8, conditions are created for a very good recovery of nitrogen from ammonium nitrate and for obtaining a greater amount of dry matter.

On the albic luvisol from the Albota area, with pH = 4.7, the optimal dose of manure was 40-60 t/ha, associated with 50-100 kg N/ha and respectively 50-100 kg P_2O_5/ha from mineral fertilizers (Lixandru and Filipov, 2012).

Figure 2 shows the data reflecting the influence of amendment, organic and mineral fertilization on the soil reaction. The most pronounced acidification is found to be generated by the systematic application of ammonium nitrate. This explains why the lowest pH (4.56) is in variant 2 fertilized with $N_{100}P_{70}K_{60}$ + 20 t/ha manure. Manure has not only a fertilizing potential but also an amendment one, the pH increasing from 4.56 to 5.28 following fertilization with 20 t/ha of manure for 55 years. Moreover, in all variants fertilized with manure, the pH of the soil increased very significantly.

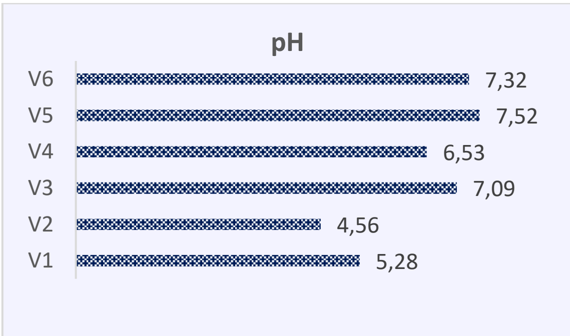

Figure 2. The influence of fertilizers, amendments and manure on soil pH

Research by Laszlo et al. (2012) in another long-term experience (50 years) with fertilizers showed that the acidification process following fertilization with ammonium nitrate is also maintained in the case of application together with simple and concentrated superphosphate plus potassium salt 40%. Prolonged manure fertilization contributed considerably to buffering the acidity caused by ammonium nitrate fertilization.

Applying amendments to acid soils and raising the pH increase the potassium-fixing capacity (Goian, 1985).

Figure 3 shows the evolution of the humus content following the applied treatments.

The application of manure together with mineral fertilizers increases not only agricultural production but also the reserve of humus in the soil. Since liming leads to the intensification of humus mineralization (Borlan et al. 1994) it is absolutely necessary that the amendment is accompanied by organic and mineral fertilization. The highest humus values, distinctly significantly higher than in the variant fertilized with 20 t/ha of manure, were recorded in variant 6 where the amendments were accompanied by fertilization with 20 t/ha of manure + $N_{100}P_{70}K_{60}$.

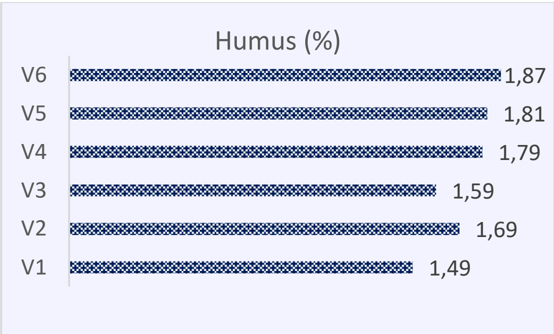

Figure 3. The influence of fertilizers, amendments and manure on the humus content

Fertilization with 20 t/ha manure + $N_{100}P_{70}K_{60}$ led to statistically significant accumulations of total nitrogen in the soil compared to the control fertilized with 20 t/ha manure. Fertilization for a long time (55 years) with 20 manure + $N_{100}P_{70}K_{60}$ made the level of soil supply with total nitrogen increase from low to medium (Figure 4).

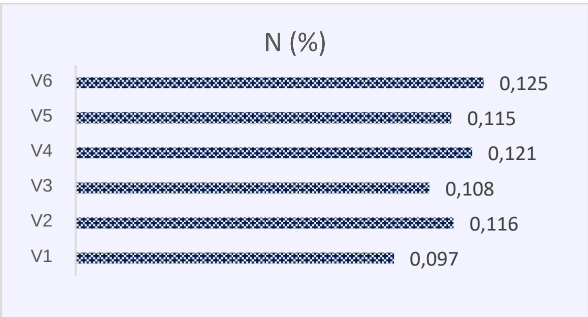

Figure 4. The influence of fertilizers, amendments and manure on the nitrogen content

Sala (2011) shows that at the level of soil fertilization in our country and the agricultural technologies practiced, especially the structure of crops and the fertilization system, there is a significant consumption of nitrogen from the soil reserve (humus) for the production of crops, a consumption that exceeds the annual rate of recovery of the organic nitrogen stock through pedogenesis processes.

