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SOIL SUITABILITY FOR AGRICULTURAL PRODUCTION IN THE AREA OF PETROVČIĆ (SURČIN MUNICIPALITY, BELGRADE)

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ABSTRACT

The aim of the paper was to conduct the research related to the examination of the soil suitability for agricultural production and its improvement (from the aspect of chemical reclamation), based on the soil texture class and main chemical parameters, in the area of Petrovčić (Surčin Municipality, Belgrade). Based on the available satellite images and the pedological map, scale R=1:50.000, soil types (Eutric Cambisol, Solonchak and Solonetz) and observation places where sampling was performed, were determined and located. Composite soil samples were taken during July and August in 2019, at pre-determined locations in a disturbed state from a depth of 0-30 cm and transported to the laboratory. Soil acidity and the content of $CaCO_3$ and total N were analysed according to international standard metods. Available P and K were analysed by AL-method, spectrophotometrically and flamephotometrically, respectively. SOM content was determined using the humus method of Kotzman. Textural soil class was obtained using the International Union of Soil Science (IUSS) texture triangle. Based on the data obtained in this study it was established that the Petrovčić agricultural areas are suitable for intensive agricultural field production, namely the cultivation of maize, wheat and sunflower. Therefore, general recommendations for fertilizers and liming materials application, including the type, dosage and time of application, are given for the mentioned field plants. Regularly data monitoring in changes on the basic chemical parameters of the tested soils would be desirable in order to give appropriate recommendations for improving their fertility.

Keywords: Petrovčić, Surčin, chemical parameters, textural class, field production.

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INTRODUCTION

The Municipality of Surčin is located in the Pannonian Plain, on its southern edge along the Sava River, and represents the westernmost part of the plain area of the Belgrade town. It is primarily characterized by the agricultural and processing sector, and then by trade and service activities. According to data from 2012, the area of agricultural soil in the territory of the Municipality of Surčin was 72.7% (20.928 ha), where the total agricultural area makes up about 9% of the agricultural area of Belgrade. The soils of Surčin are mainly arable and very suitable for intensive crop production. Of the agricultural areas, the most widespread are arable soils and gardens, followed by meadows, pastures, orchards and vineyards. From a pedological point of view, the most common types of soil are brown cambic, hydrogenic, gleyic and halomorphic (saline) soils, which formation is the result of the diverse influence of pedogenetic factors, mainly climate, relief, parent substrate and vegetation (Strategija održivog razvoja Gradske opštine Surčin 2012 – 2021. godine, 2012). These factors, acting individually or together, have contributed to the formation of diverse soils in terms of production value in the studied area. However, Zeremski et al. (2021) stated that the occurrence of halomorphic soils is not completely related to the climatic conditions and is primarily dependent on local geomorphogical and hydrological characteristics.

The quality of soils in Surčin is very different. The most fertile soil areas are in Surčin around the airport, while less fertile are in the settlements of Boljevci, Bečmen, Progar and Petrovčić. By crop type, 54% of arable soil is under cereals, 12% under industrial crops, 9% under vegetables, and 14% under fodder crops. Of the arable crops, wheat is the most common, followed by corn, soybeans, and rapeseed.

The agricultural soil of the studied Petrovčić area in 2012 was about 1666 ha (Strategija održivog razvoja Gradske opštine Surčin 2012 – 2021. godine, 2012). These soils mainly consist of arable soils intended for field production. During the field survey it was observed that certain soils, intended for agricultural production, are marginal (Karimuna et al., 2016), in the sense of their limitations, and are neglected (weedy). Full-scale agricultural production has not been carried out on these soils so far, making them underrepresented in terms of economically profitable agricultural production. Also, inappropriate application of agro-technical measures, such as mineral fertilizers and plant protection products, is cited as one of the main causes of soil degradation in suburban settlements in the Municipality of Surčin. Therefore, the position of Surčin itself, which gravitates to the capital city of Belgrade, requires the need to enable each surface and turn it into a production area pursuant to appropriate use of agro-technical measures, mainly mineral fertilizers.

The aim of the paper was to conduct examination of the basic chemical parameters and textural class of agricultural soils in the Petrovčić area (Surčin Municipality) and propose general recommendations for fertilizers and liming materials application in order to increase their fertility and suitability for agricultural production from the aspect of chemical reclamation.

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MATERIAL AND METHODS OF WORK

The trial was conducted in the area of Cadastral Municipality (CM) Petrovčić, Surčin Municipality, City of Belgrade, Republic of Serbia (grid reference: 44°47' N, 20°08' E).

Study Area.

