PHYSICAL AND CHEMICAL PROPERTIES OF SOIL IN FRUIT GROWING AREA TOPOLA (SERBIA)

Milinkovic Mira, Mitrovic Olga, Lukic Milan, Karaklajic Stajic Zaklina, Tomic Jelena, Kandic Miodrag, Paunovic M. Svetlana

Fruit Research Institute Cacak, Kralja Petra I/9, 32000 Cacak, Serbia

Corresponding author: miramilinkovic@yahoo.com

Abstract

The aim of the investigation was to assess the level of soil fertility and repair measures in order to enhance the productivity of fruit production in a traditional fruit growing area. (Municipality of Topola, Serbia). The following tests were performed: mechanical composition, physical and chemical properties of soil, total adsorbed base cation, capacity of adsorbed base cation, degree of base saturation, different types of soil acidity, contents of carbon, humus, total nitrogen, easily accessible forms of P_2O_5 and K_2O. Results obtained have shown that soils from all studied sites are of "heavy" mechanical texture with 75,40-84,90% of physical clay. High capacity of cation adsorption, low to medium hydrolytic acidity and high to almost complete saturation of adsorbed bases, has been measured. In compliance with previous analyses, it has been assessed that soils are neutral and of low acid chemical reaction, with low carbon and medium humus content and total nitrogen. Easily accessible content of P_2O_5 and K_2O varies depending on the food quantity on individual parcels with low to medium accessibility to parcels with no fruit plantations. Based on the parameters analysed, the tested soils demand repair of mechanical properties, which will facilitate greater nutrient uptake.

Keywords: soil fertility, mechanical composition, nutrients, P_2O_5, K_2O.

Introduction

Municipality of Topola in natural and geographical terms has a good basis for the development of fruit and grape growing. According to the data from Popis poljoprivrede 2012, among the largest areas under plantations is the region of Topola (Keserović, 2012). Orchards are extending to 4,623 ha or 17% of arable land, whereas vineyards on 1.056 ha (4%). Favorable agro-ecological environmental conditions of the hilly landscape of Šumadija contribute to the further development of fruit growing. A downside arising comes from substantial percentage of very clayey soil in certain regions of production, with a an extremely large share of clay

There are over 0.4 million ha of soils with heavy textured mechanical composition and over 0.1 million ha of variously degraded soils. Every year, with different degradation processes, 1,000 new hectares of land is subject to degradation. Excessive or irresponsible use of land leads to productivity fall and ultimately its destruction. As soil represents a complex and dynamic system, changes of its biological, chemical and physical properties occur under the influence of agricultural production (Milivojevic et al. 2012)

Monitoring of soil is carried out by quality and soil fertility control. Intensive agricultural production gradually leads to the depletion and degradation of soil whereby climatic factors have big impact on its fertility. There comes to degradation of its chemical properties such as the loss of nutrients, soil pollution, acidification, salinization and other physical (compaction, deterioration of the structure, formation of crust, etc.) and biological properties (disorder in number and relationship of certain groups of microorganisms, including biological and microbiological activity of soil) (Manojlovic, 2008). The quality of soil with all biological, chemical and physical properties varies in dependence of agro-technical measures applied such as tillage, crop sequence and management of crop residues

(Fuentes et al., 2009). Different agro-technical measures often have significant impact on soil properties resulting in a change of the soil quality (Islam and Weil 2000).
The aim of the research is to determine agro-physical, physical and chemical properties of the soil in fruit growing area of the Municipality of Topola and the repair measures.

Material and methods

The land was sampled in the fall of 2016, in a rural area of the Municipality of Topola. The samples were collected on parcels that are not under orchards (meadows, plough fields, stubble field, fallow land, fodder) and parcels under different types of fruit species, of two depths: 0-30 cm, 30-60 cm. Sampled parcels were marked with GPS coordinates with number of samples in village areas, determined on the basis of arable land and agricultural production, Popis poljoprivrede (2012).
Agro-mechanical, physical and chemical analyses included examination of: mechanical aggregate composition of soil by sieving and sedimentation of different mechanical fractions JDPZ (1997), determination of the sum of exchangeable adsorbed alkaline cations (S meq $100g^{-1}$) (method Kappen-a), determination of hydrolytic soil acidity (H meq $100g^{-1}$), cation exchange capacity (T meq $100g^{-1}$), the level of saturation with adsorbed bases (V%).
Agro-chemical characteristics of soil are determined by the following methods: pH of the H_2O and 1 MKCl-in (potentiometrically); humus (by the method of Kotzman); total nitrogen (method according to Kjeldahl); readily accessible phosphorus and potassium (AL method, P_2O_5 - colourimetrically, K_2O – light photometrically).

