THE STATUS OF TRACE ELEMENTS IN SOILS ON ORGANIC AND CONVENTIONAL FARMS IN SERBIA

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Abstract: *The aim of the research was to compare the impact of organic and conventional farming systems on soil quality with respect to trace elements (TEs) status. A study was carried out on seven pilot farms located in Vojvodina, the northern part of Serbia. The investigation was conducted at three representative farms certified for organic production and four conventional farms, in total on 96 production fields with different history of farming practices. Total and plant-available concentrations of TEs (DTPA) were determined in soil samples taken from 0-30 cm depth. The concentration of TEs was measured by atomic absorption spectrometer (AAS).*

Keywords: TRACE ELEMENTS (TEs), TOTAL CONCENTRATION, PLANT-AVAILABLE CONCENTRATION, ZINC (Zn)

1. Introduction

The concentration of trace elements (TEs) in soil is an indicator of possible excesses or deficiencies for plant nutrition, animal and human health and also environmental quality. Conventional agricultural production is characterized by intensification and high input of fertilizers and pesticides, which can cause both - TEs deficiencies (due to increasing demand for one or few TEs), or high accumulation of TEs (due to unbalanced fertilization and improper use of pesticides). Although risk for accumulation of TEs in soil is smaller in organic farming compared to conventional, the monitoring of these soils is important and has benefits.

Organic agriculture in Serbia is characterized with constant growth of areas under certified production. Number of organic producers and the area under organic farming systems are constantly increasing due to growing market demands for healthy and safe food. It is estimated that more than 10000 ha are under organic systems.

Our previous results (Manojlović et al., 2011; Manojlović and Čabilovski, 2011) did not show significant differences in the soil fertility between organic and conventional production in average for the investigated sites, as short period of transition to organic production (2-4 years) was not long enough that the positive impacts of organic production are reflected in soil fertility. Optimum to high soil fertility, determined in average for all tested sites in organic production, indicating good natural conditions necessary for successful organic farming in Serbia.

The results of the analysis of soil, food and feed samples from Vojvodina, northern part of Serbia (Čuvardić et al., 2006) showed high variability in the concentrations of essential and toxic trace elements between some locations in Vojvodina Province. Low concentrations of available microelements (Zn, Cu, Fe and Co) in soil and alfalfa samples were measured in soils with low texture as well as those with high pH-value and content of calcium carbonate. High total contents of Cu, Ni, and Cr in soil, as well as high content of Hg in alfalfa, found in some locations, indicated a necessity of monitoring their contents in soils and plants. However, later studies showed that TEs concentration was increased on micro-locations due to either geochemical factors or industrial and agricultural activities (Manojlović and Singh, 2012; Ninkov et al., 2012).

Consumers of the food products from organic and but also conventional agriculture in Serbia are more and more interested in their quality, particularly concentration of heavy metals and pesticides residues, which is very much dependent on the soil quality. In order to prevent soil contamination by TEs but also to increase essential TEs on soils where there is a need for that, it is important to analyze and monitor soil quality.

The aim of the research was to compare the impact of organic and conventional farming systems on soil quality with respect to trace elements (TEs) status.

2. Material and methods

A study was carried out on seven pilot farms located in Vojvodina, the northern part of Serbia. The province of Vojvodina is the most important agricultural region in Serbia, covering the Southeastern part of Pannonian Basin, with 88% of its total area being arable Vidojević & Manojlović (2007).The investigation was conducted at three representative farms certified for organic production (Stara Pazova, Kisač, Ljutovo) and four conventional farms (Rivica, Indjija, Kraljevci, Novi Slankamen) in total on 96 production fields with different history of farming practices.

Main soil chemical properties were analyzed by the following methods: the pH was measured in a 1:2.5 soil/water and soil/1MKCl suspension; the $CaCO_3$ content volumetrically using Scheibler calcimetar; the humus content by the Tjurin method; N total by CHNS analyzator Elementar; available phosphorus and potassium were extracted using the ammonium lactate solution (Egner and Riehm, 1960), and phosphorus was measured by spectrometer and potassium flame photometer.

Total and plant-available concentrations of TEs (DTPA) were determined in soil samples taken from 0-30 cm depth. The concentration of TEs was measured by atomic absorption spectrometer (AAS).

3. Results and discussion

3.1. Basic soil properties

The results showed high variability in soil fertility not only between the farming systems (organic/conventional), but also within the same production system - between different locations and even between plots on the same farm. Soil samples taken from conventional farms had lower pH values and lower humus contents compared to the samples from the organic farms (unpublished data).

Table 1: *Basic properties of soils from organic and conventional farms.*

Parameter	Min	Max	Average
pH [H_2O; 1:10]	7.0	8.67	8.2
pH [KCl; 1:10]	6.34	8.01	7.3
$CaCO_3$ [%]	1.68	24.0	8.9
Humus [%]	0.54	6.01	2.42
Total N [%]	0.03	0.3	0.12
P_2O_5 [mg 100^{-1}g]	3.08	188	24.7
K_2O [mg 100^{-1}g]	11.4	120	22.8

3.2. Essential trace elements

The total concentration of TEs in the soil indicates the potential of the soil to provide plants with microelements. Availability of TEs for plants depends on a number of factors, such as: pH-value land, $CaCO_3$ content, soil texture, and organic matter content.

