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Functional Diversity and Activity of Microbial Communities is Altered by Land Use Management in Agricultural Soil of North-East Slovakia

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Abstract—This research was conducted in two farms with different management in north-east Slovakia. The aim of this study was to examine interrelationship between functional biochemical and microbial indicators of soil quality, and their suitability to differentiate areas under contrasting management regimes. Soil samples from two ecological and conventional farming were applied to Biolog EcoPlate and average colour development (AWCD), richness (R) and Shannon diversity index (H) were calculated. Additionally, selected physicochemical and microbial indices were analysed. Over the 5-year study period, it was found that ecological farming contributed to an increase of organic matter and high dose of organic amendment maintained soil pH. Enzymatic tests revealed that activity of most studied enzymes showed higher values in ecological system. Microbial population from the soil under ecological management showed higher metabolic activity. Also the differences of diversity and richness index were observed. Activity and functional diversity of microbial population in the ecological farming were significantly correlated with favourable soil reaction and a higher content of organic matter. We conclude that microbial parameters are most effective indicators of management induced changes to soil quality, and that a variety of microbial analyses should be used when considering the impact of management on soil quality.

Keywords: ecological farming system, conventional farming system, Biolog EcoPlates, soil enzymes, physicochemical properties

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Changes in land use and management practices have significant influence on soil biochemical and physical properties. They are considered to be among the main change of soil quality and there is worldwide concern about the environmental costs of conventional intensification of agriculture. Ecological agriculture aims to harness ecosystem services to sustain crop production while degradation of the ecosystem is minimized [1, 2]. A number of work have been produced to provide quantitative estimates of soil quality. Many authors showed and rated soil quality by assessing key soil function, each of which is quantified using physical, biochemical and microbial parameters [3–5]. In case of biochemical indicators, soil organic matter is typically used as a measure of soil quality.

The improvement of soil organic carbon content can be increased with use of organic amendments, such as animal manure or crop restudies, that can be incorporated into the soil to improve soil quality [6]. A variety of microbial parameters also have the potential for use as diagnostic indicators of soil quality and the measurement of the status and activities of microbial population contributing to soil processes provide particularly rapid and sensitive characterizing changes to soil quality. Additionally, the metabolic characteristics and diversity of soil microbial communities are known to be sensitive to the management [7]. Soil degradation as a consequence of land use intensification is one of the major environmental concerns. Conventional farming systems can lead to deterioration of soil physical, chemical and biological properties, because of intensive and inappropriate use of pesticides and fertilizers [8]. Impact on soil organisms, changing in their composition and activity by management practices is significant and because of soil biota play a key role in biochemical processes in soil ecosystem, preservation of soil microbial diversity is essential [9, 10].

In Slovakia there are several farms that activities are carried out in ecological farming systems and incorporate organic fertilizers and crop residues into the soil system, practice shallow tillage and crop rotation, not using any herbicides, fungicides, mineral fertilizers or burning crop residues. These practices favour microbial diversity and activity, because these microbial attributes are sensitive to soil management practices [3, 11] and their modification may precede detectable changes in soil physicochemical properties and thus provide an early signal of improvement or a warning of degradation [12].