Results and discussion

The results of mechanical and physical composition of the soil chemical analyses are shown in Table 1 and 2 in the area of 4 settlements with the largest percentage of fruit production.
Mechanical composition of all analysed soils is, by texture class, heavy clay. Portion of physical clay fractions is 75.40-84.90%, whereas the share of clay fraction 34.00-52.10%. Content of physical sand fractions is 15.10-24.60% and the share of coarse sand 0.00-0.66%.

Table 1. Mechanical composition of soil, Municipality of Topola

Settlements	Depth	Content of mechanical fractions (%)						Soil class
		2-0,2	0,2-0,02	0,02-0,002	<0,002	>0,02	<0,02	
		mm						
Šume	0-30	0.66	21.84	29.20	48.30	22.50	77.50	Heavy clay
	30-60	0.02	22.28	24.60	52.10	23.30	76.70	Heavy clay
Belosavci	0-30	0.02	24.58	41.40	34.00	24.60	75.40	Heavy clay
	30-60	0.04	20.76	40.90	38.30	20.80	79.20	Heavy clay
Vinča	0-30	0.00	15.10	35.70	49.20	15.10	84.90	Heavy clay
	30-60	0.02	18.48	32.60	48.90	18.50	81.50	Heavy clay
Blaznava	0-30	0.00	20.20	29.70	50.10	20.20	79.80	Heavy clay
	30-60	0.00	19.30	28.90	51.80	19.30	80.70	Heavy clay

Results in Table 2. indicate that soils have a high cation exchange capacity, low to high hydrolytic acidity and high to almost full saturation with adsorbed bases. Soils at the site Vinča have values of hydrolytic acidity 4.26-5.79 meq $100g^{-1}$ and a high level of saturation with adsorbed bases. Similar

research results are also found at the site Šume. Soils in the villages of Belosavci and Blaznava have the most suitable physical and chemical properties.

Table 2. Physical and chemical characteristics of soil, Municipality of Topola

Settlement	Depth	S	H=T-S	T	V
		meq $100g^{-1}$			%
Šume	0-30	28.24	4.11	32.35	87.29
	30-60	29.38	6.13	35.51	82.74
Belosavci	0-30	24.81	3.48	28.29	87.69
	30-60	21.06	3.95	25.01	84.21
Vinča	0-30	31.83	5.79	37.62	84.61
	30-60	29.66	4.26	33.92	87.44
Blaznava	0-30	34.05	1.38	35.43	96.10
	30-60	35.23	1.42	36.65	96.13

The minimum and maximum values of the soil fertility basic analysis results in the area of 24 settlements in the Municipality of Topola are shown in Table 3. A review of the lowest and highest values of parameters tested within a settlement show the quality of soil and availability of certain nutrients.

Substitutional soil acidity (pH/KCl) in certain areas of the Municipality of Topola is in the class of acid soils (Junkovac, Rajkovac, Mascar, Belosavci, Donja Trešnjevica). At other sites sampled, soils are in the class of low acid (pH / KCl 5.5-6.5) to slightly alkaline (pH / KCl 6.5-7.2). There are no changes within the soil reaction interval with changing of sampling depth.

Active soil acidity on most sites is neutral to slightly alkaline, and in the area of settlements Žabari, Vojkovci, Topola selo, Božurnja, Ovsište, Vinča, Plaskovac, Donja Šatornja i Blaznava, low to medium alkaline. According to the carbonate content, low carbonate soils are present (0-2% $CaCO_3$) at a number of sites. A very high content of carbonate, increasing with the sampling depth to > 25% $CaCO_3$ is found in the villages of Topola, Božurnja and Ovsišta, whereas other sites are carbonate-free or medium carbonated.

The presence of humus in soil depends on the cadastral culture grown on the sampled soil. Humus horizon (0-30 cm) is medium supplied with humus, and in some localities, results show its high supply. With depth of sampling, the content of humus decreases and the supply is usually low (1-3% humus). The values of humus content in the soils under plantations of different fruit species are, in the humus horizon 71.4% of the samples is humus and 22.9% is low humus. In sub-humus horizon, 80.0% is low humus whereas 20.0% are humus samples.