The data presented in figure 5 highlight very significant accumulations of phosphorus in the variants fertilized with 20 t/ha manure + $N_{100}P_{70}K_{60}$ (V6) compared to the variant fertilized with 20 t/ha manure (V3).

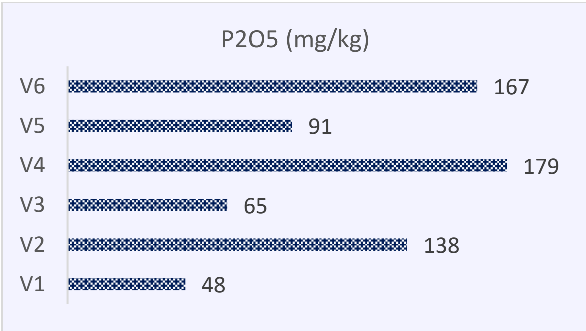

Figure 5. The influence of fertilizers, amendments and manure on mobile phosphorus in the soil

The albic Luvisol on which the experiment was located has an average content of 15 mg/kg of mobile phosphorus (Laszlo et al., 2012). Fertilization with 20 t/ha of manure for 55 years led to the accumulation of values of 48 mg/kg phosphorus, the level of soil supply increasing from low to high values (Florea et al.). Fertilization with manure + $N_{100}P_{70}K_{60}$ led to high phosphorus accumulations (highly significant compared to fertilization with manure alone), stimulated accumulations in the amended varieties.

Marin et al. (2022) found that long-term fertilization (42 years) with doses of 40-160 kg/ha phosphorus led to a very significant increase in the level of mobile phosphorus in the soil. The highest accumulations of mobile phosphorus in the soil are obtained following organic + mineral fertilization.

Under natural conditions, the supply of mobile potassium of albic luvisol is very low (64 mg/kg). The best solution for increasing mobile potassium reserves in the soil is organic fertilization with cattle manure associated with the application of mineral fertilizers. The data in figure 6 highlight large accumulations of mobile potassium in the long-term experience, values exceeding 301 mg/kg in all cases, very high values. Fertilization with $N_{100}P_{70}K_{60}$ led to significant increases over fertilization with 20 t/ha manure alone.

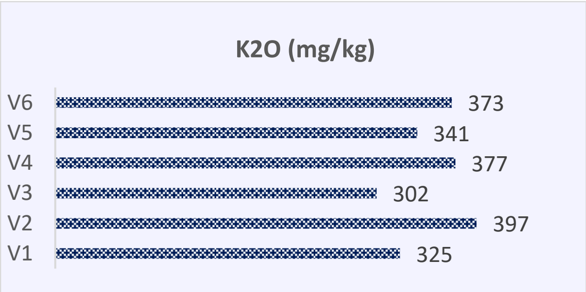

Figure 6.The influence of fertilizers, amendments and manure on mobile potassium in the soil

Laszlo et al. (2012) found that the amendment has the effect of reducing the potassium content primarily due to the much increased export of potassium, together with the incomparably higher productions obtained under these conditions, compared to the control without amendment.

Potassium has a catalytic and energetic role, regulates growth functions, water metabolism, influences harvest quality, increases plant resistance to diseases, pests, frost, falling and breaking, storage, etc. (Lăcătusu, 2016).

The amount of exchange bases (figure 7) increased very significantly with the amendment, providing a much greater resilience capacity to the albic luvosol, and conditions for increased production by ensuring the plant's calcium needs.