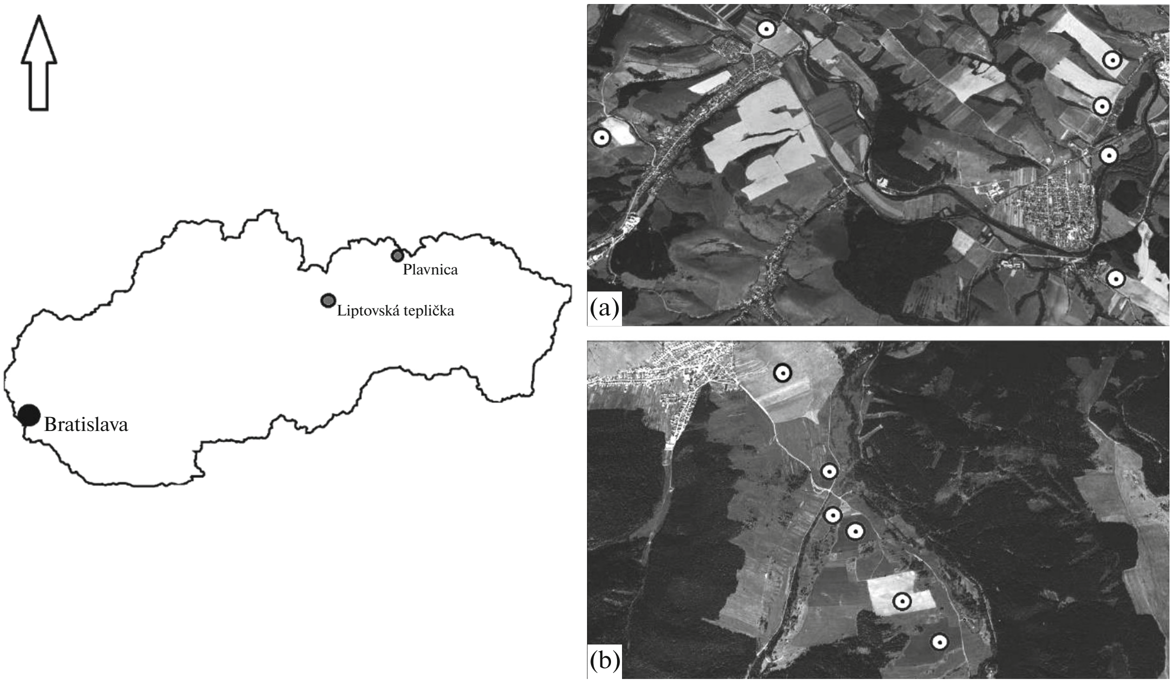

Fig. 1. Experimental localities of the studied areas in (a) Plavnica (conventional farming system) and (b) Liptovská Teplička (ecological farming system).

Although several studies have addressed the activity in agroecosystems under different land use practices [3, 8], little is known about microbial functional diversity and its changes by intensive practices in soil ecosystems. Community level physiological profiles (CLPPs) based on the ability of microorganisms utilize different carbon substrates have been successfully used and they are essential in the assessment of the impact of anthropogenic disturbances on soil ecosystem functioning [13]. Garland and Mills [14] developed a community-level redox technique (the Biolog approach) based on sole C-source utilization for estimating functional microbial community diversity.

In this study we evaluated (i) the functional diversity of microbial communities using Biolog EcoPlates and (ii) selected physicochemical and microbial indicators of soil quality in soils under two different management systems (conventional and ecological). The added value of this study is the long-term determination of the diversity and activity of the microbial community in two differently managed ecosystems.

MATERIALS AND METHODS

Study sites and soil sampling. The research was carried out during years 2014–2018 (in the vegetation season during summer) in two farms that apply conventional (49°16′ N; 20°46′ E) and ecological (48°57′ N; 20°05′ E) farming systems. Both farms are situated in the marginal region of north-eastern of Slovakia (Fig. 1). The farm in Liptovská Teplička that applies ecological farming system (EF) has started its activity since 1996 and is situated in the Low Tatras National Park at an altitude ranging from 846 to 1492 m a.s.l. The whole area is in cold zone with the average precipitation from 700 to 1200 mm. In terms of pedological division, the area is represented mainly by Cambisols mostly moderate and strongly skeletal. Arable land is fertilized with manure at a rate of about 30 t ha^{-1} once in two years in the spring season. In the crop structure, fodder crops represent the biggest portion of the crops (almost 50%), potatoes 16–18% and cereal acreage represents approximately 33%. Crop rotation is: perennial fodder (clover mixture), perennial fodder (clover mixture), winter crops (winter wheat, winter rye, triticale and winter barley), root crops (potatoes), spring crops (spring barley and oats) and annual mixture (oats pea, peas and ryegrass).

The farm that applies conventional farming system in Plavnica (CF) is situated at an altitude ranging from 300 to 900 m a.s.l. with the annual precipitation from 800 to 1100 mm. The largest area is represented mainly by Cambisols, mostly moderate to heavy and moderate skeletal. The farm was established in 1993 and its main activity is cultivation of medical plants. In the current crop structure, medical plants represent more than 55%, forage 20.7% and cereals almost 18%. Crop rotation is: forage, forage, medical plants, cereals, forage and medical plants. Arable land is fertilized mainly with mineral fertilizers: NPK/CaS—N 7.4 kg ha^{-1} P 22.3 kg ha^{-1} K 22.3 kg ha^{-1}, granulated superphosphate 19%—P 54.34 kg ha^{-1} Ca 85.8 kg ha^{-1} S 34.32 kg

ha^{-1}, ammonium saltpeter—N 86.40 kg ha^{-1}, NPK—N 21 kg ha^{-1} P 13.9 kg ha^{-1} K 13.9 kg ha^{-1}. This farm also applies ecological farming systems on some of their fields (mainly for medical plants production), but for this research we have collected samples from the conventionally managed fields.

