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THE INFLUENCE OF LONG-TERM FERTILIZATION WITH NITROGEN AND PHOSPHORUS ON THE NPK CONTENT IN SOIL

Nicoleta MĂRIN[1], Maria NEGRILĂ[2]

[1]National Research and Development Institute for Soil Science, Agro-Chemistry and Environment - ICPA Bucharest, 61 Marasti Blvd, District 1, Bucharest, Romania
[2]Agricultural Development Research Station Teleorman, Draganesti-Vlasca, Teleorman, Romania

Corresponding author email: marinnicoleta37@yahoo.com

Abstract

This paper presents the experimental results obtained from a long-term experience after 29 years of fertilization with nitrogen and phosphorus. The applied nitrogen derived from ammonium nitrate and phosphorus from concentrated superphosphate (in dosages of 0, 40, 80, 120, 160 kg/ha). The application of phosphorus fertilizers led to very significant increases of mobile phosphorus content for all application dosages. Mobile phosphorus values increased from 60 mg/kg for P0 to 204 mg/kg for P160 kg/ha. Total phosphorus presented very significant increases for the application dosages of 80, 120 and 160 kg/ha (from 0.094% P for the unfertilized control to 0.146% P for the 160 kg P/ha dosage). Mobile potassium level decrease in soil as a result of nitrogen and phosphorus fertilization. The ammonium nitrate determined a decrease of the soil reaction and varied depending on the applied dosage, from 5.75 for the unfertilized control to 5.37 pH units.

***Key words**: long-term experience, nitrogen, total and mobile phosphorus, total and mobile potassium.*

INTRODUCTION

To meet the society constantly increasing requirements of alimentary nature, the production increasing per unit area is needed, since the expansion of cultivated areas is achievable only in certain regions of the world, South America, Central Africa, East and Southeast Asia with high costs, due to poor quality of land and large investments for their arrangement in order to build new agricultural systems.

Specialized organizations FAO, after analyzing various solutions for increasing food resources for mankind, concluded that, for now, the only safe and major source for obtaining higher quantities of food resources are the agricultural ecosystems, and to enhance these food resources is necessary to intensify the production process, obtaining large quantities of agricultural products per unit area (Sala, 2007).

In Romania overall situation of soils quality it is unsatisfactory due to many restrictive factors of production capacity as: periodic excessive humidity of soil or prolonged drought, alkalizing or salinisation of soil, low and extremely low humus reserve, compacting, poor supply with macro and micronutrients, soil pollution or remove aside lands out of farming.

Agrochemical study of agricultural land substantiates rational use of fertilizers and amendments, in order to obtain higher production both in terms of quantity and quality, to increase soil fertility condition, and for environment protection.

The various aspects of agrochemicals development of the soil are highlighted by the results obtained after many long-term experiences on stationary, about the content of nitrogen, phosphorus and potassium (Borlan et al., 1994).

In order to determine the increasing of the plant's production, actions are taken through a complex of measures for improving the properties of soil and environmental conditions by satisfying an extent as possible the requirements for plant nutrition, as well as through a series of steps on plants in order to increase their ability to absorb substances and energy from the surrounding environment (Sala, 2007).

Long term experiments plays a vital role in analyzing the stability of crop production, trends in soil quality, technological progress and changes in environmental factors, but also the budget calculation of nutrients (Kunzova et al., 2009).

MATERIALS AND METHODS

Samples were harvested from the experimental field of SCDA Teleorman after 39 years long-term fertilizing with ammonium nitrate and phosphorus in superphosphate by 5 degrees: 0, 40, 80, 120, 160 kg/ha. The effect of application fertilizers with nitrogen and phosphorus was follow on the content of total nitrogen, total and mobile phosphorus, and total and mobile potassium from the soil.

Soil samples were collected at the end of the wheat crop vegetation, from the depth of 0-20 cm.

