CONTENT OF PHOSPHORUS IN ARABLE LAND ON THE TERITORY OF THE CITY OF NIS

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Abstract: Phosphorus has the status of an essential element for plant growth and development because it is contained in numerous compounds which are of the crucial significance for the physiological –biochemical processes. The aim of this paper was to examine the saturation of the soil with easily available phosphorus forms on the territory of the city of Nis in 2015. The total of 284 samples from 110 farms were collected. The analysis showed that that the soil of this area is well provided with easily available phosphorus. 40.8% samples belong to the class of supplied or even well-supplied soil, with the phosphorus content from 7% to 15% whereas only 5% of the samples belong to the class of the soil low in phosphorus.

Key words: phosphorus, availability, soil, Nis

Introduction

Phosphorus is a nonmetal, which is usually in a five-valent form in nature, and, due to its reactivity, it is not available in a free form, but as a part of numerous organic and non-organic compounds. It originates from about 170 minerals (apatite, phosphorite, vivianite, amblygonite, monazite, wavellite, triplite), with the biggest share of around 90% belonging to apatite and phosphorite (Gudžić, 2015).

The biggest part of soils exploited for the agriculture for a longer period of time contain between 60 and 80% of the nonorganic form of phosphorus, whereas 20 to 40% contain the organic-tied phosphorus (Jelić, 2012). The total amount of phosphorus in the soil is variable and ranges from 0,03-0,3%, and in our soil from 0,02 – 0,2 (Gudžić, 2015). Knowing that the biggest amount of phosphorus comes from rocks and minerals, as well as from organic compounds, thus making the phosphorus supplies exhaustible, the phosphorus circulation in the soil is a very important microbiological process.

The soil categorization based on the content of phosphorus easily available to plants is of high significance for the usage of phosphorus fertilizers. The researches carried out so far show that the phosphorus levels which are needed for the plant growth and development are lower for fruit trees and vine than for arable crops. This is due to the fact that the phosphorus in fruit and vine is much lower than in arable crops and vegetables. The scientific research shows that the optimum level of the easily available phosphorus for vine and fruit production is about 15mg P_2O_5 per 100mg of soil. For example, the recommended quantity for plum, which is the most common kind of fruit in Serbia (Grčak et al., 2017) is about 30 to 40 kg ha^{-1} P_2O_5.

Phosphorus has an irreplaceable role for a plant. It is involved in the process of photosynthesis, breathing, connecting of the endothermic and exothermic reactions,

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synthesis of the primary and secondary compounds, and also, it is a part of nucleotides, nuclear acids, phospholipids and numerous co-enzymes. Beside the above mentioned functions of phosphorus, it also has a part in the energy transfer (Kastori and Maksimović, 2008).

It is necessary for a good rooting forming of the flower buds. Those are the periods when the needs of plants are the greatest, that is, first, at the beginning of the vegetation during the intensive growth of the root, and the second time at the beginning of the development of the generative organs. Since phosphorus is almost immobile in the soil, it is necessary to input phosphorus around the root zone before these periods. In nature, acid (pH<5), limestone and alkaline usually lack phosphorus. In acid terrains, after the input, phosphorus is blocked by aluminum and iron and in alkaline soils by calcium which builds calcium phosphates.

The aim of this paper is to examine the content of phosphorus available to plants on the territory of the city of Nis and its municipalities.

Materials and methods

The concentration of the available forms of phosphorus in the soil is expressed in mg P_2O_5 of $100g^{-1}$ of the soil. There is a number of chemical methods to define the phosphorus available to plants which are based on the extraction of phosphorus from soil samples by the means of extraction. The most commonly used means of extraction are diluted mineral and organic acids and puffer salt solutions.

The results of these methods are compared with the results of the vegetation experiments in containers and field mirrors. On the basis of these results, the limit values of the content of the available phosphorus are defined. According to Egner, the extraction is carried out by the means of the acid puffer solution (whose pH value is 3,3) 0,02N Ca-lactate in 0,01N HCl. The phosphorus is defined in a colorimetric form from the extract, and in our case, it was done by the means of spectrophotometer. The methods which were used in the soil examination were acquired by the Yugoslav Society for the Soil Analysis (JDPZ, 1966).

