PHOSPHORUS DYNAMICS ON ACIDIC GRASSLAND SOIL

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Abstract: *Phosphorus is one of the major nutrients that influences plant growth but the amount of bioavailable phosphorus in soil may have a negative effect on grassland production. A critical issue that affects the phosphorus bioavailability is soil acidity. There are several strategies on how to manage phosphorus availability on such soils. A number of studies have shown that high doses of phosphorus application can optimize plant performance, these doses have a long residual effect and cause increased pH, CEC or organic content. However, application of phosphorus in small doses, can have long term benefits from economic point of view. In this paper we propose to study the dynamics of phosphorus on a pajiste an acid soil (aluviosol) at pH = 5.3. This meadow is situated in the village Borlova, Caras-Severin, at the foot of Mount Mic Were applied fertilizer nitrogen and phosphorus in 4 variants and 4 repetitions arranged in randomized blocks, as follows: N0P0, N1P0, N0P1 and N1P1, where N0P0 unfertilized control, N1 = 150 kg N/ha was applied split (100 kg/ha before the vegetation and 50 kgN/ha after the first stitch) and P1 = 50 kg P2O5/ha. P was applied once before the vegetation. Soil samples were taken at 0-10 cm depth, dried in air, grounded and sieved trough 2 mm sieve. Total phosphorus content in soils was determined by extraction in aqua regia and available phosphorus content by Egner - Rhiem – Domingo method. Reading of total phosphorus and available phosphorus concentrationfrom soil samples was done with Cintra 101 spectrophotometer After analysis it was found that although total phosphorus content in the soil is high available phosphorus content is relatively low. Maximum plant available P occurs at approximately pH 7. As pH changes in either direction, P availability is decreased. Although P levels increase with P fertilizer applications, the available content is low, so it is crucial that P fertilizer be applied annually at reasonable rates to satisfy plant needs.*

Key words: *acid soil, phosphorus, grassland, fertilization*

INTRODUCTION

Phosphorus is an important nutrient in crop production, since many soils in their native state do not contain sufficient available phosphorus to maximize crop yield (BARBER, 1984). In soils, phosphorus is present as mineral and organic form. Each form consists of a sequence of several compounds between which exists an equilibrium, including inorganic P and organic P. One unique characteristic of P is its low availability due to slow diffusion and high fixation in soils. All of this means that P can be a major limiting factor for plant growth (SHEN ET. AL, 2011).

Phosphorus is taken up from the soil solution by plant roots as orthophosphate ions, principally $H_2PO_4^-$ and to a lesser extent HPO_4^{2-}. Several factors can influence both the rate and amount of P taken up by the plant and, therefore, can affect the recovery of a single application of P fertilizer. The same factors can also affect the recovery of P reserves accumulated in the soil from past additions of P as fertilizer or manure (CROCKER AND HOLFORD, 1994).

The extent to which grassland shows a yield response to phosphorus fertilizer is influenced by soil type, by past fertilizer application and by whether the sward is regularly cut or glazed (WHITEHEAD, 2000). Other factors which influence phosphorus fertilizer application are: soil pH and phosphorus status, the acid soil tolerance of grassland species to be grown, the presence of aluminium in the topsoil.

The concentration of P ions in soil solution is a good indicator of P availability to permanent grasslands (GALLET ET AL. 2003). However, at any given time during the growth cycle, the quantity of P ions in solution represents only about 1% of the P annually taken up by plants. Hence, approximately 99% of P taken up by plants is derived from the soil solid phase (GRANT ET AL., 2005).

Changes of plant-available soil P is explained by difference between P input to the soil and P uptake by plants (BONIFACE AND TROCME´ 1988; MCCOLLUM 1991; MESSIGA ET AL. 2010). These relationships consider soil P ions to exist in discrete pools that contain available and unavailable forms of P ions (MESSIGA ET AL. 2012).

The aim of this paper is to determine soil content in plant available phosphorus and the percentage of available phosphorus from total phosphorus form on a grassland acid soil fertilized with nitrogen and phosphorus.