In the laboratory phase, in order to determine the elements the following analytical methods were used:

• total nitrogen content (N%): Kjeldahl method, disintegration with H_2SO_4 at 350°C, a catalyst of potassium sulfate and copper sulfate - SR ISO 11261:2000.

• accessible phosphorus (mobile) after Egner-Riehm-Domingo method and colorimetric dosed with blue by molybdenum after Murphy-Riley method (ascorbic acid reduction).

• accessible potassium (mobile) extraction by Egner-Riehm-Domingo method and by dosing flame photometry.

RESULTS AND DISCUSSIONS

1. Influence of NP fertilization on the nitrogen content of the soil

Nitrogen is one of the fundamental elements of plant nutrition, essential for the growth of plants, theirs leaf area and there of it determines the increasing the quantity of fruit and seeds (Dodocioiu et al., 2009).

In Romania, research conducted within the National Monitoring System of Soil Quality on a network of 16x16 km, showed that on 0-50 cm depth of the soil nitrogen supply is very low (<0.101%) to 23.36% of the surface (220 sites), small (0.101 to 0.140%) in 27.60% of the area (280 sites), medium (0.141-0.270%) in 36.73% of cases (346 sites), higher (0.271-0.600%) to 10.40% of the cases (98 sampling points), and very high (>0.600%) in 4.48% of cases (42 points). It shows that low values, very low and extremely low represents 65.41% of the agricultural area of the country (Dumitru, 2000).

Following 50 years of research at the Experimental Center of crop rotation in Ivanovice in the Czech Republic showed that the production of winter wheat was influenced primarily by the cultivated variety, followed by the effect of fertilizers, previous cropping and manure application (3). Several researchers have found that the application only of NPK fertilizers can not sustain productivity in intensive culture systems, while the inclusion of organic fertilizer improves the physical properties, soil fertility and crop yields (Jiang et al., 2008).

Long term application of the compost prepared in the farm, or in combination with NP, improved level of nutrients for: P, K, Ca, Mg and Zn in the first 10 cm of the soil, while the application of the fertilizer with NP contributed only to the increase of phosphorus levels in the soil (Bedada et al., 2016).

The data presented in Figures 1, 2 and 3 concerning the evolution of the nitrogen content of the soil, show that fertilization with phosphorus, das not offer significant changes in nitrogen supply of the soil. The total nitrogen content in the soil increased significantly after the application of 40 and 80 kg N/ha doses (from 0.166% at control without fertilizers to 0.171% at both applied doses). A very significant increase of the total nitrogen values were noted on application of 120 and 160 kg N/ha. Following effect of interaction of the two fertilizer it is found that application of 160 kg N/ha without phosphorus fertilizer, nitrogen content of the soil increased significantly distinct. Significant increases were brought by applying doses of N120 and N160, together with P40 and P80.

Application of the ammonium nitrate has led to fall of soil pH. After 39 years of fertilizing the soil falls to moderate acid class, values between 5.95 and 5.30 pH units, which require the application of amendments. The humus content is between 3.66% and 4.27%, the degree of base saturation have the values between 73% and 81%.

A group of experts from the European Community who studied the efficiency of nitrogen use (EUN) as an indicator for use of nitrogen in agriculture and food systems have shown the relation: EUN = nitrogen exits on the harvested yeld/inputs of nitrogen. It was concluded that the target values for nitrogen use efficiency (EUN), the outputs of nitrogen and the nitrogen surplus depends on the type of farming system and conditions of climate, soil, environment, as well as the type of nitrogen used. This means that the targets are specific to the system and location.

The reference values (50% < EUN < 90%; nitrogen output > 80 kg/ha and year, the excess nitrogen < 80 kg/ha and year, serving as a first attempt to reach such set point values are based on experts considerations on the production and environmental objectives for a particular culture system. Those targets proposed are averages in Europe. For example global average nitrogen outflows from agricultural land in the EU 27 in 2000 were about 80 kg/ha, while the global average EUN sector crop production was 44% and excess global environment of nitrogen in agriculture EU27 including livestock was about 80 kg/ha. In 2010 EUN in the EU 27 increased to over 50% (Oenema et al., 2015).