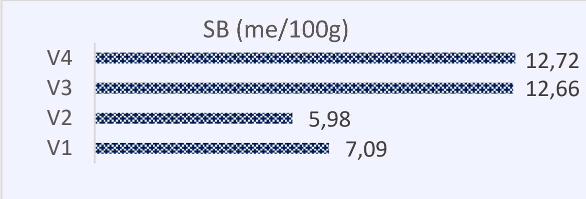

Figure 7. The influence of fertilizers, amendments and manure on the amount of bases in the soil

Calcium is the necessary element for maintaining the cellular plasma in an active and stable state, for maintaining the acid-base balance by neutralizing excess organic acids. Calcium participates in the formation of cell walls through calcium pectate; intervenes in the process of cell division, contributes to the development of the root system. Calcium has an important role in the action of detoxifying the body from other ions: Al, H, Fe, Mn and some radicals resulting from the metabolism process or that enter plants as a result of their excess in the nutritional environment (Avarvarei et al., 1997).

Hydrolytic acidity increases very significantly under the influence of long-term fertilization with mineral fertilizers, especially ammonium nitrate (figure 8).

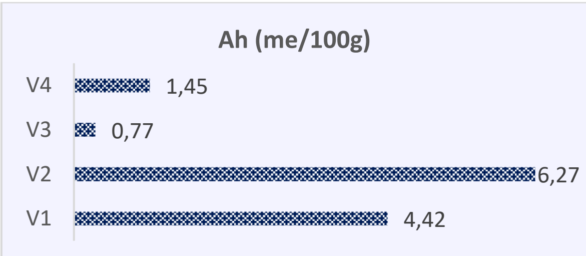

Figure 8. The influence of fertilizers, amendments and manure on the hydrolytic acidity of the soil

Amending very significantly reduces the level of hydrolytic acidity. It starts from the consideration that to neutralize one milliequivalent of H+ ions from 100 g of dry soil, one milliequivalent of CaCO3 is required, which corresponds to 50 mg CaCO3/100 g soil or 500 mg CaCO3 /1kg soil. So CaCO3 t/ha = Ah · 1.5. (Davidescu et al., 1981).

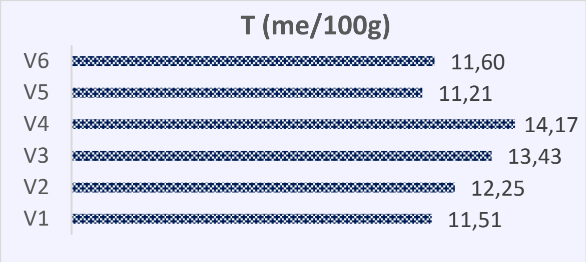

Figure 9. The influence of amendments and manure on the total cationic exchange capacity of the soil

The total cationic exchange capacity (figure 9) increased distinctly significantly in the variants amended to keep pH values at 6 + organic fertilization and in the variant that received, in addition to amendments, organic plus mineral fertilization.

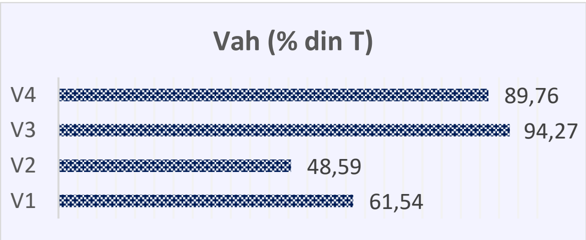

Figure 10. The influence of fertilizers, amendments and manure on the degree of saturation in soil bases

The lowest value of the degree of saturation in bases (48.59%) was determined in option 2, in which organic and mineral fertilization was applied, highlighting a need for high amendment (figure 10). Fertilization with 20 t/ha of manure led to a degree of saturation in bases (V% = 61.54%) which highlights a medium need for amendment (Davidescu and Davidescu, 1981).

CONCLUSIONS

Romania's soils are diverse in terms of their acid or alkaline reaction, and agricultural practices focus on adjusting pH to maximize production.

Calcium carbonate amendment and proper fertilization are essential for maintaining and improving soil quality and agricultural production.

Due to the drought, corn yields were low in all fertilization options. The highest production was in the variant where the soil was amended to maintain the pH at 6.0 and a combination of manure and mineral fertilizers was used.

Fertilization with manure and mineral fertilizers influences soil pH, humus content and levels of nitrogen, phosphorus and potassium. Amending acidic soils with limestone (calcium carbonate) and proper fertilization are essential for maintaining and improving soil quality.

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