THE DISTRIBUTION OF MICROORGANISMS IN DIFFERENT TYPES OF AGRICULTURAL SOILS IN THE VOJVODINA PROVINCE

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Abstract: *The soil fertility is determined by its composition and properties. Soil properties have a strong impact on a range of processes influencing crop yield, including microbial diversity. The distribution of microorganisms in soil is influenced by numerous abiotic and biotic factors, primarily by soil type, plant species, soil usage and tillage, use of organic and mineral fertilizers, irrigation, pesticide application, etc. Therephore, the objective of this study was to examine the distribution of microorganisms in different types of agricultural soils in the Vojvodina Province. The distribution of soil microbes was assessed on the basis of indirect dilution method on appropriate nutritive media. The total number of microorganisms was determined on soil agar, the number of azotobacters on nitrogen-free medium using „fertile drops" method, ammonifiers on mesopepton agar – MPA, N-fixing bacteria on Fiodor medium, actinomycetes on synthetic medium and fungi on Czapek-Dox agar. Incubation temperature was 28°C, while incubation time depended on the tested group of microorganisms. All investigated microbial groups were found in all locations. Number of the microorganisms was uneven by type of soil. Studies have shown that the highest total number of bacteria was obtained on humogley and chernozem, in the locations of Bečej, Begejci and Kula. The highest distribution was recorded on chernozem, at the locations where the plough-field and harvest residues of maize were found, as well as on fluvisol and humogley. The highest number of ammonium-fixing bacteria was recorded in Zrenjanin, on chernozem. N-fixing bacteria were the most abundant on cambisol, in the locations of Petrovaradin and Vršac, as well as on chernozem, in the locations of Crna Bara, Orlovat, Popinci and Kula. The results showed that the highest number of actinomycetes was obtained in Žednik, on chernozem. The highest number of fungi was observed in Petrovaradin and Vršac, on cambisol. On average, abundance of the most studied microbial groups was the lowest in arenosol, solonchak, solonetz and pseudogley, while the highest distribution was obtained in chernozem, humogley, cambisol and fluvisol.*

Key words: *microorganisms, soil, Vojvodina*

INTRODUCTION

The soil is habitat for many and various microorganisms that form its biological phase. Intensive agricultural production, irrational use of large quantities of pesticides and mineral fertilizers, wastewater irrigation, significantly impairs the quality and fertility of agricultural soils (ONDER et al., 2007). As the most important link in the overall metabolic activity of soil, microorganisms play a significant role in recycling of plant nutrients, maintenance of soil structure, detoxification of noxious chemicals, and control of plant pathogens and plant growth (GILLER et al., 1998; FILIP et al., 2002). The presence of large numbers, activity and diversity of microorganisms is a good indication of soil properties (MILOŠEVIĆ et al., 1999). The distribution of microorganisms in soil is influenced by numerous abiotic and biotic factors, primarily by soil type, plant species, soil usage and tillage, use of organic and mineral fertilizers, irrigation, pesticide application, etc. (JARAK I SAR., 1997).

The dominance of certain groups of microorganisms affects the processes of synthesis and degradation of matter and thus determines the soil quality (MILOŠEVIĆ et al., 2003). Each soil type has its own microflora that is positively or negatively affected by the way of soil

usage, which directly reflects on soil fertility (TINTOR et al., 2011). Numerous studies have shown the high general soil biological activity in various soil types down to 30 cm depth, i.e. lowering of the total microbial abundance with increasing soil depth (GOVEDARICA et al., 1993; MILOSEVIC et al., 2000; MARINKOVIĆ et al., 2007).

Therephore, the objective of this study was to examine the distribution of microorganisms in different types of agricultural soils in the Vojvodina Province.