In this experiment the efficiency use of the nitrogen was 211% in terms of applying a dose of 40 kg N/ha, 122% in variants fertilized with 80 kg/ha nitrogen, 85% in variants fertilized with 120 kg/ha N and 81% in terms of fertilization 160 kg/ha nitrogen. It can be concluded that the application of nitrogen doses up to 80 kg/ha led to a mining type agriculture, based on the use of nitrogen from the soil, while doses of 120 to 160 kg/ha nitrogen falls within the desired range of nitrogen use efficiency. If the index of recovery of nitrogen is below 50%, there is a risk of the inefficient use and, thereof, the amounts of nitrogen use efficiency is very low.

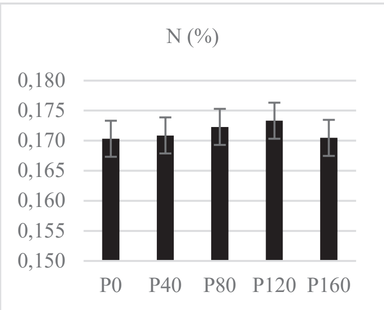

Figure 1. Phosphorus fertilization influence on the nitrogen content
LSD 5% = 0.003 %
LSD 1% = 0.004 %
LSD 0.1 % = 0.006%

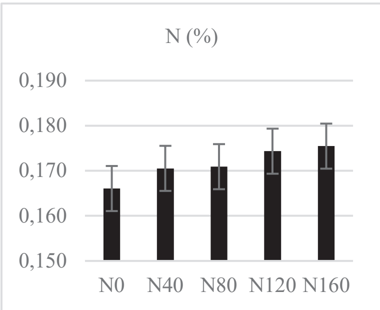

Figure 2. Nitrogen fertilization influence on the nitrogen content
LSD 5% = 0.005%
LSD 1% = 0.006%
LSD 0.1% = 0.008%

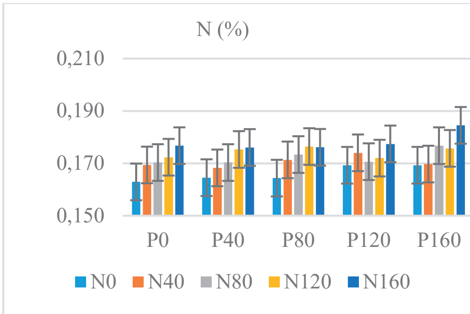

Figure 3. NP fertilization influence on the nitrogen content
LSD 5% =0.011%
LSD 1% = 0.014%
LSD 0.1%= 0.019%

2. Influence of fertilization with NP on total and mobile phosphorus content in soil

Phosphorus is an essential element for plant and animal growth, needed to maintain profitable plants and animal production (Dobermann et al., 1996).

In Romania researches made within the Soil Quality Monitoring System in 16 x 16 km network showed that in the 0-50 cm depth, supply of the soil with phosphorus is extremely low (< 4 mg/kg) to 11.36% of the surface (107 sites), very low (4-8 mg/kg) in 21.02% (198 points), low (9-18 mg/kg) in 33.01% of cases (311 sites), the average (19-36 mg/kg) in 20.70% of cases (195 sampling points), high (37-72 mg/kg) in 9.45% of cases (89 points) and very high (> 72 mg/kg) in 4.48% of cases (42 points). It shows that low values, very low and extremely low represents 65.41% of the agricultural area of the country (Dumitru, 2000).

Unlike this situation in the Netherland where the amount of phosphorus in soils can be found in very high doses it was necessary to reduce the organic and mineral fertilizers with this element, and to find possible solutions to reduce the amount of phosphorus in the organic fertilizer.

A significant amount of P in the grain is in the form of phytate, which can't be digested by pigs and chickens. Thus, are used additives with enzymes to animal feed in order to increase the efficiency of phosphorus uptake during digestion. These enzymes may reduce the need for supplemental P in food and, possibly, reduce the P content of the manure (The Pennsylvania State University, 2001).