The chemical analysis were done in 2015 in the Agriculture Counceling Expert Service in Nis, where the level of the available phosphorus was defined by AL-method according to Egner and Riehm. The soil samples were taken from the depth of 0-30cm with arable and vegetable cultures, and from 0-60cm in orchards and vineyards. Each sample consisted of 20 to 25 individual samples (with the land up to 5ha) from the depth of 0-30cm, on the land with existing orchards and vineyards or planned for these cultures.

The collected and analyzed samples were from 284 pieces of land from 110 farms.

The data processing was carried out by the statistics-mathematics method in the IBM SPSS Statistics-Version 20 computer program.

Results and discussion

The analysis comprised all the municipalities of the City of Nis: Crveni Krst, Medijana, Niska Banja, Palilula I Pantalej. The content of the available phosphorus,

P205 in 100g air-dry soil was analyzed as a part of fertility control. The data from 284 pieces of land from 110 farms were processed.

Depending on the depth from which the sample was taken (Table 1) we can see the difference among different pieces which are already planted or are planned to be planned by arable and vegetable cultures (78,9%) in comparison to the ones which are already planted or are to be planted by orchard and vineyard cultures (21,1%).

Tabel 1. The number of samples and areas with the depths from which the samples were taken

Depths from which the samples were taken	Number of samples	Percent (%)	Area (ha)
0-30 cm	224	78,9	93,54
0-60 cm	60	21,1	21,74
Total	284	100,0	115,28

On the basis of the processing of the data from 284 pieces of land on the farms in the Nis municipality, it was concluded that 34,5% of the analyzed samples were the parts badly supplied by the available phosphorus (under 10%). The part with moderate supply, with the easyly available P_2O_5 $100g^{-1}$ from 10 to 20% had the share of 37% of the analyzed agriculture areas. The class of the soil well-supplied by the easily available phosphorus where the P205 100g-1 was 20% had the share of 27,8% (Table2).

Table 2. The sample share of particular classes based on the content of the available P_2O_5 (the categorization by Jelic, 2012) according to the analysis of 284 pieces of land

Classes	Content mg P_2O_5 $100g^{-1}$ in soil	Number of pitches	Percent of pitches (%)	Cumulative percent
Badly supplied - poor	< 10	98	34,5	34,5
Moderate supplied	10 - 20	107	37,7	72,2
Well supplied - rich	> 20	79	27,8	100,0
Total	-	284	100,0	-

The existing classification of the content of the available phosphorus can be, up to a certain extent, inaccurate due to the wide intervals of particular groups of the phosphorus availability. In order to understand the dynamics of the P_2O_5 in 100g of the air-dry soil, it is necessary to redefine the supply levels. According to the detailed classification (Graph 1) on the basis of the total phosphorus (Wahtman) the land which is partially suitable for cultivating plants normally(under 2% P_2O_5 $100g^{-1}$ soil) has the share of only 1,1%. In the class of the land which is very low or low in phosphorus the dominant samples are the ones with the content of 4-7% P_2O_5 $100g^{-1}$ with the share of 13,4%, whereas the class with supplied and well-supplied land, where the phosphorus content was 7 to 15% has the share of 40,8%

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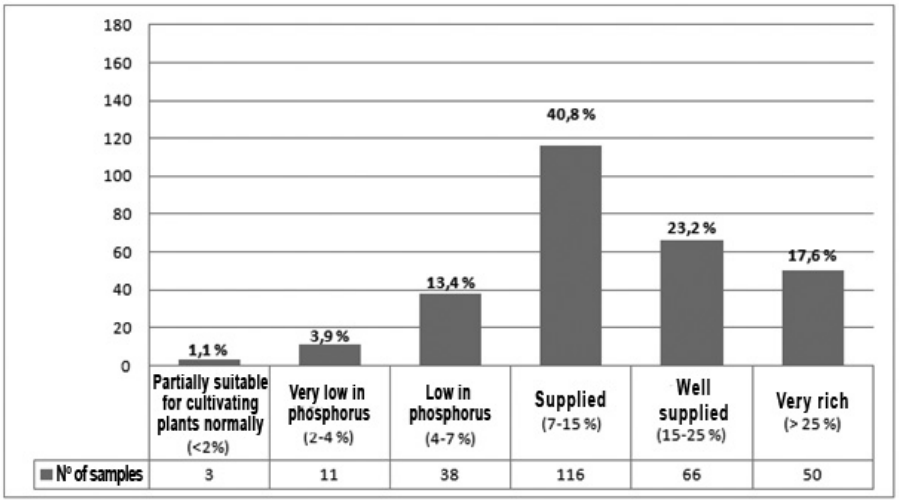