Based on the pedological map of the Institute of Soil Science, scale R=1:50.000, and available satellite images, soil types and their exact locations of sampling were determined (Figure 1). The studied soils were Eutric Cambisol and halomorphic soils - Solonchak and Solonetz.

The climate of the entire territory of the Surčin municipality is moderately continental (Strategija održivog razvoja Gradske opštine Surčin 2012 – 2021. godine, 2012). Climate data from the meteorological station Surčin (location: 44°49’ N, 20°17’ E), for a series of 16 years of observation (period 2003-2018), were taken from the available meteorological yearbooks of the Republic Hydrometeorological Institute of the Republic of Serbia. To display the beginning and duration of the dry and wet periods for the studied locality, the Walter diagram was used (Figure 2).

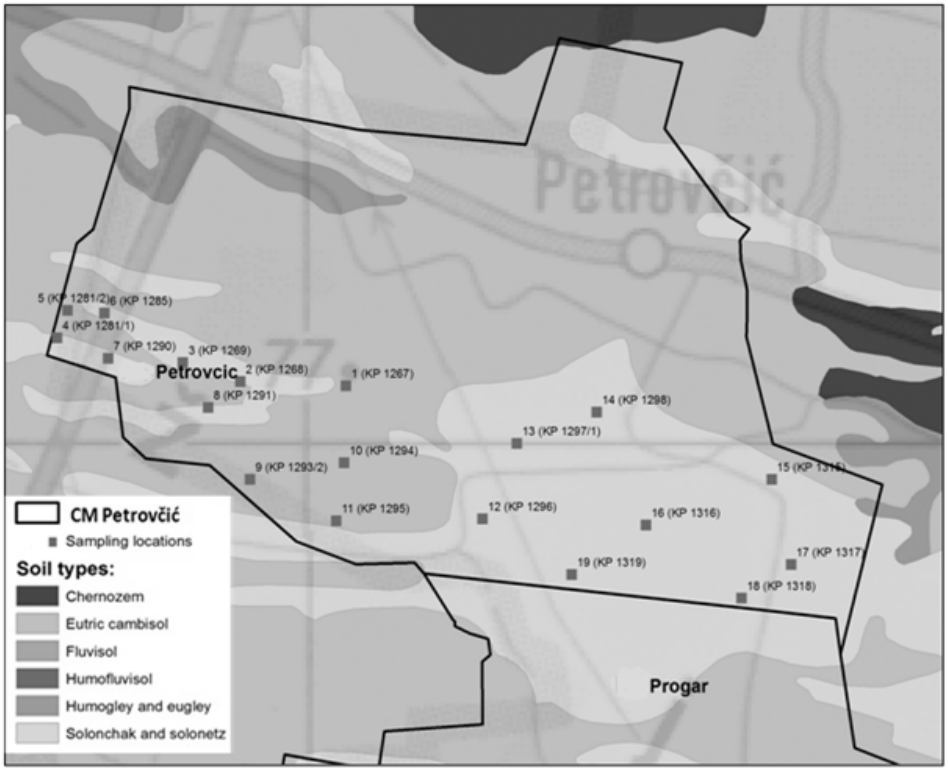

Figure 1. Pedological map and sampling locations of CM Petrovčić study area (source: Institute of Soil Science, 2019)

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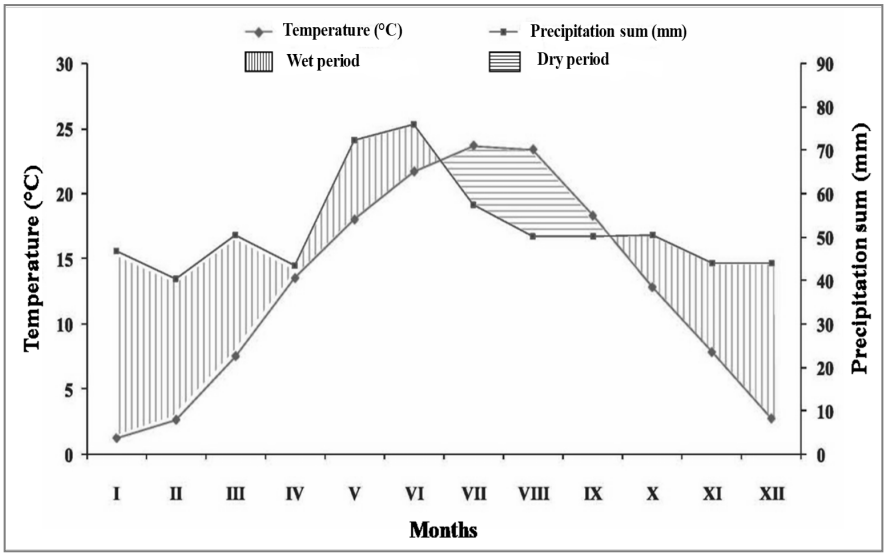

