Scientific Papers. Series A. Agronomy, Vol. LXV, No. 1, 2022
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

LONG -TERM NITROGEN AND PHOSPHORUS FERTILIZATION EFFECTS ON SOIL PROPERTIES

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Abstract

More and more attention is being paid to assessing the effect of long-term fertilization considering global warming to ensure sustainable soil fertility management. The aim of this study is to evaluate the soil properties under mineral fertilization in long-term experimental fields. These experiments were carried out in the experimental fields of SCDA Livada. In order to evaluate the effect of fertilization, with progressive doses of nitrogen and phosphorus, with 5 graduations, there were taken and analysed 75 soil samples. Following the statistical processing of the data obtained, it was observed that nitrogen and phosphorus fertilization significantly influenced soil properties. Based on these results it could be established the optimal doses of fertilizers that should be applied on soil in order to improve the quality of soil in terms of environmental protection. Also, these results contribute to contemporary knowledge regarding sustainable land use.

Key words: *fertilization, soil properties, experimental field.*

INTRODUCTION

In recent years people face with finding optimal solutions to problems related to climate change in direct relation to the need to provide optimal yields to crops that provide food for humans and animals. There is also the permanent concern to preserve soil quality and environmental protection. Over time it was demonstrated that long-term fertilization fields experiments provide useful information, particularly how can be quantified soil characteristics changes considering various rates of fertilizer and weather conditions (Korschens, 2006). It is important to avoid excessive doses of chemical fertilizer application which will adversely affect soil chemical properties, resulting in soil hardness and acidification, which eventually lead to a decline in soil organic matter and fertility (Wan et al., 2021).

What is more, excess P or N that are accumulated in soils could be an environmental concern because these can pollute water resources through field runoff and soil leaching (Piotrowska-Długosz et al., 2016). Consequently, a great attention has been focused on the ecological effects of excessive P and N, and on optimizing P and N fertilization. In this context, the paper presents the effect of phosphorus and nitrogen fertilization on soil quality indicators in the long-term experimental fields to Livada, in order to put into evidence, the evolution of soil characteristics with different doses of mineral fertilization with nitrogen and phosphorus.

MATERIALS AND METHODS

Soils were sampled in 2019 from a long-time experimental field, established in 1961 to SCDA Livada - Satu-Mare County, Romania, a unit located in the North West region of Transylvania (23°12' east longitude and 47°86 'north latitude), 132 m above sea level. The soil type was luvosol, characterized by the presence of a horizon B more or less developed, with clay content between 30-35%, a slightly acidic and acidic soil reaction (pH) (the trend being in the direction of acidification), the humus content (which was mainly formed on the basis of fulvic acid) is low and the presence of aluminum ions due to potential acidity. The experiment is of the bifactorial type with five graduates, with progressively increasing doses of phosphorus (0, 40, 80, 120, 160 kg / ha) and nitrogen (0, 40, 80, 120, 160 kg / ha). The soil samples were collected from a 0-20 cm soil depth. The soil samples were air-dried, crushed and passed through a 2 mm sieve.

Soil pH was measured using the potentiometric method (1:2.5 w/v, soil: water). The soil organic carbon content (SOC) was determined on 0.2mm grounded soil samples using dichromate oxidation followed by titration with ferrous ammonium sulphate.

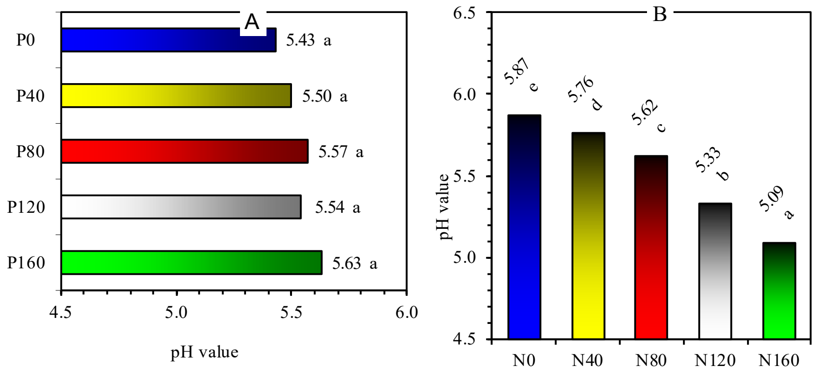
Analysis conducted to determine phosphorus and potassium contents (available forms) were performed by ammonium lactate acetate extraction (at 3.75 pH) followed by a colorimetric determination for phosphorus (P) and by flame atomic emission spectrometry determination for potassium (K) content (Romanian Standard STAS 7184 19-82) based on the Egner Riehm Domingo method.