MATERIAL AND METHOD

Experimental field is located on permanent grassland from Borlova village, in the valley of the Sebeş river, at Nord-West from the Muntele Mic mountain and at approximately of 15 km Caransebeş city. Climatic data registered at meteorological station Caransebeş shows an average of annual temperature of 10.5° C. Average precipitation level is 737.2 mm. The experiment was started in 2011 on a fluvic gleyc soil with physic-chemical parameters presented in table 1.

Were applied fertilizer nitrogen and phosphorus in 4 variants and 4 repetitions arranged in randomized blocks, as follows: N0P0, N1P0, N0P1 and N1P1, where N0P0 unfertilized control, N1 = 150 kg N/ha was applied split (100 kg/ha before the vegetation and 50 kgN/ha after the first stitch) and P1 = 50 kg P_2O_5/ha. P was applied once before the vegetation.

Table 1.

Physic-chemical properties of experimental filed from Borlova

	UM	0 – 5 cm	5 – 10 cm	10 – 20 cm
Coarse sand (2.0 – 0.2 mm)	%	22.0	23.5	20.7
Fine sand (0.2 – 0.02 mm)	%	29.0	25.7	26.9
Silt (0.02 – 0.002 mm)	%	27.9	27.5	28.3
Coloidal clay (> 0.002 mm)	%	21.1	23.3	24.1
Physical clay (> 0.01 mm)	%	38.3	41.1	43.3
pH in water		5.30	5.16	5.08
Humus	%	10.5	5.71	4.06
Available P	ppm	25.7	16.6	5.5
Available K	ppm	158	89	62
Sum of bases (SB)	me/100	11.35	9.07	8.03
Hydrolytical acidity (AH)	me/100	12.73	12.27	11.82
Cationic exchange capacity (CEC)	me/100	24.08	21.34	19.85
Degree of base saturation (V)	%	47.13	42.50	40.45

Soil samples were taken at 0-5 cm depth, dried in air, grounded and sieved trough 2 mm sieve. Total phosphorus content in soils was determined by extraction in aqua regia and available phosphorus content by Egner - Rhiem – Domingo method (AL–P). Reading of total phosphorus and available phosphorus concentration from soil samples was done with Cintra 101 spectrophotometer, at wavelength of 730 nm.

RESULTS AND DISCUSSIONS

Application of N and P fertilizers resulted in different values of total P in the soil (Figure 1). The average of these values in the first year of experimentation (2011), are ranged from 812.5 ppm (± 69.5) and 910.0 ppm (± 295.8). It is noted that the version that applied only fertilizer N (N1P0) total phosphorus is much higher compared to other variants though this difference is not significant (*P=0.2507*).

