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Available Phosphorus and Exchangeable Potassium in some Albanian Soils Extracted by Different Extraction Methods

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Abstract

Available Phosphorus and Exchangeable potassium are important indicators to evaluate the potential of the soil to supply the plants with phosphorus and potassium. Currently, in our labs the basic extraction method to determine the available phosphorus is Mehlich III method exchangeable whereas potassium is determine by extraction with ammonium acetate. Furthermore, studies have been carried out for evaluation of the available phosphorus and exchangeable potassium in Albanian soils with CAL and EUF extraction methods as well as the correlations between them. The objective of this paper is to determine the quantity of available phosphorus extracted by Mehlich III method and to compare the results with available phosphorus extracted with CAL method as well as exchangeable potassium extracted with ammonium acetate and to compare the results with potassium extracted with CAL method.

Keywords: Soil, phosphorus, potassium, Mehlich III method, CAL method.

1. Introduction

One of the main factors of the soil fertility is the amount of P and K available for plant nutrition. Different techniques are proposed in the literature to determine the available P and K in soils by extraction with diluted salt solutions. The soil testing results are used for P and K fertilizer recommendations [1] [3].

Based on the amounts of available nutrients, Sims and Johnson [11] used soil testing to classify the soils in three categories with very low, low, and medium nutrient contents.

The processes of P and K release into soil solution is time dependent and have been described with two parameters. The first parameter is the total amount of P and/or K released in a certain period of time. The second is the intensity of P and K releases. The meaning of the term "intensity" is related to the rate (the amount released per unit of time) of P (and/or K) release in a period of time smaller than the total observation time, during which the total amount released is evaluated. The intensity of the P and K release is not seriously considered in fertilizer recommendation programs [5] [2].

However, the bioavailability of soil P and K, i.e. P and K uptakes, was well correlated to the amount of P and K released with diluted salt solution when the intensity / quantity concepts of nutrient availability were considered in the calculation of the P- and K-uptakes [9] [8] [13].

In some cases, the amounts of available P and K determined by soil extraction methods are not well correlated to the P- and K-uptakes. This may rely on the fact that plant roots mobilize and release more P and K as compare to the diluted salt solutions used in the CAL-, DL-, and Mehlich 3 methods.

Although a lot of studies are conducted in Albania, little is known and published in the European literature about the soil fertility, mineralogy, and the level of nutrients in Albanian soils. In a study carried out by Sinaj et al. [12] P availability in some Albanian soils is reported. Also some studies carried out in some Albanian soils for release kinetics of K are reported [4]. In order to characterize better the P and K dynamics and provide updated experimental data related to these very important nutrients in Albanian agriculture, the objective of this paper is to determine the quantity of available phosphorus extracted by Mehlich III method and to compare the results with available phosphorus

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extracted with CAL method as well as exchangeable potassium extracted with ammonium acetate and to compare the results with potassium extracted with CAL method.

2. Material and Methods

This study is carry out as a pot experiment in greenhouse.

Initial content of phosphorus and potassium in the soil and some physical and chemical properties are given in Table 1.

Table 1. Physical and chemical properties of the soils studied

Samples	Chemical Properties						Soil particles (%)			Textural Classes
	pH	OM (%)	N (%)	$CaCO_3$ (%)	mgPkg^{-1} soil	mgKkg^{-1} soil	2 – 0,05 mm	0,05 – 0,002 mm	<0,002 mm	
S-1	8	2,49	0,27	9,46	114,0	138,0	13,04	60,68	26,28	Silt Loam
S-3	8,2	1,85	0,19	8,47	9,6	122,0	11,4	61,88	26,72	Silt Loam
S-4	8,1	2,81	0,27	3,89	196,6	192,6	5,68	65,88	28,44	Silty Clay Loam
S-7	8,1	1,85	0,1	2,66	49,7	165,6	22,2	54,5	23,3	Silt Loam

2.1 Pot Experiment

The experiment was set up in UBT- greenhouses.