MATERIAL AND METHODS

Soil microbial distributions have been examined in 50 locations around Vojvodina. These locations were under agricultural soils of eight soil types. Chernozem was represented with 30 samples. The other soils were represented with following number of samples: humogley - 8, fluvisol - 4, cambisol, pseudogley, solonetz - 2, and solonchak, arenosol – 1. It was found 4 different ways of soil usage and tillage: plough-field area (without vegetation and with harvest residues) the most common way, with 42 samples, pasture and forest with 3 samples and vineyard with 2 samples. GPS technology (Global Positionin System) was used to locate representative sites of agricultural soils. Soil samples for microbiological analyses were taken in November 2010 from 0-30 cm depth.

The distribution of soil microbes was assessed on the basis of indirect dilution method on appropriate nutritive media to determine the total number of microorganisms, the number of azotobacters, ammonifiers , N-fixing bacteria, actinomycetes and fungi. The total number of microorganisms was determined on soil agar, the number of azotobacters on nitrogen-free medium using „fertile drops“ method (ANDERSON, 1965), the number of ammonifiers on mesopepton agar – MPA (POCHON and TARDIEUX, 1962), N-fixing bacteria on Fiodor medium, actinomycetes on synthetic medium according KRASILJNIKOV (1965) and fungi on Czapek-Dox agar. Incubation temperature was 28°C, while incubation time depended on the tested group of microorganisms. All microbiological analyses were performed in three replications and the average number of microorganisms was calculated at 1.0 g absolutely dry soil.

RESULTS AND DISCUSSION

The soil fertility is determined by its composition and properties (morphological, physical, chemical and biological). Soil properties have a strong impact on a range of processes influencing crop yield, including microbial diversity. The abundance and activity of certain systematic microbial groups are positively or negatively correlated with soil chemical properties. Above 60% of arable soil in Vojvodina is slightly alkaline, above 20% were neutral reaction and only 8% of the acid reaction (BOGDANOVIĆ et al., 1993). Adaptations of microorganisms to different soil properties and a broad range of pH and salinity may lead to better competition and survival.

All investigated microbial groups were found in all locations. Number of the microorganisms was uneven by type of soil (Tables 1 and 2). Table 1 shows the number of microorganisms on a chernozem soil of different locations and Table 2 the number of microorganisms on the other soil types, also at various locations.

The total number of bacteria, number of azotobacters and dehydrogenase activity reflect general soil biological activity and therephore could be reliable representatives of its fertility (GOVEDARICA et al., 1992). Studies have shown that the highest total number of bacteria was obtained on humogley and chernozem, in the locations of Bečej (64.22×10^8) (Tab. 2), Begejci (63.04×10^8) and Kula (61.67×10^8) (Tab. 1). The smallest, but also high total number of bacteria that is measured in hundereds of millions of colonies per 1 gram of absolutely dry soil, was observed on a chernozem soil, in the locations of Ban. Aranđelovo, Horgoš and Boka, on humogley, arenosol and solonetz (Tab. 2).