In order to assess the provision of TEs to plants, concentration of plant-available TEs was determined after their extraction with DTPA solution (Fig. 1). The results show a variable concentration

of essential TEs (Fe, Mn, Cu and Zn) in soil but the concentration of plant-available forms were adequate and above the lower limit of the optimal provision. Therefore, it is not expected that plants react positively to the fertilization with these elements. However, soil in Srem (Indjija, Rivica, Kraljevci, N.. Slankamen) is characterized by low concentration of available Fe (by an average of 7.4 mg kg^{-1}), which is insufficient for plant species that have increased needs for this element (fruit and grapes).

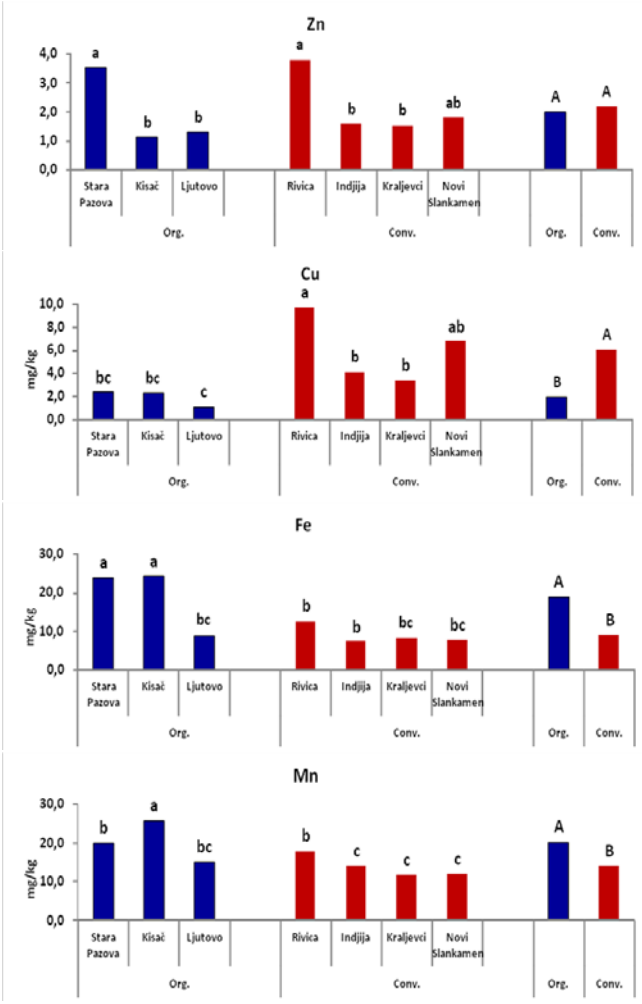

Fig. 1 *Concentration of essential plant-available TEs (Zn, Cu, Fe, Mn) in soils from organic and conventional farms.*

Some of the TEs, Cu, Zn, Mn, Fe, Mo, B, and Ni that are essential for plant growth, can become toxic to plants at high concentrations. Fig. 2 shows the total concentrations of Zn and Cu in investigated soils from organic and conventional farms.

According to Regulation on permitted amounts of hazardous and harmful substances in agricultural soil and methods for their testing (Off. Gazette of RS, no. 11/1990), maximum concentrations of Zn and Cu in soil are 300 and 100 mg kg^{-1}, respectively. Although, the limit for Cu in organic production is more strict (50 mg kg^{-1} of soil, according to Off. Gazette of RS, no. 51/2002), concentrations of Cu in all samples are just below the limit. Fig. 1 already showed low DTPA concentrations of Zn, Cu, Fe, Mn. In previous study of Popović et al. (2011) on soils in the vicinity of thermal power plants in Serbia, Bosnia and Croatia, the chemical speciation indicated that more than 99% of all investigated metals (Cd, Cu, Pb and Zn) in soil water extracts were complexed to fulvic acid. This is connected to relatively high soil pH (>6.5) and high contents of soil organic matter in these soils. Authors concluded that these soils have a large metal retaining capacity and high industrial activity had insignificant effect on soil quality with respect to bioavailability of TEs in these soils.