The base saturation, (V) was calculated, with the formula $V = SB_{Kappen}*100/T$. The sum of the exchange bases (SB) expressed in meq/100g of soil was obtained by summing the individually determined basic exchange cations (SB = Ca + Mg + Na + K). The total cation exchange capacity expressed in meq/100g of soil was obtained by summation (T = SB + SH).

Statistical analysis was performed using analysis of variance (ANOVA), followed by Tukey's range test (honestly significant difference), for multiplecomparison between all pairs of averages.

RESULTS AND DISCUSSIONS

It is observed that, regardless of the applied phosphorus fertilizer dose, there were no statistically assured changes in soil reaction. The lowest average pH value was obtained for non-phosphorus fertilized variants. Instead, nitrogen fertilization causes statistically assured decreases in the pH value, for each graduation, the highest value being obtained in the non-fertilized version and the lowest in the version with the highest dose of nitrogen fertilization (Figure 1).



* Values followed by the same letter are not significantly different at the 5% level (P< 0.05) according to the Tukey´s HSD (Honest Significant Difference) test

Figure 1. Effects of phosphorus (A) and nitrogen (B) fertilization on soil pH value

It is well known that soil acidification processes lead to increasing of aluminium solubility which can became toxic for agricultural plants or affect establishment and growth of legumes (Whitley et al., 2016). Consequently, in case of samples with a pH value under 5.70, the exchangeable aluminum (Al_{ex}) content was determined. The results obtained showed that exchangeable aluminum content in these soil samples was extremely low (<0.4 meq/100 g soil) and very low (0.44-0.88 meq/100 g soil) (Table 1). Since 1976 Awad observed that the application of nitrogen fertilizers has led to a significant decrease in pH values and raised extractable Al levels Increasing the dose of N in the soil (doses of nitrogen over 80 kg/ha) has led to increasing of exchangeable aluminum content. Concerning the application of high rates of phosphate decreased the concentration of soluble soil-Al (Awad et al., 1976). For the maximum dose of P (160 kg/ha) the lowest values of changeable aluminum were determined under conditions of high doses of N.

Table 1.The values of the exchangeable aluminum content determined in the soil samples

P fertilization	P_0	P_0	P_0	P_{40}	P_{40}	P_{80}	P_{80}	P_{120}	P_{120}	P_{120}	P_{160}	P_{160}
N fertilization	N_{80}	N_{120}	N_{160}	N_{120}	N_{160}	N_{120}	N_{160}	N_{80}	N_{120}	N_{160}	N_{120}	N_{160}
Al_{ex} (meq/100 g)	0.11	0.55	0.88	0.22	0.44	0.22	0.44	0.22	0.33	0.44	0.16	0.27

As one of the main indicators for soil fertility is humus content (Zhakashbaeva et al., 2015) it was important to know if the humus content in the soil samples of this research are influenced by different doses of mineral fertilization (Figure 2).

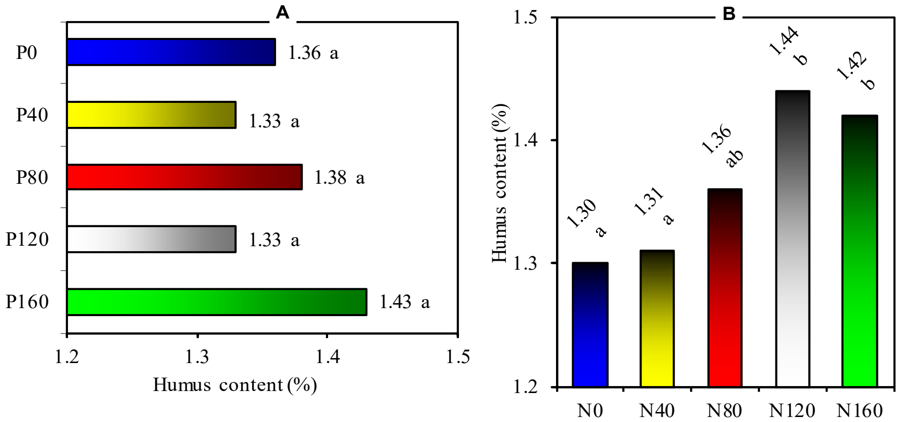


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Figure 2. Effects of phosphorus (A) and nitrogen (B) fertilization on humus content in the soil

It was noticed that humus content did not change significantly under the influence of different doses of phosphorus applied, the average values ranging between 1.33 and 1.43%. Nitrogen fertilization led to increases in humus content, with the highest average values being obtained on plots where higher doses of nitrogen fertilization were applied (N_{120}, N_{160}) compared to the control and N_{40}, these increases being statistically assured. Regarding soil available phosphorus became a parameter more and more important considering the tendency of applying excess P fertilizer which could cause environmental problems (Cao et al., 2012; Ohm et al., 2017). As expected, in our experiment, fertilization with different increasing doses of phosphorus influenced the available phosphorus content in the soil, causing statistically assured increases. The nitrogen fertilization caused variations in available phosphorus contents ranging between 95 and 111 mg/kg (Figure 3).