Soil samples for biochemical and microbial indices were collected from six permanent research sites from both farms from the depth of 0.05 to 0.15 m. The sampling was done at the same time in both farms in early summer season (May–June). In each site, six randomly chosen plots (1 × 1 m) were selected. All soil samples (total of 72 samples) were transferred in the plastic bag to the laboratory and homogenized manually before analysing. Part of the soil samples were air-dried, sieved through a 2 mm sieve and used for measurement of soil chemical characteristics. The rest of freshly collected samples were sieved and maintained at 4°C until processing. Samples for functional diversity determination were inoculated as soon as possible in order no changing in microbial community (within 48 hours).

Soil analysis. Air-dried soil samples were used to measure soil pH and organic carbon content. Additionally, gravimetric soil moisture was calculated on 50 g of fresh subsamples after drying in a 105°C oven for 24 hours. Soil pH was measured in a 1 : 3 mixture of soil and 0.01 M CaCl_2 solution using a digital pH meter. Soil organic carbon was determined by the Turin's method [15].

Enzymatic activity assays were determined using field-moist soil samples, which were sieved through a 2 mm sieve and properly homogenized. Activity of acid and alkaline phosphatase were determined by Grejtovský [16], catalase and urease activity by Khaziev [17]. All determinations were performed in triplicate. The corresponding controls were done for each soil and enzyme activity by the same analysis described, but without the addition of the substrate at the moment of initiating reaction. Activity of all enzymes was measured in a spectrophotometer creating a reference curve.

To evaluate the metabolic potential of whole microbial communities, samples were inoculated in Biolog EcoPlates (Biolog, Hayward, CA, USA), microtiter plates which contains, in triplicate, 31 ecologically relevant carbon substrates with a redox-sensitive tetrazolium indicator of microbial respiration [18]. Prior to inoculation, samples were extracted in 0.85% NaCl, shaken for 1 hour, additionally diluted 10× and centrifuged. Each sample was inoculated in one plate (in triplicate) and incubated in dark at the temperature 25°C. Before the first incubation, the initial measurement was taken and colour formation was measured at 590 nm at regular intervals (every 12 hours) for 10 days using a Microplate Reader. Any corrected optical density (OD) value higher than 0.006 was considered as a positive result for substrate utilization [19]. Average well colour development (AWCD), calculated as the average optical density across all wells per plate, was used as an indicator of general microbial activity.

The Shannon diversity index (H′) and richness (R) were calculated for each community according to Derry et al. [20] and showed overall CLPPs diversity. The Shannon diversity index is one widely used index for comparing diversity between various habitats and summarize the diversity of a population in which each member belongs to a unique group. In ecology, species richness refers to number of species in a given area and indicates how some of the resources potentially available to the community are used [21]. The substrates were divided into six substrate categories, according to their chemical nature: amino acids, carbohydrates, carboxylic acids, amines, phenols and polymers.

Statistical analyses. All statistical operations were performed in R studio program [22]. Spearman's correlation coefficient was used to detect relationships among characteristics of soil microbial activity and functional diversity. Mann–Whitney non parametrical test was used to determine significant differences in soil properties between various management practices (ecological and conventional).

RESULTS AND DISCUSSION

Soil functional diversity. Physiological profiling indicates differences between soil microbial functional diversity, which studies cultivable functional diversity of the whole microbial communities. The use of 31 carbon substrates present in Biolog Ecoplates was sensitive to detect short-term changes in the microbial functional diversity in response to different managed samples from the agricultural fields. After 10 days of incubation, versatility of the substrates was observed in all soil samples. Significant differences ($p < 0.01$) were found in number of positive results, diversity and evenness between the different management practices that is shown in Table 1. Sites under ecological farming system showed higher richness and diversity index compared to the sites under intensive agriculture.

Previous reports also demonstrate the similar observation, where undisturbed, native and organically managed fields contained high functional potential of carbon source utilization in microbial community [11]. The AWCD reflects the oxidative capacity of soil microorganisms developing in the plates and may be used as an indicator of microbial activity. Figure 2 shows the pattern of carbon substrate utilization by each community under two different farming systems. Almost all carbon sources were metabolized at least by one community. High utilization of easily-degradable carboxylic acids and carbohydrates in both farming systems show that bacterial community are stressed due to low nutrient status. High affinity was reported to D-xylose and 2-hydroxybenzoic acid as constituents of root exudates [23]. Phenolic compounds and

