

## Status of plant available phosphorus in Nisava area of the South and Eastern Serbia

Miodrag JELIC<sup>1</sup> – Violeta MAKLENOVIC<sup>2</sup> – Vlado KOVACEVIC<sup>3</sup> – Desimir KNEZEVIC<sup>1</sup> – Aleksandar PAUNOVIC<sup>4</sup>

1: University of Pristina-Kosovska Mitrovica, Faculty of Agriculture, Kopaonicka bb, 38219 Lesak, Serbia, E-mail: miodragjelic@yahoo.com

2: Extension Service Agrorazvoj Niš, 18000 Niš, Leskovačka 4, Serbia

3: University J. J. Strossmayer in Osijek, Faculty of Agriculture, Kralja P. Svacica 1d, 31000 Osijek, Croatia

4: University of Kragujevac, Faculty of Agronomy, Cacak, Serbia

**Abstract:** In the period 2010-2014, total 12447 soil samples (0-30 cm depth) covering 9027 ha of cultivable lands of Nisava area (town Nis and six municipalities: Svrljig, Gadzin Han, Razanj, Doljevac, Aleksinac and Merosina in South and Eastern Serbia region) were collected with the aim to test their agrochemical properties. In this study, status of plant available phosphorus (P) evaluated by the AL-method was shown. About 23% of the samples were very low supplied ( $<5.0\text{mg P}_2\text{O}_5\ 100\text{g}^{-1}$ ) by P. By the addition of low supplied group (the range is  $5.1\text{-}12\ \text{P}_2\text{O}_5$ ), the rate rose up to 61.3% of samples. These categories of soils were recommended to fertilize more than consumed P (K) by crops. Only 12.4% of soil samples were high and very high supplied with available P ( $>20\text{mg P}_2\text{O}_5\ 100\text{g}^{-1}$ ). Recommend fertilization of these categories of soils by P could be maximal up to range of their removals by crops.

**Keywords:** soil, phosphorus, AL-method, ranges of availability, Nisava district.

### Introduction

Yields of field crops in Serbia are considerably lower compared to the yield possibilities of the high-yielding cultivars and degree of climate and soil potential. Average grain yields of two main field crops; maize and wheat, in a 3-year period (2010-2014) were  $5.33\ \text{t ha}^{-1}$  (maize) and  $3.80\ \text{t ha}^{-1}$  (wheat). In this period, in Serbia 1 2137 374 ha year<sup>-1</sup> (36.8% of used arable land) and 513 098 ha (15.6%) were covered by these two crops, maize and wheat, respectively (SY, 2014). Low yields of main field crops in Serbia could be in close connection with low consumption of mineral fertilizers, less than  $80\text{kg ha}^{-1}$  calculated on active ingredients ( $\text{N} + \text{P}_2\text{O}_5 + \text{K}_2\text{O}$ ) basis.

Weather characteristics are considerably affecting the yield of maize (Kovacevic et al., 2014) and wheat (Marijanovic et al., 2010). With that point of view, drought and high temperatures, especially in spring months, are oft in connection with the lower yields of maize and other spring crops, except the sunflower (Kovacevic and Kaucic, 2014). In addition, yields of field crops in the Southern and Eastern Serbia region (SES) is considerably lower in compare with those in Vojvodina region (VR). For example, yields in SES for 2010-2014 period were for 34% (maize) and 23% lower (wheat) in compare with yields of these crops in VR ( $4.00$  and  $6.03\ \text{t ha}^{-1}$ ,  $3.23$  and  $4.17\ \text{t ha}^{-1}$ , for maize and wheat, respectively – SY, 2014). These differences were caused mainly by the lower soil fertility in SES due to unfavorable physical and chemical characteristics. It were found in Croatia and Bosnia and Herzegovina, that low plant available phosphorus (P) and potassium (K) levels are main limiting factor of field crop yields and these phenomena are mainly in combination with additional less favorable soil characteristics, for example, acid reaction and domination of either sandy or clay texture (Kovacevic et al., 2006; Komljenovic et al., 2010).