Figure 2. Climate diagram according to Walter - ratio of dry and wet periods for 16 years of observation

The diagram was obtained on the basis of average monthly mean values of air temperature and average monthly precipitation amounts in the ratio 3:1. The data were processed graphically. Accordingly, the dry period occurs from the end of June and lasts until the 4th week of September, while the wet periods occur from the beginning of January and lasts until the end of June, and from the 4th week of September until the end of December. This precipitation regime is most favorable for crop production, as sufficient precipitation occurs during the drought-sensitive June growing season.

Study Design.

Field work included soil sampling with a probe at pre-determined locations from a depth of 0-30 cm in disturbed state, their packaging, transport and storage, using standard sampling methods (ISO 18400-102:2017; ISO 18400-105:2017). Soil samples (124 in total) were taken during July and August 2019 on 18 locations (cadastral parcels, CP) within CM Petrovčić. The recording of all samples and their transport to the laboratory was done in the optimal time interval.

Data Analysis and Statistical Methods.

Pretreatment of samples for physico-chemical analysis included an adequate soil preparation, where the soil samples were air-dried, crushed and passed through a sieve with a diameter of ≤2 mm (SRPS ISO 11464:2004), followed by granulometric composition and main chemical analyses. Textural soil class was determined using the International Union of Soil Science (IUSS) texture triangle (Moeys, 2018), based on granulometric composition (share of clay, sand and silt fractions) of soil. These fractions were analyzed using a standardized sieving and sedimentation method (ISO 11277:2009). Soil acidity (pH in H_2O and 1M KCl, v/v: soil:H_2O=1:5, soil:1M KCl=1:5) was analysed potentiometrically, using glass electrode (SRPS ISO 10390:2007). The content of $CaCO_3$ was determined volumetrically (SRPS ISO 10693:2005), and total N - by dry combustion using elemental CNS analyzer Vario EL III (SRPS ISO 13878:2005). Available P (P_2O_5) and K (K_2O) were analysed by AL-method according to Egnér-Riehm et al. (1960), spectrophotometrically and flamephotometrically, respectively. SOM (Soil Organic Matter) content was determined using the humus method of Kotzman (Dzamić et al., 1996).

The presentations of the results are performed using Microsoft Office Excel 2007 statistical and mathematical program, where the data of mean (AVR), STDEV, distribution and frequency, were calculated. GIS software was used as a platform for geostatistical data analysis in spatial data processing.

RESULTS AND DISCUSSION

The presentation of results and their interpretation were performed according to obtained data on granulometric composition, textural class and basic chemical properties of the tested soil samples in the area of CM Petrovčić. Also, presentation of results included general recommendations for application of mineral fertilizers and lime material from the aspect of chemical reclamation.

The results of granulometric parameters in samples of all analyzed soil types indicated that 97% of the examined samples belongs to the textural class of light clays, 2% belongs to silty clay, while 1% belongs to silty clay loam.

The results of chemical parameters in Eutric Cambisol (Table 1) indicated the following features: very acidic to acidic reaction for pH in 1M KCl (4.47-5.50), very acidic to slightly acidic reaction for pH in H_2O (5.37-6.30), with all samples without $CaCO_3$; very low to low provided with available P (0.84-8.73 mg 100 g^{-1}), low to highly provided with available K (11.17-26.72 mg 100 g^{-1}), and moderately provided with total N (0.13-0.19%) and SOM (2.00-3.03%) (Dzamić et al., 1996). The results of $CaCO_3$ contents are according to the obtained pH values, where very low pH values indicate an adequate use of limestone and chemical fertilizers. Rajičić et al. (2020) stated the importance of combined use of lime and rational doses of mineral fertilizers in reducing soil acidity and improving plant quality. Determined low P values may be a consequence of many things, such as the presence of Ca in alkaline soils, but mostly of reduced P nutrition (Popović, 1989), where higher doses of P fertilizer should be applied.