The presence of total nitrogen corresponds to the content of humus, with mean values prevailing. The results show that half of the land of the total number of tested sites are with very low to low supply of accessible phosphorus (<10 mg 100^{-1} g). A good supply of accessible phosphorus is measured at sites with intensive nutrition of fruit plantations and is related to individual sites (of nutritional food) without correlation with other parameters tested.

Soils of the Municipality of Topola are medium to highly supplied with accessible potassium. These research parameters show that the most common area of fruit production in Topola is on soils of smonitsa (vertisol). Soils of smonitsa are potentially fertile, due to deep humus horizon though unfavorable physical and water-physical properties (Miljković, 1996). Sanding, entering of sand is one of physical methods of soil repair. What is more, it is desirable that the sand is the smallest possible so it could be mixed and glued with clay and dust more efficiently (Miljkovic, 2005). (Miljković, 2005).

Degree of evolution, substrate groups and depth of humus horizon are the criterion for the classification of smonitsa into subtypes, varieties and forms (Škorić, 1986). Soils of this type are of heavy texture, due to the large proportion of clay (Gajić and Zivkovic 2002), with only 5% of air. Chemical properties are more favorable. Adsorption capacity is 50 or more ekv. mmol / 100 g of soil, and the base saturation is also high, approx. 90%.

Table 3. Minimum and maximum values of agro-technical analyses by depth of the sampled soil, Municipality of Topola