Aim of this study was testing P nutritional status in soils of the Nisava district of SES and making recommendations on improving fertilization practice in accordance with corresponding soil properties.

## Materials and methods

This study was carried out during five years period (2010, 2011, 2012, 2013 and 2014) on different soil types. Total 12447 soil samples were analyzed from 2010 to 2014. By these samples, the covered area was 9027 ha in seven municipalities of the area (mean 0.725ha sample<sup>-1</sup>). Majority of samples (8431 or 67.7%) were taken in the area belonging to municipalities Svrlijig (24.8%), town Nis (23.0%), and Aleksinac (19.9%). Rest of soil samples (4016 or 32.3%) were taken in municipalities Doljevac (15.6%), Gadzin Han (8.1%), Merosina (5.3%) and Razanj (3.3%). The soil samples were taken by auger up to 30 cm of depth. Soil analyses were made in the agrochemical laboratory of Extension Service Agrozavoj (eng. Agrodevelopment) Nis. Evaluation of plant available P was made by AL-method (Egner et al., 1960).

### *General soil and climate characteristics of the Nisava area*

Majority of agricultural lands in Central Serbia are unfavorable in physical and chemical properties. Those are mostly lowland or hillside types of pseudogley or its leached variants, acid vertisols, podzolic eutric cambisols, diluvial, brown, or leached brown soils of mountainous regions. Those soils are rather poor in bases, medium to heavily acidic, have very poor texture and poor organic content and more or less ill; suited for cultivation of most cereal and maize crops (Đalović et al., 2010). The acidity of these soils, their high contents of H<sup>+</sup> ions and low contents of essential plant nutrients, primarily P and Ca, are limiting factors for high and stable yields of cultivated cereals and maize crops (Kovačević et al., 2006).

Recent investigation world widely have shown that massive deterioration of small grains on acid soils caused by elevated concentrations of mobile forms of some toxic elements (Al, Fe, Mn), whose contents become especially evident when no phosphorus nutrition is performed or the Ca components in missing from nitrogen fertilizers (Jelić, 1996).

Table 1. Precipitation and mean air-temperatures (mean 1961-1990) in Nis (the data of the State Hydrometeorological Institute in Belgrade)

Precipitation and air-temperatures: long-term means 1961-1990 in Nis (Serbia)													
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Precipitation (mm)													
	41.3	40.3	45.3	51.3	66.7	69.7	43.6	43.3	43.6	34.1	56.8	53.6	590
Mean (x) air-temperature (°C): m = minimal values; M = maximal values													
m	-3.5	-1.3	1.8	6.1	10.4	13.4	14.5	14.4	11.1	6.5	2.4	-1.4	6.2
M	3.8	7.1	12.3	18.0	22.9	25.9	28.0	28.5	24.8	18.9	11.7	5.4	17.3
x	0.2	2.9	7.0	12.0	16.6	19.6	21.2	21.4	18.0	12.7	7.0	2.0	11.7

The climate of Nisava area is moderate continental, with an average temperature of 11.7°C. July and August are the warmest months of the year, with the average of 21.3°C. The coldest month is January, averaging at 0.2°C. The average of the annual precipitation is 590mm (Table 1).

## Results and discussion

In general, soils of Nisava area were less favorable properties regarding their plant available phosphorus in compare with their plant available potassium status. For example, even about 23% of the samples and the same level of covered areas sampled were very low supplied (less than  $5.0 \text{ mg P}_2\text{O}_5 \text{ } 100\text{g}^{-1}$ ) by phosphorus (Tables 2). By the addition of low supplied group, the situations with P status changed to 61.3% (very low + low P supplies). These categories of soils are needed to be fertilized more than the removed P by crops with the aim to improve their nutritional P status.