In the Philippines in rice culture it tries to minimize the accumulation of phosphorus in the soil above the sufficient levels for optimal growth of the crop, by applying the phosphorus fertilizer locally. Unlike the management of nitrogenous fertilizers, to maximize the level of recovery of phosphorus is less important, this is due to the fact that P is less mobile in the soil, the inputs of phosphorus, other than the fertilizer are small, and a large part of the the residual phosphorus fertilizer applied to the plant remains available for subsequent crops (Dobermann et al., 1996).

By comparing the content of phosphorus in three long-term experiments (30 years) have shown that the type of soil, due to different contents of organic matter, have a significant influence on phosphorus dynamics.

Application of the phosphorus both in the form of fertilizer inorganic and organic as manure has a considerable influence on the accessibility, absorption, washing or fixing of phosphorus, but the rate of recovery by culture of phosphorus from the mineral fertilizers does not exceed 35%, with the lowest recovery (18%) in the soils with the highest content of clay from Rothamsted. The most efficient use of phosphorus (on average 47% to 37% from Rothamsted BadLauchestaedt) was on soils treated with manure. The largest quantity of phosphorus washing or fixed (8 and 25 kg/ha/year) appears in soils treated with superphosphate (Blake et al., 2000).

Following the experiments carried out at Rothamsted Experimental farm, it was found that about 13% of the reserve of P fertilizers and manures gained from the available phosphorus is retained as determined by Olsen method (extraction with sodium bicarbonate to pH 8.5) (Johnston et al., 1992). Other studies have also shown that for every 100 kg ha^{-1} P would increase the excess phosphorus of 2-6 mg/kg of soil (Tang et al., 2008).

The interaction of N with P may be called the most significant interaction between nutrients having practical significance (Aulakh et al., 2007). Research has shown the ratio N/P for cereals (n = 759) and indicated that over 40% of crop production reach a maximum when this ratio is relatively tight, ranging between 4 and 6 (Sadras, 2006).

When the P fertilizer input exceeds the P outputs of the culture, the accumulation of P in soil increases gradually in time (Kuo et al., 2005). The information obtained from the fractionation scheme, P was used to estimate the behavior of applied P and the relationship between the P shapes applied and to the plant nutrition with P (Ryan et al., 1985; Furlani et al., 1987; Cox et al., 1997). Thus, for the development of P long-term management strategies, it is important to establish forms and characteristics P remaining in the soil after repeated application of fertilizers (Takahashi et al., 2007).

Total phosphorus content in the arable layer of soil is the difference between the inputs of phosphorus (with fertilizers, take up by roots from underlying horizons) and exports (exports harvest, losses by erosion), in which, for plant nutrition, the main source is phosphate neocluşi mineral particles from the surface of the soil. The plant nutrition is determined by the processes of desorption and diffusion of phosphate ions in the soil solution (Borlan et al., 1990).

Long-term experiments is a means of measuring the sustainable management systems in agriculture (Ramsussen et al., 1998). Since the dose of phosphorus applied, the low efficiency of phosphorus absorbed by crop plants is the main problem imposed to phosphorus fertilization (Takahashi et al., 2007).

The experimental data obtained in long-term experience, after 39 years of fertilization with ammonium nitrate and superphosphate showed that mobile phosphorus in the soil has increased very significantly at all doses applied, from 60 mg/kg in the control to 204 mg/kg at 160 kg P application/ha per year. Total phosphorus concentration increased significantly distinct from the application 40 kg P/ha, and very significant at application rates of 80, 120 and 160 kg/ha, from 0.094% in the control to 0.146% in variant treated with 160 kg P/ha.

By applying nitrogen in doses of 80, 120 to 160 kg/ha, the phosphorus content decreased very significantly, from 144 mg/kg to 132 mg/kg. Nitrogen fertilization has led to increased yield and also to increased consumption of phosphorus. The accumulation of total phosphorus in soil showed no statistically increases under the influence of nitrogen fertilization.