Settlement	Depths	pH		$CaCO_3$	Humus	N	P_2O_5	K_2O
		KCl	H_2O	%	%	%	mg $100g^{-1}$	mg $100g^{-1}$
Žabari	0-30	6,63-6,70	7,53-7,55	2,41	3,03-3,74	0,15-0,19	14,78-26,47	26,82-29,02
	30-60	6,65-6,75	7,66-7,88	2,41	2,45-2,95	0,12-0,19	8,37-12,23	19,97-20,25
Junkovac	0-30	5,28-5,32	6,13-6,27	0,00	3,80-4,66	0,19-0,23	4,23-13,75	25,18-26,77
	30-60	4,59-5,47	6,20-6,61	0,00	2,33-3,04	0,12-0,15	4,18-9,58	21,22-25,38
Šume	0-30	5,94-6,20	6,81-7,16	0,99-1,53	3,54-3,65	0,18	7,56-11,77	>30
	30-60	5,66-6,15	6,49-7,29	0,85-1,27	1,47-2,77	0,08-0,14	2,43-9,34	26,78->30
Gornja Trnava	0-30	6,07-6,63	7,12-7,51	1,13-1,81	3,09-5,67	0,10-0,28	4,62-14,02	20,23->30
	30-60	6,13-6,26	7,28-7,37	0,97-1,53	1,56-2,74	0,08-0,14	2,57-5,36	18,12->30
Svetlić	0-30	6,04-6,11	7,14-7,15	0,99-1,81	2,56-4,24	0,13-0,21	2,85-10,37	25,52->30
	30-60	5,60-5,81	6,97-7,05	0,70-1,41	2,09-3,65	0,10-0,18	1,55-3,82	22,07-24,58
Donja Trnava	0-30	5,87-6,49	6,86-7,46	1,13-1,41	2,12-4,39	0,10-0,22	3,43-8,52	18,93-32,24
	30-60	5,90-5,99	6,93-7,53	0,70-1,69	1,39-2,74	0,07-0,14	1,61-2,43	15,30-20,96
Natalinci	0-30	6,12-7,19	6,94-8,05	1,69-3,24	3,33-3,57	0,17-0,18	4,88-18,17	17,41-24,82
	30-60	5,93-6,38	6,88-7,26	1,11-1,97	2,45-3,01	0,12-0,15	3,43-21,77	18,39-18,78
Kloka	0-30	5,74-5,85	6,59-6,93	0,99-1,41	3,51-3,57	0,17-0,18	6,59-9,57	21,46-28,75
	30-60	5,48-5,80	6,55-6,74	0,00-1,11	2,06-2,39	0,10-0,12	3,88-5,06	13,62-22,06
Rajkovac	0-30	5,19-5,75	6,07-6,53	0,00-1,25	3,27-4,30	0,16-0,21	11,77-14,18	25,45->30
	30-60	5,14-5,80	5,99-6,49	0,00-1,25	2,21-2,86	0,11-0,14	8,38-9,17	22,37->30
Maskar	0-30	5,34-5,49	6,27-6,53	0,00	2,59-3,06	0,13-0,15	2,57-7,83	15,52-19,56
	30-60	5,36-5,40	6,25-6,35	0,00	2,27-2,36	0,11-0,12	2,18-7,86	14,43-20,98
Jelenac	0-30	5,48-5,97	6,78-7,02	0,00-0,83	2,50-2,95	0,13-0,15	13,65-17,42	25,63-27,16
	30-60	5,23-5,62	6,68-6,84	0,070	1,62-2,18	0,08-0,11	6,08-16,58	20,17-20,18
Belosavci	0-30	5,22-6,01	6,54-6,95	0,00-1,41	3,45-4,69	0,17-0,23	5,49-8,22	27,64-27,76
	30-60	5,41-6,17	6,54-7,20	0,00-1,83	2,53-3,42	0,13-0,17	3,97-4,17	17,05-25,38
Krćevac	0-30	6,30-6,52	7,17-7,30	0,83-2,11	4,30-4,34	0,21-0,23	>30	>30
	30-60	6,44-6,67	7,28-7,47	0,99-2,54	3,51-3,74	0,18-0,19	>30	>30
Donja Trešnjevica	0-30	4,48-5,09	5,81-7,09	0,00	2,83-3,30	0,14-0,16	2,65-4,07	16,37-17,46
	30-60	4,37-4,74	5,81-6,10	0,00	2,09-4,51	0,10-0,22	1,68-1,83	14,48-16,06
Gornja Šatornja	0-30	5,89-6,37	6,67-7,36	1,25-1,41	3,95-4,51	0,20-0,22	1,52-24,78	8,02-14,78
	30-60	6,11-6,31	6,97-7,27	0,99-1,83	2,53-3,03	0,13-0,15	1,00-12,37	7,43-17,49
Vojkovci	0-30	6,95-7,01-	7,54-7,81	5,64-7,33	3,09-3,18	0,15-0,20	6,35->30	12,54-13,97
	30-60	6,86-7,17	7,39-7,97	5,28-7,75	2,01-3,51	0,10-0,17	1,78-6,02	8,62-18,37
Topola selo	0-30	6,42-7,23	7,39-8,15	1,11-14,24	2,89-5,66	0,14-0,28	2,97-22,57	19,18->30
	30-60	6,02-7,34	7,21-8,28	0,83->25	1,30-2,68	0,06-0,14	1,48-15,42	11,35->30
Lipovac	0-30	4,53-5,98	5,64-7,02	0,00-1,27	2,86-4,45	0,14-0,22	1,68->30	21,58-28,77
	30-60	4,72-5,75	6,24-6,43	0,00-0,83	2,68-3,42	0,13-0,17	1,55->30	12,63-24,83
Božurnja	0-30	5,97-7,41	7,07-8,19	1,69->25	3,21-5,63	0,16-0,28	3,38-29,08	23,76->30
	30-60	5,79-7,25	7,04-8,35	0,85->25	2,71-3,80	0,14-0,19	2,28-24,06	12,78-27,52
Ovsište	0-30	6,73-6,99	7,62-8,03	1,81-10,15	3,98-4,27	0,20-0,21	6,02->30	>30
	30-60	6,78-7,05	7,69-7,86	1,81->25	1,50-3,65	0,09-0,18	2,22->30	>30
Vinča	0-30	6,79-7,04	7,52-8,13	1,81-7,05	2,18-6,01	0,09-0,18	14,28-28,38	27,83->30
	30-60	6,87-7,11	7,80-8,21	2,26-9,59	1,80-3,51	0,11-0,30	2,83-16,75	19,57->30
Plaskovac	0-30	6,32-7,02	7,06-7,81	0,83-1,97	3,24-5,45	0,16-0,27	2,63->30	26,82->30
	30-60	5,83-6,98	6,94-7,94	1,41-2,26	1,62-2,62	0,08-0,13	2,21-6,08	20,39->30
Donja Šatornja	0-30	6,07-6,89	7,61-7,86	1,21-3,81	2,33-3,36	0,12-0,17	3,02-25,72	13,87-25,52
	30-60	5,54-6,86	6,81-7,88	0,56-2,82	1,71-3,60	0,09-0,18	8,02-11,24	10,58-19,62
Blaznava	0-30	6,45-6,91	7,05-7,66	0,99-3,24	3,65-4,83	0,18-0,24	7,32->30	>30
	30-60	6,62-6,94	7,31-7,68	1,41-2,68	1,89-2,95	0,09-0,15	4,50-22,83	19,62->30

The soil reaction is neutral 6,7-7,2, whereas carbonate subtypes are weakly basic with pH ranging from 7-8. Humus content ranges from 3-5%, being rich in nitrogen accordingly. Their phosphorus is low though with good supply of potassium. The quoted results are in accordance with the results of our investigations for the majority of analysed sites.