The experiment was set up in five treatments and four replication according to the following scheme:

V_1	Without Fertilizer
V_2	NK in rates (100 mg N kg $^{-1}$ soil, 100 mg K kg $^{-1}$ soil)
V_3	NKP_1 in rates (100 mg N kg $^{-1}$ soil, 100 mg K kg $^{-1}$ soil , 50 mg P kg $^{-}$ soil)
V_4	NKP_2 in rates (100 mg N kg $^{-1}$ soil, 100 mg K kg $^{-1}$ soil, 100 mg P kg $^{-1}$ soil)
V_5	NKP_3 in rates (100 mg N kg $^{-1}$ soil, 100 mg K kg $^{-1}$ soil, 150 mg P kg $^{-1}$ soil)

- Nitrogen was used as Ammonium Nitrate (NH_4NO_3);
- Phosphorus was used as granular superphosphate;
- Potassium was used as KCl + K_2SO_4.

As a test plant was selected Ryegrass (*Lolium multiflorum*) using at 0.5 g seeds per pot and taking 4 mowing.

2.2. Initial soil analysis

For the evaluation of soil selected for the experiment was conducted the following analysis

- Mechanical analysis (%) (Method of Pipetes).
- Soil pH_{H2O} was determined with pH meter.
- Humus (%) (Method of potassium Bikromatit)
- Total Nitrogen (%) (Micro Kjeldahl method)
- $CaCO_3$ (Volumetric method)
- Available phosphorus (mg P kg^{-1} soil) (Olsen method)
- Exchangeable Potassium (mg K kg^{-1} soil) (Ammonium Acetate method)

For the evaluation of the results of the experiment were carried out for each variant and replication the following analysis:

- The ryegrass dry weight (grams per pot)
- Available phosphorus extraction by:
  - Method of Calcium Acetate Lactate (CAL) [10].
  - Method of Mehlich III [7].
- Exchangeable Potassium extraction by:
  - Method of Calcium Acetate Lactate (CAL) [10].
  - Method of Ammonium Acetate.

3. Results and Discussions

3.1. Impact of soils and soil treatments in the ryegrass production

Ryegrass production is presented in Table 2. The results are given in grams per pot as dry matter and are sum of four mowing.

Ryegrass response to soil fertility and fertilization is very clear. In the soils S-1, S-4 and S-7 nitrogen is limited but also potassium is necessary for e good crop production, so fertilization with nitrogen and potassium is very important. In the soils S-1 and S-7 a small amount of phosphorus fertilizers need to use. While in the soils S-3, all the three elements are limited, so the fertilization is very important for the good yield.

Table 2. Yield of ryegrass

Treatments	Dry Matter (g per pot)			
	S-1	S-3	S-4	S-7
Without Fertilizer	11,74	9.00	15,57	7,13
NK	28,28	12,88	34,90	27,82
NKP_1	30,25	32,40	34,04	29,24
NKP_2	30,16	32,38	32,96	30,89
NKP_3	30,4	34,47	35,71	31,51
$DMV_{0,05}$	3,68	2,29	1,94	1,51
$DMV_{0,01}$	5,09	3,17	2,68	2,08
$DMV_{0,001}$	7,03	4,38	3,70	2,88

3. 2. Available phosphorus in soils extracted by different methods.

In this study, phosphorus was extracted using Calcium Acetate Lactat (CAL) and Mehlich III extraction solution and distilled water.

Results are presented in Tables 3 and 4.

From the data presented in paper it is clear that between the different soils in the extractable phosphorus are important. It is obvious that soil with code S-3 has an available phosphorus content about 6-12 times smaller than in other soils. This is true for both extraction methods that we have analyzed.

It also seems clear influence of fertilization on the amount of available phosphorus in the soil. It seems in all soils that we have analyzed. In the soil S-3, content of the available phosphorus in the plots with fertilizers is higher than in the plots without ferticizers but the differences are smaller than in other soils (S-1, S-4, S-7) while the relative increase (%) of the available phosphorus is several times greater. In the other tested soils the rate of change is similary. It is true especially for phosphorus extracted with Mehlich III method.