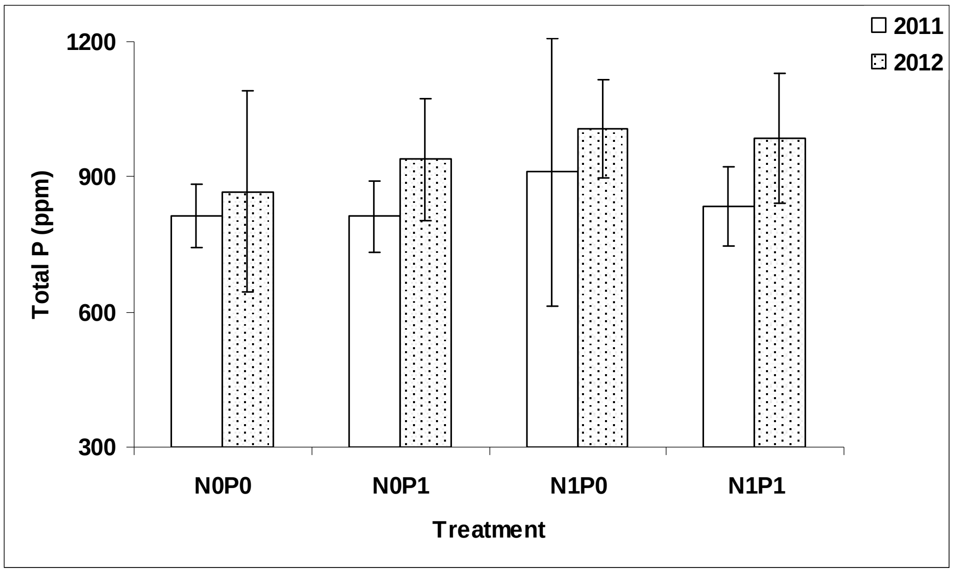

Fig. 1. Total P (ppm) quantity evolution in two years of experiment

In the second year of experimentation (2012) average values of total phosphorus are ranged between 867.0 ppm (± 223.4) and 1006.5 ppm (± 107.5), these values are higher than the values of the previous year. Like the previous year, this year, value of the total P in variant were only N was applied is greater than the total P values determined in the other variants, but in this case the difference is not significant (*P = 0.1352*).

If in the first year of experimentation the effect of phosphorus application is not visible, the values of the variants were P was applied being close to that of control, for year 2012, there is a differentiation between the variants about 100 ppm, but these differences are not significant (*P = 0.7532*).

The fact that in the variants which received only N, total P values are higher can be explained by the fact that the application of nitrogen causes a more pronounced mineralization of organic matter and release of higher P quantities, in various forms. (RUSU ET. AL, 2005)

Regarding available phosphorus (P-AL) it can be observed (Figure 2) that in the first year of experimentation, its values are between 3.2 ppm (± 1.3) and 7.8 ppm (± 5.1), the highest value being obtained in the variant with P fertilization only (N0P1) and the lowest in the variant weret only N was applied. The values obtained by the treatment increases in the following order N1P0<N0P0<N1P1<N0P1. This behavior is achieved and Stroia (2007) on a soil with an identical pH values determined by Olsen method. Although the application of

phosphorus results in a higher amount of P, the differences between variants with P application and variants without P are not significant ($P = 0.0630$).

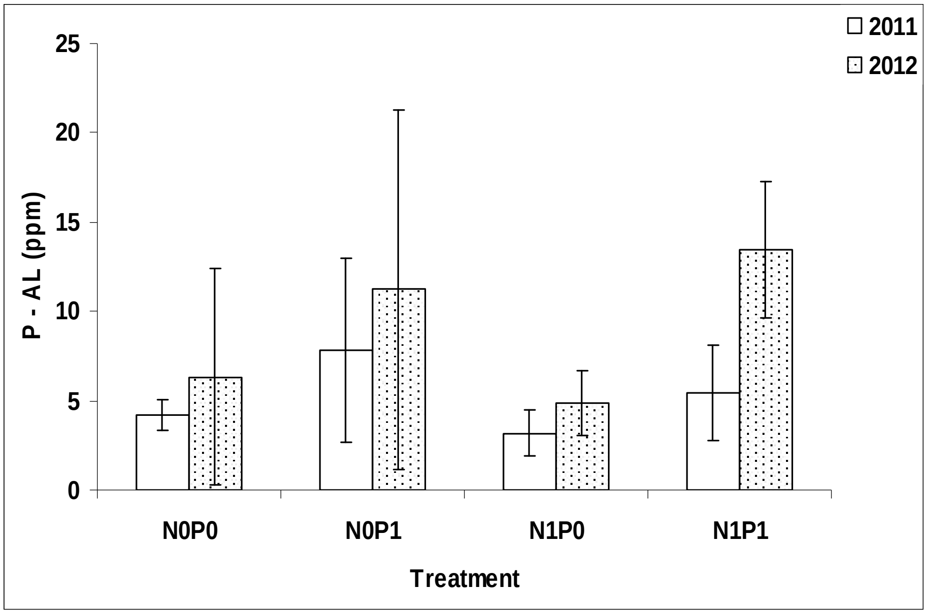

Figure 2. The Evolution of mobile Phosphorus P-AL (ppm) during 2011 and 2012

In the second year of experimentation available P values are ranged between 4.9 (± 1.8) and 13.4 (± 3.8), these values are higher than the previous year due to the residual effect of phosphorus applied. For this year values increase is different over last year, in the following order: N1P0<N0P0< N0P1< N1P1.