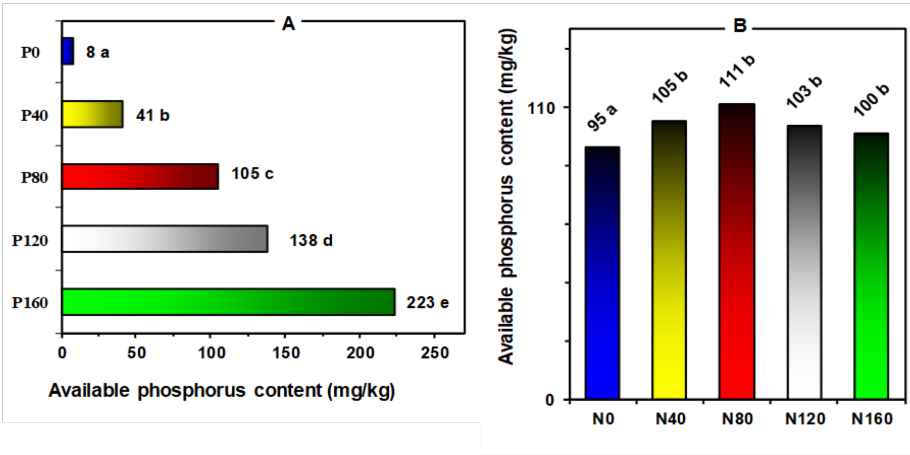

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Figure 3. Effects of phosphorus (A) and nitrogen (B) fertilization on available phosphorus content in the soil

Besides phosphorus, another important macronutrient for sustaining plant growth and reproduction, resistance to drought, water excess, high or low temperatures is potassium (Figure 4).

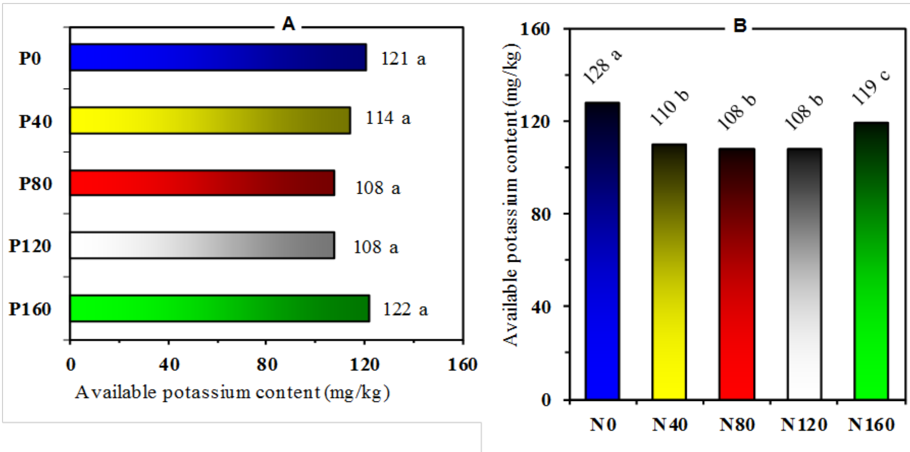

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Figure 4. Effects of phosphorus (A) and nitrogen (B) fertilization on available potassium content in the soil

Phosphorus fertilization did not produce statistically assured changes in the mobile potassium content of the soil and in the case of nitrogen fertilization, the average values of the available potassium content remained in the range of average values in terms of potassium supply status for crops field, values ranging from 108 to 128 mg/kg. ($T = SB_{Kappen} + SH$) and is a fundamental soil property used to predict plant nutrient availability and retention in the soil (Culman et. al., 2019). The SB values increased significantly, the highest value being obtained when fertilizing with P_{160}.

Fertilization with N_{120} and N_{160} led to statistically assured decreases in SB mean values compared to control and the first two doses of fertilizer (Figure 5).