The interaction of these two fertilizer gave the following results: the application of the nitrogen fertilizer without phosphorus, led to a significant decrease in mobile phosphorus in the soil at the application 120 and 160 kg N/ha. Fertilization with 120 kg N/ha without P led to a very significant reductions of the content of mobile phosphorus. In variants that were applied to 80-160 kg P/ha on the background of fertilization with nitrogen content of total phosphorus in the soil increased significantly (from 0.108% to 0.118% at the dose of 80 kg N/ha), and very significantly (from 0.134% to 0.150% at the dose of 160 kg N/ha) (Figures 4-9).

Fertilization with higher doses of phosphorus than the P take it by yield, led to increases significantly the content of phosphorus in the soil in the first 20 years of the experiment (Hera, 2013).

Mineral fertilization with nitrogen only has a negative influence of the phosphorus content of the plowed soil layer.

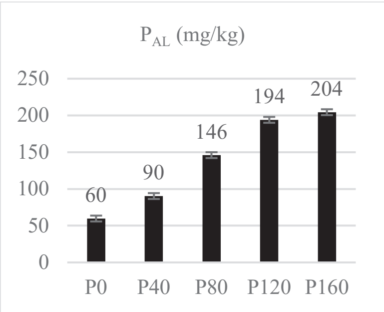

Figure 4. Influence of phosphorus fertilization on the mobile phosphorus content
LSD 5% = 4%
LSD 1% = 6%
LSD 0.1 % = 10%

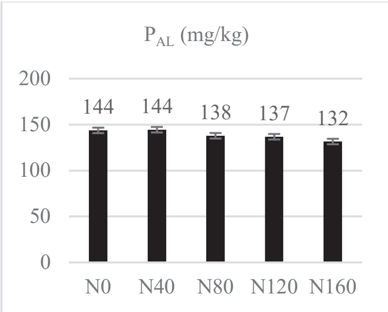

Figure 5. Influence of nitrogen fertilization on the mobile phosphorus content
LSD 5% = 3%
LSD 1% = 5%
LSD 0.1% = 6%

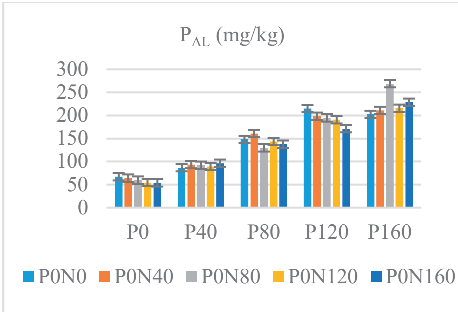

Figure 6. Influence of NP fertilization on the mobile phosphorus content
LSD 5% = 8%
LSD 1% = 10%
LSD 0.1%= 14%

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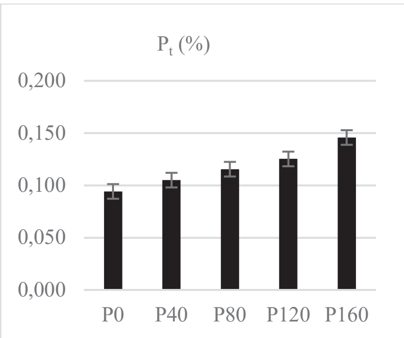

Figure 7. Influence of phosphorus fertilization on the total phosphorus content
LSD 5% = 0.007%
LSD 1% = 0.010%
LSD 0.1 % = 0.015%

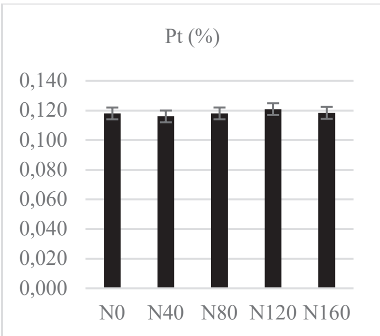

Figure 8. Influence of nitrogen fertilization on the total phosphorus content
LSD 5% = 0.004%
LSD 1% = 0.005%
LSD 0.1% = 0.007%