Table 1

The number of microorganisms on a chernozem soil

Location	Number of microorganisms (g^{-1} absolutely dry soil)					
	Total number x 10^8	Azotobacters x 10^2	Ammonifiers x 10^6	N-fixers x 10^6	Actinomycetes x 10^4	Fungi x 10^4
Žednik	44.72	22.10	25.63	79.45	184.52	12.81
Aleksa Šantić	39.75	16.35	10.06	33.97	100.64	17.61
Tornjoš	33.25	18.99	22.42	52.30	84.68	16.19
Gakovo	22.12	22.01	33.86	64.33	81.26	11.29
Kula	61.67	2.95	206.37	180.42	125.00	16.51
Srbobran	26.29	24.13	10.16	116.83	54.60	2.54
Srpski Miletić	17.38	24.74	29.18	65.96	64.70	7.61
Nadalj	8.73	25.99	70.61	11.55	87.30	8.99
Ruski Krstur	23.02	30.51	161.05	17.61	86.81	5.03
Parage	17.64	27.68	110.72	14.16	60.51	14.16
Rimski Šančevi	28.10	9.58	111.11	10.22	53.64	10.22
Žabalj	27.92	32.72	239.97	63.26	67.63	8.73
Maglić	20.99	29.80	92.00	53.13	53.13	2.59
Crna Bara-Čoka	21.15	23.54	42.79	198.07	52.57	4.89
Kikinda	32.35	20.53	87.19	109.93	40.43	5.05
Begejci	63.04	18.84	184.21	131.58	50.24	1.20
Zrenjanin	35.93	16.36	319.56	11.55	68.02	7.70
Orlovat	44.06	21.34	18.83	192.07	62.77	5.02
Kozjak	38.55	3.16	145.37	68.26	75.84	15.17
Idvor	32.15	10.05	136.88	65.30	46.46	6.28
Padina	42.94	22.29	273.73	120.54	91.66	8.79
Crepaja	23.32	18.79	36.65	96.84	38.23	5.10
Deliblato	29.41	2.55	141.95	126.05	131.73	10.22
Bavanište	9.86	20.90	82.37	41.18	49.92	8.74
Šid	24.40	22.72	133.23	145.69	37.36	8.72
Rivica	18.97	19.70	205.67	139.16	46.80	12.32
Ruma	20.99	4.59	247.93	107.57	39.35	7.87
Indija	16.56	4.12	165.57	127.65	53.08	5.06
Sremska Mitrovica	21.62	6.00	121.37	109.99	11.38	0
Popinci	13.59	19.74	165.65	188.95	66.00	3.88
Chernozem - average	**28.68**	**18.09**	**121.07**	**91.45**	**68.87**	**8.34**

The ecological distribution of *Azotobacter* spp. is related with diverse factors which determine the presence or absence of this bacterium in an specific soil such as soil characteristics and climate conditions and includes organic matter content, moisture, C/N relation and pH (TEJERA et al. 2005). In our study, the lowest distribution of azotobacters was obtained on cambisol at the location of Vršac (0.30 x 10^2), while on pseudogley and humogley, at the locations Morović and Bečej (Tab. 2) azotobacters were not detected. The highest distribution was recorded on chernozem (Tab. 1) at the locations where the plough-field and harvest residues of maize were found, as well as on fluvisol and humogley.

The highest number of ammonifiers was recorded in Zrenjanin (319.56 x 10^6) (Tab. 1). Similarly, the high abundance of ammonifiers was obtained at other locations on chernozem, as well as on humogley, cambisol and solonetz, while the lowest number was found on fluvisol, in the location of Sanad (8.13 x 10^6) (Tab. 2). MARINKOVIĆ et al. (2008) found the highest microbial activity in the location with the highest content of phosphorus and potassium. On soils low to medium productivity, such as undeveloped, sandy arenosol or salinized, alkalized solonchak and solonetz, application of agricultural measures can positively affect the chemical properties and led to a high presence of microorganisms in that soil types.

N-fixing bacteria were the most abundant on cambisol, in the locations of Petrovaradin and Vršac, as well as on chernozem, in the locations of Crna Bara, Orlovat, Popinci and Kula, and on humogley, in the locations of Ilandža and Torda. The smallest number of N-fixers was recorded on humogley - Ban. Aranđelovo, on arenosol – Horgoš, on pseudogley - in Morović (Tab. 2) and on chernozem - in Rimski Šančevi, Nadalj and Zrenjanin (Tab. 1).

Table 2

The number of microorganisms on the other soil types

Location	Number of microorganisms (g^{-1} absolutely dry soil)					
	Total number x 10^8	Azotobacters x 10^2	Ammonifiers x 10^6	N-fixers x 10^6	Actinomycetes x 10^4	Fungi x 10^4
Kać	21.91	30.80	60.24	73.93	76.67	2.74
Bačko Novo Selo	22.41	21.32	135.22	64.56	74.31	4.87
Sanad	37.03	24.96	8.13	111.43	55.72	4.64
Kupinovo	17.70	21.00	147.32	95.63	103.39	3.88
Fluvisol - average	**24.76**	**24.52**	**87.73**	**86.39**	**77.52**	**4.03**
Bečej	64.22	0	11.29	33.87	1.41	14.11
Bogojevo	17.69	27.71	129.70	140.31	73.10	9.43
Ban. Aranđelovo	1.35	2.65	303.19	4.10	0.13	1.46
Rusko Selo	30.28	6.66	64.19	118.69	21.80	8.48
Torda	39.96	17.51	68.76	194.60	53.19	11.68
Vršački Ritovi	48.54	18.62	260.64	106.38	55.85	9.31
Ilandža	49.08	23.78	45.66	201.65	48.19	16.49
Donji Tovarnik	13.03	12.90	77.43	64.52	24.52	7.74
Humogley - average	**33.02**	**13.29**	**120.11**	**108.01**	**34.77**	**9.84**