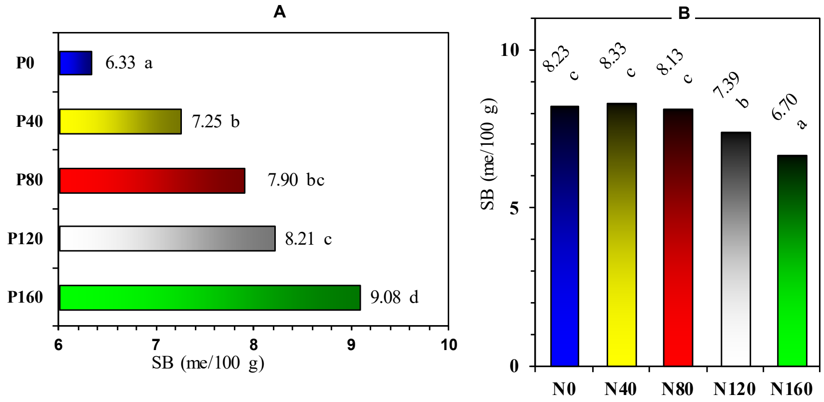

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Figure 5. Effects of phosphorus (A) and nitrogen (B) fertilization on SB content in soil

No significant changes in total exchange acidity (SH) were obtained for phosphorus fertilization but nitrogen fertilization led to statistically assured increases, the highest average value being obtained for N_{160} fertilization (Figure 6).

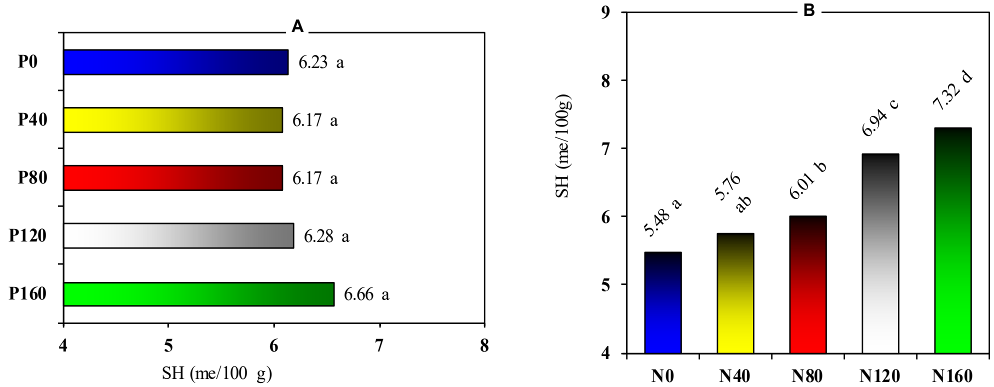

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Figure 6.Effects of phosphorus (A) and nitrogen (B) fertilization on exchange acidity (SH) in soil

Base saturation (V) contents increased with increasing phosphorus dose, the highest value being obtained at the maximum dose of phosphorus, the increase being statistically assured compared to the control and with the plot fertilized with P_{40}. Nitrogen fertilization shows a decreasing trend, a statistically assured decrease for higher doses (Figure 7).

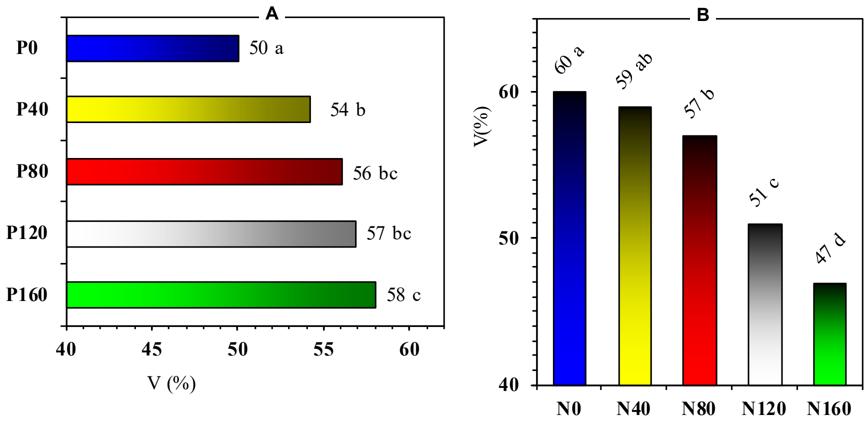

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Figure 7. Effects of phosphorus (A) and nitrogen (B) fertilization on base saturation (V) in soil

CONCLUSIONS

Mineral fertilization with high doses of nitrogen results in soil acidification and increased exchangeable Al content in soil which can induce Al toxicity to plants. Increasing doses of phosphorus influenced the available phosphorus content in the soil, causing statistically assured increases. The continuation of long-term experiments proves to be the best solution for the most accurate assessment of the effects of mineral fertilization on the environment and for the sustainable management of the fertility of acid soils in Livada. This kind of research over a long period of time can provide predictability models in the context of climate change, allowing the optimal application of fertilizer doses according to the trend of evolution over time of various soil quality indicators.

ACKNOWLEDGEMENTS

This work was supported by a grant of the Ministry of Agriculture and Rural Development, project ADER 153/2019 and a grant of the Romanian Ministry of Research, Innovation and Digitization, project number 44 PFE /2021, Program 1 – Development of national research-development system, Subprogramme 1.2 – Institutional performance – RDI Excellence Financing Projects.

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