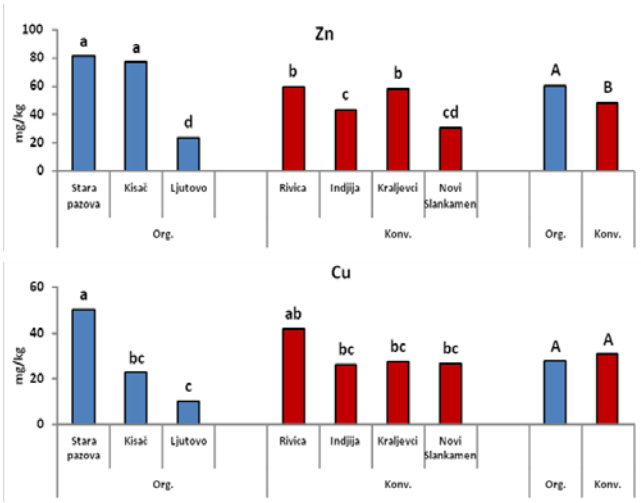

Fig. 2 *Total concentration of essential TEs (Zn, Cu) in soils from organic and conventional farms.*

3.3. Toxic trace elements

Mean values for the total concentration of toxic TEs in the soil taken from the tested farms are shown in Figs. 3 and 4. The total concentration of all analyzed toxic TEs in the soil, except for Ni, was lower than the maximum permissible content of the Regulation on permitted amounts of hazardous and harmful substances in agricultural soil and methods for their testing (Off. Gazette of RS, no. 11/1990). The total concentration of Ni in few individual plots were above maximum permissible levels prescribed by law (50 mg kg^{-1}) and were most likely natural geochemical origin, according to review Manojlović and Singh (2012).

Since the solubility and availability of TEs for plants depends on a number of factors in soil, such as: pH-value, $CaCO_3$ content, soil texture, organic matter content, in order to estimates of the potential entry of these toxic elements into the food chain (soil-plant) plant-available concentration of heavy metals was determined after their extraction with DTPA. Plant-available concentration of investigated TEs (Cd, Pb, Ni, Cr) are very low (not shown) and does not present a threat to the food chain.

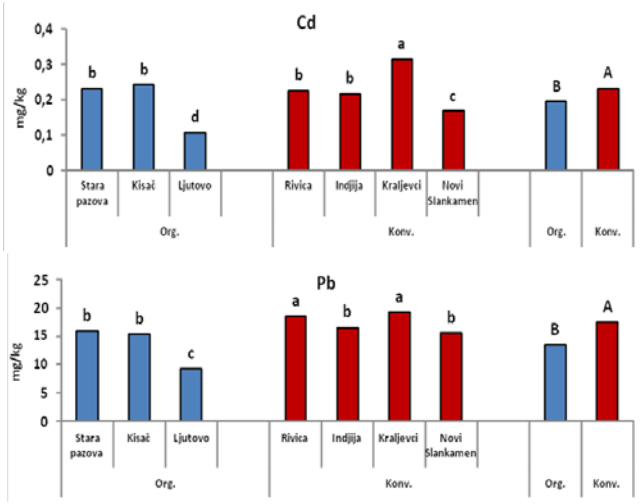

Fig. 3 *Total concentration of toxic TEs (Cd and Pb) in soils from organic and conventional farms.*

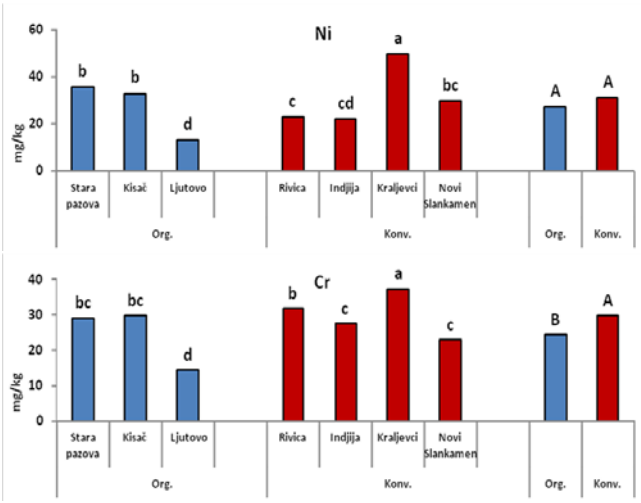

Fig. 4 *Total concentration of toxic TEs (Ni,and Cr) in soils from organic and conventional farms.*

4. Conclusion

The results have shown that total TEs concentrations in soils are under maximum allowance values and therefore risk of TEs contamination is low. However, low level of plant available TEs, particularly zinc (Zn), are found on the most of the investigated plots.

The concentrations of available microelements (Fe, Mn, Cu and Zn) in all soil samples were above the lower limit of optimal provision and field crops and will not positively react to the fertilization with these elements. Soils in Srem are characterized by a low concentration of available Fe which is insufficient for the crops that have increased needs for this element (fruit and grapes).

Regulations on permitted amounts of hazardous and harmful substances in soil and methods for their examination in 1990 (Gazette of RS, no. 11/1990) defines the maximum allowable values for heavy metals in soil. The total content of all analyzed heavy metals in the soil, except Ni, was lower than the maximum content specified in the Regulation. The total content of Ni in certain plots in Srem is above the maximum permitted level prescribed by law (50 mg kg-1) and probably is the natural geochemical origin, as demonstrated by previous research.

Total concentrations of Pb, Cr and Cd were significantly higher in soils from farms with conventional agricultural production compared to soils from farms with organic production.

4. References

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