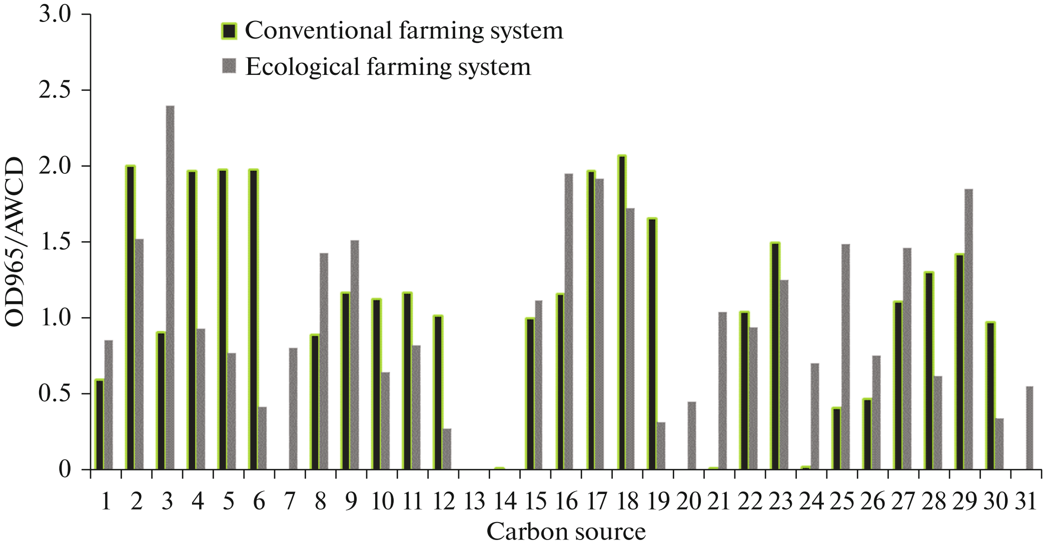

Fig. 2. Carbon source utilization by the communities at day 10 (25°C). Average data represents OD divided by the AWCD. Carboxylic acids: (1) pyruvic acid methyl ester, (2) D-glucosaminic acid, (3) D-galacturonic acid, (4) γ-hydroxybutyric acid, (5) itaconic acid, (6) α-ketoburytic acid, (7) D-malic acid. Polymers: (8) Tween 40, (9) Tween 80, (10) α-cyclodextrin, (11) glycogen. Carbohydrates: (12) D-cellobiose, (13) α-D-lactose, (14) β-methyl-D-glucoside, (15) D-xylose, (16) i-erythritol, (17) D-mannitol, (18) N-acetyl-D-glucosamine, (19) glucose-1-phosphate, (20) D,L-α-glycerol phosphate, (21) D-galactonic acid γ-lactose. Phenols: (22) 2-hydroxybenzoic acid, (23) 4-hydroxybenzoic acid. Amino acids: (24) L-arginine, (25) L-asparagine, (26) L-phenylalanine, (27) L-serine, (28) L-threonine, (29) glycyl-L-glutamic acid. Amines: (30) phenyl ethylamine, (31) putrescine.

polymers (Tween 40, Tween 80) were also efficiently metabolized by microorganisms. Polymers are suggested to be accumulated in psychrophilic conditions by algae and fungi in order to grow at low temperature [24], where our research was carried out.

Functional diversity of microbial population is affected by many factors. The study of Chavan and Nadanathangam [25] revealed changes in metabolic profile in the presence of metal nanomaterials and the authors show that testing ecotoxicity of toxic elements using readily culturable bacteria is a practical approach. The other research noted that the soil edaphone had effect not only on biological properties in soil systems, but also significantly changed parameters of functional diversity of the microbial community of soil [26].

Soil physicochemical and microbial indices. Water in the soil is very important factor affecting the existence of life in the soil environment. The biological activity in the soil system is favourably influenced by the optimal values of soil moisture. At present, great emphasis is placed on preserving and improving the structure, especially by cultivating and using all available organic fertilizers, because only structural soil with the sufficient organic substances is able to retain maximum moisture and transfer it to plants, especially in times of drought [27]. In the ecological farming system, the high concentration of organic carbon significantly affects the values of physical indices and overall we can state that ecological management have a more favourable effect on the physical properties and stability parameters of the soil structure [28]. The average values of soil physical and biochemical indices show Table 1. Long-term sustainable growing systems are able to optimize and stabilize the values of chemical parameters [29] that was also shown in our study.