Table 3. CAL –P extracted in different soils and soil treatments

Treatments	CAL –P (mg P/kg soil)			
	S-1	S-3	S-4	S-7
Without Fertilizer	84.1	8.1	155.69	63.5
NK	79.3	7.9	155.92	65.7
NKP_1	89.2	10.3	154.01	91.8
NKP_2	103.0	19.8	177.44	90.3
NKP_3	111.8	25.7	191.46	117.7
Average	93.49	14.36	166.90	85.80

Table 4. Mehlich III extracted in different soils and soil treatments

Treatments	Mehlich III - P (mg P/kg soil)			
	S-1	S-3	S-4	S-7
Without Fertilizer	31.48	0.74	28.04	14.22
NK	26.52	0.53	25.79	10.32
NKP_1	32.24	1.03	27.01	16.16
NKP_2	42.90	2.98	35.89	22.26
NKP_3	47.36	8.64	44.06	30.06
Average	36.10	2.78	32.16	18.60

3.3. Exchangeable Potassium in soils extracted by different methods

In this study, potassium was extracted using Calcium Acetate Lactat (CAL) and Ammonium Acetate extraction solution.

Results are presented in Tables 5 and Fig. 2.

From the data presented in paper it is clear that between the different soils in the exchangeable potassium are very closed. It is obvious that soil with code S-3 has an exchangeable potassium content about 10 - 40 % smaller than in other soils. This is true for both extraction methods that we have analyzed.

It also seems an influence of fertilization on the amount of exchangeable potassium in the soil. It seems in soils S-1 and S-3. In those soils, content of the exchangeable potassium in the plots with fertilizers is lower than in the plots without fertilisers. In these soils needs for potassium fertilization are higher than amounts that we have used in treatments.

3.4. Correlations between different extraction methods

Correlations between different extraction methods of available phosphorus and exchangeable potassium are given in Figures 2 and 3.

Table 5. CAL –K extracted in different soils and soil treatments

Treatments	CAL –K (mg K/kg soil)			
	S-1	**S-3**	**S-4**	**S-7**
Without Fertilizer	53.73	47.62	61.12	54.00
NK	44.69	40.40	59.25	46.70
NKP_1	46.66	41.28	56.43	51.12
NKP_2	44.23	42.24	65.90	50.93
NKP_3	43.12	42.05	57.74	52.86
Average	46.49	42.72	60.09	51.12