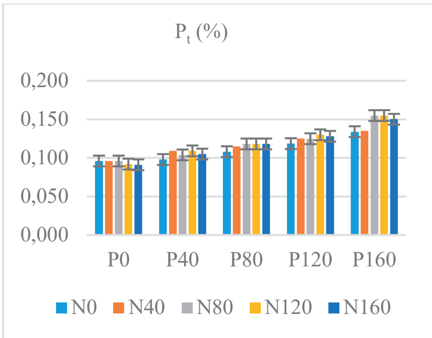

Figure 9. Influence of NP fertilization on the total phosphorus content
LSD 5% = 0.007%
LSD 1% = 0.009%
LSD 0.1%= 0.012%

3. The influence of long term NP fertilizer on the content in total and mobile potassium of soil

Potassium is a macronutrient that plays a key role in the synthesis of the cells, enzymes, proteins, starch, cellulose and vitamins, in the transport of nutrients and their absorption, which confers resistance to abiotic and biotic factors and improve the quality of crops (Epstein et al., 2005; Pettigrew, 2008).

The issue of sustainable management of soil potassium was partially ignored in recent decades, agricultural use of nitrogen and phosphorus was considered a more important issue. It has become apparent that mixed systems can exhausted soil in K interchangeably if this is not replaced by the minerals in the soil with the amount of K export crops. The release rate is dependent on the balance and fixing K in the soil, which confirms that they are reversible processes which depend on absorption of plant and fertilizer application (Simonsson et al., 2007).

In order to avoid the lack of K and to support the long-term productivity, a continuous supply of potassium in the soil occurs from the soil inner reserve (Andrist-Rangel et al., 2007).

Budgets or balance sheet items are increasingly used to assess the sustainability and long-term effects of nutrient management in the agro systems (Smaling et al., 1999; Dargaard et al., 2006).

In Figures 10-15, is shown the mobile potassium content of the soil, due to the NP fertilization, it decreased significantly distinct from the application of 160 kg N/ha and 160 kg P/ha.

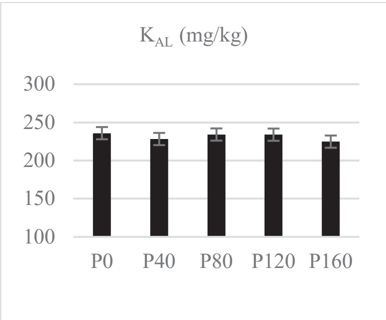

Figure 10. Influence of phosphorus fertilization on the mobile potassium content
LSD 5% = 8%
LSD 1% = 11%
LSD 0.1 % = 16%

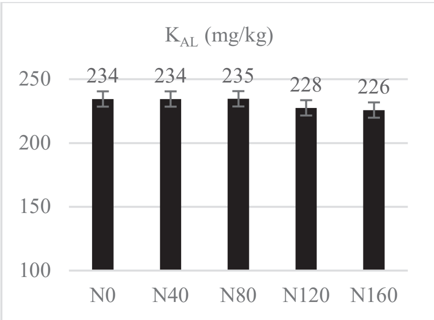

Figure 11. Influence of nitrogen fertilization on the mobile potassium content
LSD 5% = 6%
LSD 1% = 8%
LSD 0.1% = 11%

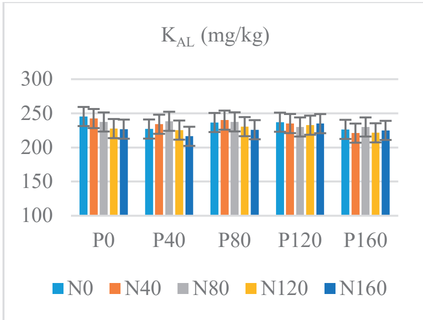

Figure 12. Influence of NP fertilization on the mobile potassium content
LSD 5% = 14%
LSD 1% = 19%
LSD 0.1%= 25%