Certain subtypes of soil are characterized by a low content of phosphorus, which is generally found in acid soils. Availability of phosphorus in acid soils is known to decrease due to its immobilization

with free Al^{3+} and Fe^{3+} ions (Debnath et al. 2000). Methods of dealing with low phosphorus content is phosphorization as a measure of ameliorative application of phosphorus fertilizers and liming in order to increase the accessibility of phosphorus from soil reserves. If soils are low in phosphorus, fertilization is carried out by complex fertilizers with high phosphorus, whereas in case of good supply with phosphorus and potassium, the fertilizers with approximately equal relation of the two elements should be used. (Ubavić and Bogdanović 1995).

Conclusions

Soils of the region investigated are heavy clays, with high cation adsorption capacity, low to medium hydrolytic acidity and high to almost full saturation with adsorbed bases.

Acidity of the respective soil is in the class of acid to medium alkaline with prevailing low acid (pH/KCl 5,5-6,5) to low alkaline (pH/KCl 6,5-7,2) soils. With the depth of sampling, there are no changes within the soil reaction interval. Active acidity of soil, on majority of sites has neutral to weak alkaline reaction. According to the analysis results of most of the parameters examined, a significant portion of the area belongs to a carbonated type of soil, with some differences in the content of carbonate influenced by degradation processes and soil evolution in smonitsa. Confirmation of the obtained results and recognition of the microlocality of growing grapes, cherries, peaches, nectarines and others requiring the presence of carbonate are tolerant of the increased carbonate content. The presence of humus in the soil corresponds with the type of soil and surface horizon is medium supplied with humus, which decreases with a depth of sampling. The presence of total nitrogen is in accordance with the content of humus, with mean values of the content prevailing. There is very low to low supply with accessible phosphorus. (<10 mg 100^{-1} g). A good supply of available phosphorus is measured on the sites with intensive nutrition of crop plantations. The soils are well supplied with potassium. All this shows that the soils of the area analysed are potentially fertile, where agromelioration improvement in the structure and mechanical composition, humification and phosphating should be applied.

Acknowledgements

The research was funded by the Ministry of Agriculture and Environment of the Republic of Serbia through the project "Arrangement of agricultural land in the region of Šumadija and Raška, using agromeliorative measures to develop fruit production" and partly by the Ministry of Education, Science and Technological Development of Republic of Serbia (grant number 31080 TR).

References

1. Debnath, A., Bhattacharrjee, T. K, Debnath, N. C. (2000): Behaviour of inorganic phosphate fractions in limed acid soils. J. Indian Soil Sci. 48: 829-831.
2. Dugalić, G. Gajić, B. (2012). Pedologija. Agronomski fakultet, Čačak.
3. Fuentes, M., Govaerts, B., De Leon, F., Hidalgo, C., Sayre, K. D., Etchevers, J., Dendooven, J. (2009). Fourteen years of applying zero and conventional tillage, crop rotation and residue managements systems and its effect on physical and chemical soil quality. European Journal of Agronomy, 30: 228-237.
4. Gajić B. and Živković M. (2002). Specifična površina smonica aleksinačke kotline. Journal of Agricultural Sciences , 47, (1): 19-27.
5. Islam, K. R. and Weil, R. R. (2000). Land use effects on soil quality in a tropic forest ecosystem of Bangladesh. Agriculture, Ecosystems & Environment. 79: 9-16.
6. Manojlović, M. (2008). Đubrenje u održivoj poljoprivredi. Monografija, Poljoprivredni fakultet, Novi Sad.
7. Milivojević J., Đekić V., Jelić M. (2012). Fertility of the arable land of the production sites of the town of Kragujevac in private ownership. Vegetable and vegetable production, 49 (2): 195-201.
8. Miljković, N. S. (1996). Osnovi pedologije, Novi Sad.

9. Škorić, A. (1986). Postanak, razvoj i sistematika tla. Fakultet poljprivrednih znanosti Sveučilišta u Zagrebu, Zagreb.
10. Ubavić, M. and Bogdanović, D. (1995). Agrohemija, Poljoprivredni fakultet Novi Sad
11. Keserović, Z., Magazin, N, Kurjakov, A., Dorić, M., Gošić, J. (2012). Poljoprivreda u Republici Srbiji. Voćarstvo. Republički zavod za statistiku.