Actinomycetes are numerous and widely distributed in soil and are very sensitive to acidity and waterlogged soil conditions. The results showed that the highest number of actinomycetes was obtained in Žednik (184.52 x 10^4) (Tab. 1) on chernozem as well as at the locations of Deliblato and Kula, while the lowest number was registered on humogley in Bečej (1.41 x 10^4) and Banatsko Aranđelovo (0.13 x 10^4). At the location of Morović on pseudogley actinomycetes were not reported (Tab. 2).

The distribution of fungi, as an important component of the soil microbiota, depending on soil depth and nutrient conditions such as nature of the organic content of the soil and other soil and climatic conditions, surface vegetation and soil texture (MARSCHNER et al., 2003). In our research, the highest number of fungi was observed in Petrovaradin (26.75 x 10^4) and Vršac (18.16 x 10^4), on cambisol (Tab. 2). The lowest distribution of fungi was obtained on pseudogley, humogley and chernozem, in the locations of Morović, Ban. Aranđelovo and Begejci, while in Višnjićevo and Sremska Mitrovica the presence of this microbial group was not observed.

On average, abundance of the most studied microbial groups was the lowest in arenosol, solonchak, solonetz and pseudogley, while the highest distribution was obtained in chernozem, humogley, cambisol and fluvisol.

GOVEDARICA et al. (1993) obtained the highest values of total bacteria, azotobacters and dehydrogenase activity on chernozem (calcareous and limeless), hydromorphic black soil and smonitza soil, while the frequency of free nitrogen-fixing bacteria, actinomycetes and fungi was inconsistent in indiviadual soil types. The results of BRANKOV et al. (2006) showed that the highest total number of bacteria, number of azotobacters and dehydrogenase activity (DHA), were obtained on chernozem, solonetz and humogley - soils with higher content of humus and nitrogen, while the smallest distribution was found on cambisol and fluvisol. TINTOR et al. (2011) found the high total number of bacteria and dehydrogenase activity on all investigated soil types, while in relation to the way of soil usage, higher general soil biological activity was recorded on non-arable soil, as well as on soils of orchards and vineyards. MARINKOVIĆ et al. (2007) found the high biological value in different soil types down to 30 cm depth. They observed the highest total microbial abundance and the number of ammonifiers and free N-fixing bacteria in solonetz, while the most azotobacters were found in the hydromorphic gley soil, and fungi and actinomycetes were the most abundant in fluvisol. Investigating the influence of different usage patterns, in chernozem soil, on occurerence of microorganisms and dehydrogenase enzyme activity, and comparing the results from 1992, TINTOR et al. (2009) recorded the increasing trend for most of investigated microbial groups,

except for ammonifiers whose number was not changed, and for azotobacters and fungi whose number was smaller.

CONCLUSIONS

All investigated microbial groups were found in all locations and number of the microorganisms was uneven by type of soil. On average, abundance of the most studied microbial groups was the lowest in arenosol, solonchak, solonetz and pseudogley, while the highest distribution was obtained in chernozem, humogley, cambisol and fluvisol.

N-fixers and fungi were the most abundant at the locations of Petrovaradin and Vršac - on cambisol, while the smallest distribution was recorded at the location of Morović – on pseudogley, where azotobacters and actinomycetes were not found. Abundance of total microbial number, the number of N-fixers and actinomycetes was high at the location of Kula, on chernozem.

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