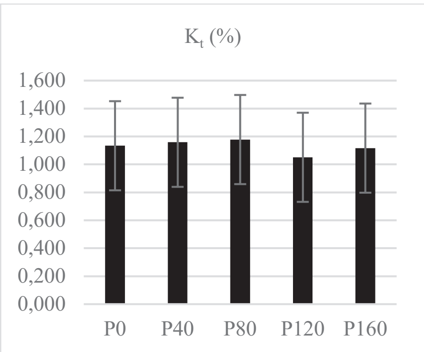

Figure 13. Influence of phosphorus fertilization on the total potassium content
LSD 5% = 0.319%
LSD 1% = 0.464%
LSD 0.1 % = 0.697%

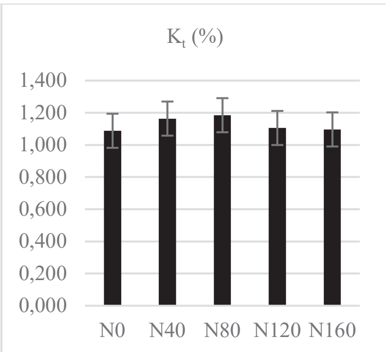

Figure 14. Influence of nitrogen fertilization on the total potassium content
LSD 5% = 0.106%
LSD 1% = 0.142%
LSD 0.1% = 0.187%

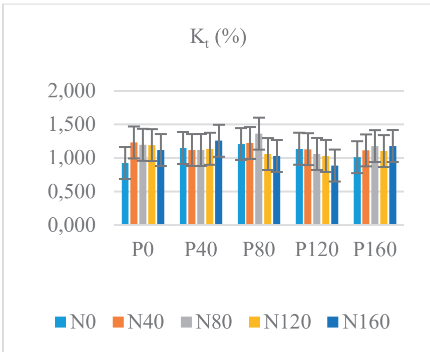

Figure 15. Influence of NP fertilization on the total potassium content
LSD 5% = 0.238%
LSD 1% = 0.318%
LSD 0.1%= 0.418%

After 39 years of the NP fertilizer, mobile potassium decreased to about 10 mg/kg compared to control variant. Although K fertilizers were not applied, the mobile potassium content of the soil fall in the class with high mobile potassium content (Florea et al., 1987).

NP fertilization did not result in statistically changes to the total potassium content of the soil.

CONCLUSIONS

Fertilization with ammonium nitrate determined a very significant increase of the total nitrogen in the soil in variants which have been applied doses of 120 and 160 kg N/ha.

The application of doses with N120 and N160 together with P40 and P80 contributed to a significant increase of nitrogen in the soil.

After 39 years of fertilization with superphosphate results showed that the phosphorus content in the soil increases significantly at all doses applied, from 60 mg/kg in the control variant to 204 mg/kg at a doses by 160 kg P/ha per year.

Application of the ammonium nitrate non fertilized with phosphorus increased agricultural production, which has led to an increase in the export of phosphorus with the harvest.

Efficacy of the use of the nitrogen was 211% in terms of applying a dose of 40 kg N/ha, 122% in variants fertilized with 80 kg/ha nitrogen, 85% in fertilized variants to 120 kg/ha N and 81% in the conditions of fertilization 160 kg/ha nitrogen.

Total phosphorus content of the soil had the largest increase with a dose of 160 kg P/ha. Total phosphorus concentration as P_2O_5 at variants fertilized with doses of 80, 120 and 160 kg P/ha reached the value of 0.055%, a value very high than normal to total phosphorus content typically black soil. In time, annual fertilization with high doses of phosphorus, leads to the accumulation to the large amounts of phosphorus in the soil with adverse effects to the environment.

Due to NP fertilization the concentration of mobile forms of potassium in the soil significantly decreased compared to the unfertilized variants. Total potassium did not suffer statistically changes.

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