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Table 1. Main chemical properties of the studied area soil samples - Eutric Cambisol

Cadastral parcel	Main chemical parameters of soil fertility (average±StDEV)						
	pH in 1M KCl	pH in H_2O	P_2O_5 (mg 100 g^{-1})	K_2O (mg 100 g^{-1})	N (%)	SOM (%)	$CaCO_3$ (%)
1294	4.49±0.34	5.37±0.33	8.73±16.05	21.81±11.11	0.19±0.04	3.03±0.63	-
1295	5.11±0.57	5.93±0.54	4.63±4.76	26.72±10.78	0.17±0.03	2.75±0.67	-
1281/2	5.40±0.00	6.10±0.00	1.68±0.00	26.14±0.00	0.13±0.00	2.00±0.00	-
1293/2	5.50±0.00	6.30±0.00	0.84±0.00	11.17±0.00	0.17±0.00	2.87±0.00	-
1267	4.47±0.12	5.39±0.17	3.61±2.33	23.44±3.16	0.16±0.01	2.66±0.18	-
Range	4.47-5.50	5.37-6.30	0.84-8.73	11.17-26.72	0.13-0.19	2.00-3.03	-

The obtained data on chemical parameters in tested Solonchak and Solonetz are displayed in Table 2.

Table 2. Main chemical properties of the studied area soil samples - Solonchak and Solonetz

Cadastral parcel	Main chemical parameters of soil fertility (average±StDEV)						
	pH in 1M KCl	pH in H_2O	P_2O_5 (mg 100 g^{-1})	K_2O (mg 100 g^{-1})	N (%)	SOM (%)	$CaCO_3$ (%)
1296	4.85±0.81	5.70±0.80	3.79±5.05	21.72±6.69	0.17±0.02	2.74±0.49	0.06±0.16
1297/1	4.78±0.72	5.75±0.68	3.03±4.45	17.95±11.09	0.16±0.04	2.58±0.69	-
1298	5.10±0.00	6.00±0.00	38.57±0.00	72.53±0.00	0.22±0.00	3.48±0.00	-
1315	4.89±0.74	5.86±0.78	3.71±4.44	20.31±6.27	0.19±0.02	3.03±0.35	0.04±0.16
1316	4.63±0.44	5.60±0.43	10.44±30.83	22.74±28.29	0.18±0.03	2.72±0.45	-
1317	4.63±0.25	5.61±0.35	3.74±1.27	13.94±3.58	0.19±0.02	2.91±0.34	-
1318	4.62±0.04	5.56±0.11	1.93±0.12	13.38±0.78	0.27±0.19	2.27±0.06	-
1319	4.61±0.50	5.64±0.41	2.04±2.90	13.86±1.99	0.16±0.02	2.57±0.32	-
1269	5.20±0.00	6.00±0.00	2.92±0.00	27.72±0.00	0.15±0.00	2.29±0.00	-
1285	4.70±0.00	5.60±0.00	0.45±0.00	18.56±0.00	0.15±0.00	2.41±0.00	-
1290	5.83±0.29	6.67±0.32	4.44±1.42	15.48±0.31	0.16±0.01	2.55±0.48	-
1291	5.61±0.54	6.40±0.56	1.04±0.78	19.16±3.42	0.14±0.02	2.34±0.24	-
1268	4.65±0.21	5.57±0.14	9.14±6.10	34.99±5.17	0.21±0.07	3.54±1.22	-
Range	4.61-5.83	5.56-6.67	0.45-38.57	13.38-72.53	0.14-0.27	2.27-3.54	-

The data showed the following properties: acid to slightly acid reaction for pH in 1M KCl (4.61-5.83), moderately to slightly acid reaction for pH in H_2O (5.56-6.67); almost all samples are without $CaCO_3$, except in the soil samples taken at cadastral parcels 1296 (0.06%) and 1315 (0.04%), which was very low carbonated; very low to very highly provided with available P (0.45-38.57 mg 100 g^{-1}), moderately to very highly provided with available K (13.38-72.53 mg 100 g^{-1}), moderately to well provided with total N (0.14-0.27%), and moderately provided with SOM (2.27-3.54) (Dzamić et al., 1996). The reason for the large range in the determined mean values of P may be found in the way of soil use, where the lowest mean values of this element were mostly determined in neglected soils, and the highest - in cultivated soils.

Acid soil reaction for both pH in tested Solonchak and Solonetz, determined in this research, are not in compliance with the data obtained in the previous study (Pessoa et al., 2019), where all studied soil samples presented alkaline character, for both pH values measured in water and pH values measured in KCl. There is a possibility that prolonged leaching of salts has occurred, leading to the formation of upper horizons with lower pH values (Driessen et al., 2001), from which soil samples were taken in this research, that is, from a depth of 0-30 cm.