Table 2. Plant available phosphorus (AL-method) ranges in level of municipalities of the Nisava area of SES region (sampling in the 2010-2014 period)

P ranges (AL-method) $\text{mg P}_2\text{O}_5 \text{ } 100 \text{ g}^{-1}$	The municipality of Nisava district: town Nis (a), Svrlijig (b), Gadzin Han (c), Razanj (d), Doljevac (e), Aleksinac (f) and Merosina (g)							Sum
	a	b	c	d	e	f	g	
	Percentage (%) of soil samples (N)							N
< 5.0	18.5	24.3	22.9	28.6	29.2	20.0	23.3	2847
5.1-12.0	32.1	43.8	48.0	34.0	38.5	36.2	37.3	4780
12.1-20.0	33.5	22.8	19.8	23.9	22.9	27.6	22.0	3232
20.1-30.0	6.8	5.2	5.8	7.4	4.4	5.7	8.0	726
> 30	9.1	3.9	3.5	6.1	5.0	10.5	9.4	862
Total (%)	100	100	100	100	100	100	100	
Total (N)	2866	3089	1009	406	1939	2476	662	12447
	Percentage (%) of covering area (ha) by soil sampling							ha
< 5.0	18.4	22.0	22.3	36.4	30.8	20.0	22.2	2065
5.1-12.0	32.0	44.6	48.7	31.1	36.2	35.0	40.0	3459
12.1-20.0	33.7	23.0	19.6	20.7	23.4	32.6	23.5	2430
20.1-30.0	7.2	5.9	5.4	5.9	4.7	6.6	7.8	554
> 30	8.7	4.5	4.0	5.9	4.9	5.8	6.5	520
Total (%)	100	100	100	100	100	100	100	
Total (ha)	1767	2678	555	387	1417	1917	306	9027

Only 12.4% of soil samples (11.9% of area covered by sampling) were high and very high supplied with available phosphorus ( $>20\text{mg P}_2\text{O}_5 \text{ } 100\text{g}^{-1}$ ). Recommend fertilization by P of these categories of soils could be maximal up to range of their removals by crops.

Soil P status in individual municipalities of Nisava area are less or more specific in comparison with the regional level (Tables 2). With that regard, soils of Nis municipality were mainly more favorable P status, as 51% of samples were in the groups of very low and low P supplies. However, soil P status in Gadzin Han municipality was considerably less favorable because 71% of samples of this municipality was very low and low in plant available P. In addition, distribution of high and very high P ranges ( $>20\text{mg P}_2\text{O}_5 \text{ } 100\text{g}^{-1}$ ) were considerably different in soils of these two municipalities. For example, 15.9% of Nis municipality samples and 9.3% of G. Han samples were very low and low supplied with P. Milivojevic et al. (2012) tested plant available P in arable land of Sumadija province of Serbia. Majority of soil samples were very acid and acid reaction with low levels of plant available phosphorus (57% very low and 19% low P status). Petosic et al. (2003) tested P availability (AL-methods) in 480 soil profiles representing an area of 31227 ha of hydromorphic soils of Sava valley area in Croatia. P availability in the surface layer (0-30 cm) in about 30% of the tested agricultural land (9440 ha) was very low P (until  $5 \text{ mg P}_2\text{O}_5 \text{ } 100\text{g}^{-1}$  of soil), other 32% (9897 ha) was in the range low P availability (from 5.1 to 10 mg), while only 17% (5445 ha) has good or very good P availability (above 20 mg). Especially a high frequency of low P availability was found in vertic gley, amphygley and hypogley soils (total 8680 ha or 28% tested agricultural

land). By combination of lime, farmyard manure and NPK fertilizers applications during the long-term period, considerable increases of plant available P in acid soils (vertisol and pseudogley) in Central Serbia, were found (Jelic et al., 2006, 2011, 2013).

## Conclusions

Inadequate supplies of plant available phosphorus are considerable factor of yield limitation in Nisava area because about 60% tested samples were in levels of very low and low group of phosphorus availability. We presume that considerable increases of field crops yield is possible by adequate phosphorus fertilization. Banding fertilization of part of planned quantity of P fertilizers, for example together with sowing or interrow cultivation is our recommendation for improving P availability, especially on soil unprovided with phosphorus.

## Acknowledgement

The present study is the part of the TP 31054 project named “Development of New Technologies of Small Grains Production on Acid Soils Using Modern Biotechnology” funded by the Ministry of Education and Science, Republic of Serbia.

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