Graph 1. The sample share of particular classes according to the supply of the available P_2O_5 100g of the air-dry soil (%) in the Nis municipality (284 samples)

The way to deal with the low level of phosphorus is the usage of phosphatisation as the measure of melioration intake of phosphate fertilizers and calcification aiming at the increase of the availability of phosphorus from the soil sources, as well as calcination if the pH value of the soil affects the acquisition of phosphorus (Jelić et al., 2015). However, it is possible to, wishing to increase the production and due to an excessive usage of fertilizers by non-experts, cause different changes in the biological balance of the agri-ecosystem thus affecting the quality of the crops (Wu et al. 1998, Kraus et al. 2000).

Delgado and Torrent (1996) in their research indicate that the soil in the European Union in the last decades has been fertilized intensely by phosphorus fertilizers even when it was not needed. The outcome is the following: the quantity of phosphorus exceeds the plants' needs. So far, such a big ecological problem has been dealt with by reducing, even not using phosphorus fertilizers at all. These authors emphasize that it is necessary to achieve the economic balance between the optimal level of phosphorus in the soil for agriculture production and ecological safety.

Phosphorus is the basic nutrient of the primary productivity of the ecosystem and agricultural production, but its inadequate usage affects the sustainability of agriculture and can have significant consequences on the environment (George at al., 2016). The approach to the sources of phosphate stones is politically sensitive and economically challenging. Phosphorus is accumulated in agriculture soil which is an economic loss for farmers and the risk is even higher due to rinsing. Beside the necessary mineral elements, the fertility of the soil is also conditioned by the quantity of humus in the soil (Grčak et al. 2017).

The author of the article *Phosphorus Famine: The Threat to Our Food Supply* (Vaccari, 2009) emphasizes that there is a problem with phosphorus and potassium, which are beside azote the most important for the sustainability of agriculture, primarily because of exhausting their supplies from the natural sources. The same author stresses

the fact that it is possible that the available world supplies of phosphorus could start being exhausted by the end of this century, if the trend keeps being steady and the population keeps growing. It is necessary to check the fertility of the agriculture soil before planting particular crops and on the basis of this to fertilize using phosphorus and potassium fertilizers. Measures on this issue are taken all over the world (Delgado and Torrent, 1996), so we need to start implementing them as well. The fertility control is a legal obligation of the owner or land user in our country, too, according to the Law on Agriculture Law (Official Herald the Republic of Serbia 62/06, 65/08, 41/09).

While examining the agriculture soil, the average pH value was 6,48. The limit values recorded were 4,20 as the minimum and 7,17 as the maximum. The indicator of variability calculated by the standard deviation by the calculation method which is ±0,39 shows that there were not significant deviations among the pH values. According to the classification (Thun), such a pH value in the soil suspension with KCl is weakly acid (Belić i sar, 2014). According to some authors (Barrow, 2016)), even lower values than this are considered good for a normal acquisition of phosphorus from the soil. Stevanovic and collaborators (1995) state that significant arable land, more precisely more than 60% in Central, South Serbia and on Kosovo are acid lands. It is known that phosphorus availability in acid lands decreases due to its immobilization by free Al^{3+} and Fe^{3+} ions (Debnath et al. 2000).

Conclusions

On the basis of the results of the analysis of 284 soil samples from 115,28ha, that is 110 farms, on the territory of the City of Nis (Srbija), we can conclude that the saturation of the soil by phosphorus is changeable, which is a consequence of different soil types, fertilization and exploitation of particular areas. It is concluded that: 5% of the samples belonged to the soil class very low in phosphorus, with the content of phosphorus from 4% to 7%. Out of the total number, 40,8% of the analyzed samples were the class of good or very good concerning the saturation with phosphorus, with the content over 15%.

The phosphorus content (also 40,8%) dominates in the soil moderately supplied by phosphorus with the limit values from 7% to 15%, but it needs to be maintained and the phosphorus level should be checked before planting and fertilizing by phosphorus fertilizers.

According to the results of the research, the soil on the territory of the city of Nis is well-supplied by phosphorus. Certainly, it is highly recommendable to analyze the soil in order to be informed about the content of phosphorus which is necessary to all producers.

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