These results are in concordance with data obtained by STROIA (2007) on a soil with higher pH This behavior can be explained by the fact that application of nitrogen as ammonium ion causes phosphate ions mobilization, passing them in the soil solution.

On soil with phosphorus deficiency and pH ranged between 5.0 – 7.5, the application of phosphorus fertilizer will usually produce a cost – effective yield response. In contrast to slightly acid to neutral soils, highly acid and calcareous soils may show little response to phosphorus fertilizer, due to its becoming rapidly soluble (WHITEHEAD, 2000).

The percentage of available phosphorus from total phosphorus (Figure 3), in 2011, is ranged between 0.39% (± 0.22) and 0.95% (± 0.63), the highest values were obtained for P1 variants. In 2012, the percentage of available phosphorus is ranged between 0.49% (± 0.20) and 1.37% (± 0.34), the maximum being obtained for all P1 variants.

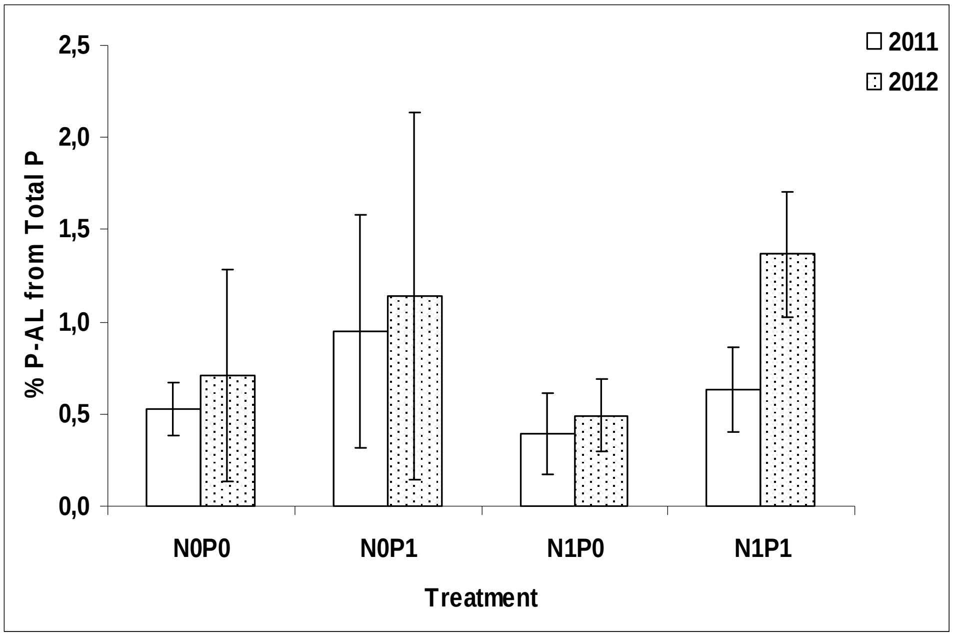

Fig. 3. Percentage of mobile Phosphorus (P – AL) from total Phophorus (P total)

It is noted that after phosphate fertilization in both years of experimentation, the percentage of P intake, is around 1%, values confirmed by the literature (MIHUT AND RADULOV, 2012). For N1P0 variant, percentage of available P is below 0.5% in both years, while in the N0P0 variant, these values are ranged between 0.5 and 0.7%.

CONCLUSIONS

Total P content of the soil is high in both years of experimentation fertilized only with N. Nitrogen application increases microbial activity in the soil, increasing organic matter mineralization rate.

Phosphatic fertilization increases the available P content, quantities that are determined being almost double compared with variants fertilized only with N. Unilateral application of nitrogen as ammonium nitrate lowers the pH and determines P retention as insoluble phosphates.

Although the percentage of available P from total P in variants fertilized with P, is about 1% according to the literature, these quantities do not satisfy this plant demands in this important nutrient..Grassland response to phosphorus fertilizer is also influenced by supplies of other nutrients, particularly nitrogen.

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