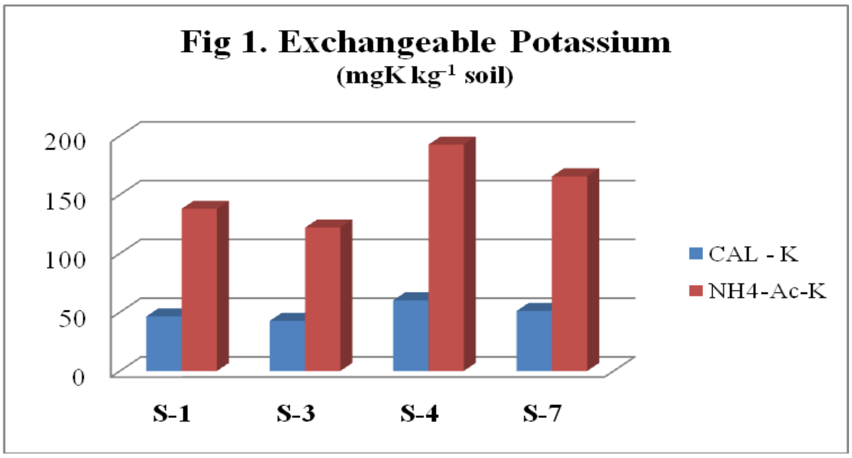

Fig. 1. Exchangeable Potassium

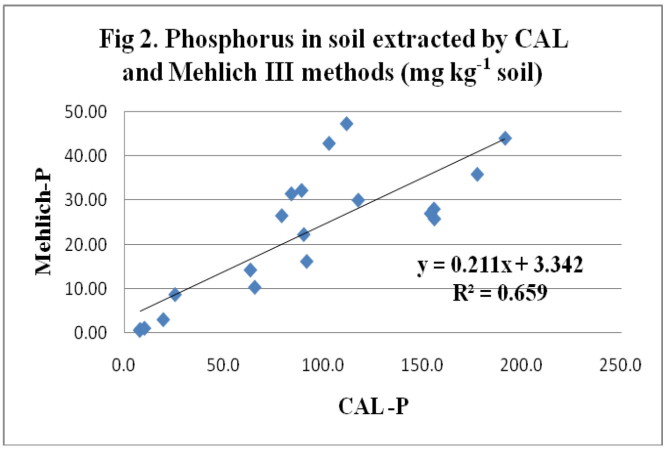

Figure 2. Phosphorus in soil extracted by CAL and Mehlich III methods (mg kg^{-1} soil)

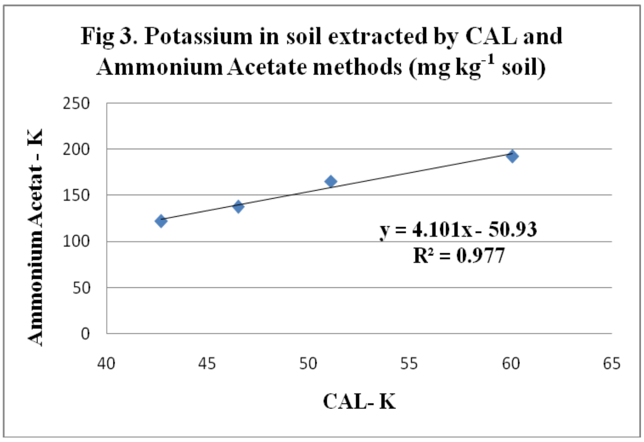

Figure 3. Potassium in soil extracted by CAL and Ammonium Acetate methods (mg kg^{-1} soil)

It seems clear that the extraction methods used has good correlations. But, these have big differences in the amount of the available form that is extracted. So, CAL extracts about 5 times more phosphorus than Mehlich III and about 3 times less potassium than ammonium acetate.
These facts show that the methods used may be suitable for the fertilization recommendation.

4. Conclusions

1. Effect of phosphoric fertilizers with superphosphate is depending on the content of available phosphorus in the soil. This is true for both extraction methods used.
2. Increase available phosphorus content in the soil is related with phosphatic fertilizers doses and content of phosphorus in soil. It is lower in poor soils, because most of added phosphorus is uptake by plants. Also it is related with fixing potential of the soil.
3. The content of available phosphorus in the soil at the range of 80-100 mg kg^{-1} soil extracted with CAL method can be considered as the critical limit of available phosphorus content in relation to the needs of the plant. So under this limit is necessary for phosphoric fertilization**.**
4. The content of available phosphorus in the soil at the range 20-25 mg kg^{-1} soil extracted by Mehlich III method can be considered as the critical limit of available phosphorus content in relation to the needs of the plant. So under this limit is necessary for phosphoric fertilization.
5. The content of exchangeable potassium in the soil at the range of 40-50 mg kg^{-1} soil extracted with CAL method can be considered as the critical limit of exchangeable potassium content in relation to the needs of the plant. So under this limit is necessary for potassium fertilization**.**
6. The content of exchangeable potassium in the soil at the range of 120-140 mg kg^{-1} soil extracted with Ammonium Acetate method can be considered as the critical limit of exchangeable potassium content in relation to the needs of the plant. So under this limit is necessary for potassium fertilization**.**
7. Between extraction methods used in these studies has good correlations.

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