Analysis of registered crop production during 2019, when the research was conducted, and the method of soil use in the area of KO Petrovčić, indicated that a large area of soil is neglected and under weed vegetation (62%). The expansion of cultivated crops to those soil areas is possible with the development of a weed control strategy, including adequate soil cultivation combined with the proper application of herbicides (Simić et al., 2013). In addition, based on terrain reconnaissance and the results obtained in this research from the depth of 30 cm, it was estimated that the CM Petrovčić agricultural areas are suitable for intensive agricultural production, namely the cultivation of wheat, maize and sunflowers. For achieving optimal and high yields of these plants, the application and level of nutrients in the soil are of great importance, so based on the results obtained, the correct selection and application of nutrients for these crops should be approached. Recommendations for the use of fertilizers that will be valid unchanged for all occasions cannot be elaborated, but they are selected and combined with each other according to the needs in the field. Therefore, general recommendations for fertilizers and liming material application, including the type, dosage and application time, pH value, the state of calcium in the soil, as well as other soil fertility parameters (Popović, 1989), are given for the mentioned field plants.

The general recommendation for the lime material introduction, in the amount of 4 t $CaCO_3$ ha^{-1} (in basic tillage), refers to the parcels 1267 and 1294.

The general recommendations for mineral fertilisation of wheat (in the fall during the basic tillage; the fertilizers amounts for plant nutrition depend on the available N in February-March) are as follows: 300 kg ha^{-1} NPK 10:30:20 + 100 kg ha^{-1} MAP (parcels: 1267, 1268, 1269, 1315, 1296, 1295); 500 kg ha^{-1} NPK 16:16:16 + 100 kg ha^{-1} MAP (parcels: 1281/2, 1291); 600 kg ha^{-1} NPK 16:16:16 + 100 kg ha^{-1} MAP (parcel: 1285); 400 kg ha^{-1} NPK 16:16:16 + 100 kg ha^{-1} MAP (parcels: 1290, 1297/1, 1317); 600 kg ha^{-1} NPK 10:30:20 (parcels: 1293/2, 1318, 1319); 500 kg ha^{-1} NPK 16:16:16 (parcels: 1294, 1316); 300 kg ha^{-1} NPK 10:30:20 (parcel: 1298).

The general recommendations for mineral fertilisation of maize (before sowing) are as follows: 400 kg ha^{-1} NPK 10:30:20 + 300 kg ha^{-1} KAN (parcels: 1267, 1269, 1315, 1296, 1295, 1281/2, 1290, 1297/1, 1317, 1294, 1316); 350 kg ha^{-1} NPK 10:30:20 + 250 kg ha^{-1} KAN (parcel: 1268); 500 kg ha^{-1} NPK 10:30:20 + 300 kg ha^{-1} KAN-a (parcel: 1285); 500 kg ha^{-1} NPK 10:30:20 (parcel: 1291); 600 kg ha^{-1} NPK 16:16:16 + 100 kg ha^{-1} MAP-a (parcels: 1293/2, 1318, 1319); 500 kg ha^{-1} NPK 16:16:16 + 200 kg ha^{-1} KAN (parcel: 1298).

The general recommendations for mineral fertilisation of sunflower (before sowing) are as follows: 600 kg ha^{-1} NPK 16:16:16 + 100 kg ha^{-1} KAN (parcels: 1267, 1269, 1281/2,1315, 1296, 1295, 1290, 1297/1, 1317, 1294, 1316); 500 kg ha^{-1} NPK 16:16:16 + 150 kg ha^{-1} KAN (parcel: 1268); 800 kg ha^{-1} NPK 16:16:16 + 100 kg ha^{-1} KAN (parcel: 1285); 700 kg ha^{-1} NPK 16:16:16 + 100 kg ha^{-1} KAN (parcel: 1291); 800 kg ha^{-1} NPK 16:16:16. (parcels: 1293/2, 1318, 1319); 400 kg ha^{-1} NPK 6:12:24 + 200 kg ha^{-1} KAN + 100 kg ha^{-1} MAP (parcel: 1298).

CONCLUSIONS

The data on soil textural class and chemical parameters in this study indicated that the examined soils of Petrovčić, Surčin Municipality, up to depth of 30 cm, are mostly suitable for intensive field production, mainly wheat, maize and sunflower. Accordingly, general recommendations for fertilizers and liming materials application, such as type, dosage and time of application, are given for the mentioned plants. The research also established that none of the analysed soil samples up to depth of 30 cm showed any signs of salinization in terms of their chemical properties, despite the fact that according to the existing pedological map of Serbia, the soil cover of the study area also consists of saline soils. Potential future research would include a detailed description of each plot with an appropriate number of soil profiles per horizons. This could give complete recommendations for the implementation of adequate soil improvement measures and intensification of crop production in the area of CM Petrovčić, Surčin Municipality.

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