Soil reaction has a significant impact on the development of plants, soil microorganisms and on the chemical and biological processes in the soil system. It affects the development and activity of beneficial bacteria, biochemical reactions, solubility of many substances, nutrient availability, soil structure, and thus virtually all soil properties. Soil reaction is one of the important factors of soil fertility, despite the fact that its value is dynamic and varies depending on the internal and exter-

Table 1. Average number and standard deviation (±) of positive results, diversity and richness for both studied localities during research period (2014–2018)

Farming system	Positive results[a]	Shannon diversity index (H)[b]	Richness (R)[b]
Ecological	30 ± 2**	3.24 ± 0.11**	10.3 ± 1.15**
Conventional	26 ± 1**	1.40 ± 0.90**	6.0 ± 1.93**

[a] Numbers of metabolized substrates (OD > 0.006, [b] OD of 0.25 (as a threshold for positive response) was taken for calculation of H and R.
** Significant differences ($p < 0.01$).

nal factors. Increased soil acidity suppresses the activity of beneficial bacteria and thus reduces biological activity, impairs soil properties, increases the mobility of some heavy metals, and therefore it is necessary to pay attention to adjusting the optimal pH and minimize calcium and magnesium losses from the soil [30]. Due to the influence of chemical fertilizers in intensive farming systems, the toxic elements enter the soil ecosystem. Such contaminated soil has significant impact on the microbiota, soil respiration, as well as other biochemical soil indices [31].

Similar research of Kolesnikov et al. [32] and Terekhova et al. [33] that studied pollution of toxic elements on various types of soil observed deterioration of biological properties, such as bacterial abundance, species structure of microbiota and activity of soil enzymes. Their study showed that biological indicators used in their study have a high correlation coefficient with soil contamination and high sensitivity to soil pollution. Therefore, it is advisable to use these biological indicators to monitor the status of soil health and quality, which is also confirmed in our study.

During the observed period, the values of the soil reaction changed minimally. The values of soil pH in the ecological system ranged from 6.2 to 6.7 on arable land. Based on these results, we can state that the soil reaction ranged in this area in the category of slightly acidic to neutral. The optimal state of this parameter is influenced by the ecological farming system, because physiologically acid mineral fertilizers are not applied in this research locality. The pH values in the conventional system ranged from 5.8 to 6.5, which creates a slightly acidic environment of the soil ecosystem. For this reason, it is important to pay attention to the soil reaction, because soil is naturally acidified through acidic atmospheric precipitation, as well as the increased release of calcium from the soil by plants. The positive impact of ecological farming on soil pH and its adjustment has been confirmed by several studies dealing with the conversion from conventional to organic farming and its long-term monitoring of the soil ecosystem [2, 4, 29].

Soil organic matter is a key component of soil quality and health and changes in agricultural management have serious impact on soil organic carbon content [34]. Soils with a low carbon content have a low ability to absorb nutrients and are very easily subject to erosion [35]. Therefore, it is important to maintain amount of soil organic matter and to ensure that losses of soil organic matter in the processes of decomposition, mineralization and humification of organic matter in the soil are fully replaced by fresh organic matter.

The main source of organic matter is organic carbon and application of high dose of organic fertilizers (manure) in ecological farming system had favourable impact on increasing amount of this parameter. The values of organic carbon content in this research ranged from 3.08 to 3.82%, which represents a locality with very good humic soils. Conventional farming systems represents a locality with moderate humic soil where values of soil organic carbon content ranged from 1.10 to 1.75%. The content of organic matter in soil system might be affected by different land use and increased mineralization of organic matter during conventional tillage may lead to a slight acidification of the soil environment. The close relationship between richness and Shannon diversity index with soil carbon (Table 2) suggest that the increase in microbial community functional potential may be explained by an increase in carbon availability as a consequence of amendment incorporation [11].

Many authors [34, 36, 37] showed a significant reduction of organic carbon in intensively managed soils compared to soils with reduced external inputs. Study of Marinari et al. [38] showed that organically managed system lasting for longer than seven years can predict an increment of soil organic matter. Their study also showed that organic farms significantly accumulate soil organic carbon matter, increase enzyme activities and soils supplied with manure have higher microbial activity than soils with chemical fertilizers.

In the studied areas, significant increase of enzymatic activities in the ecological farming systems have been observed. Despite variations among five years of sampling, the ecological management showed a higher values of soil microbial indices compared to soils of conventionally managed fields (Table 2). In this study, enzymatic activities as an indication of microbial activity, were significantly higher in ecologically managed soil compared to conventional fields. Ecological land use promoted activity of soil urease and both phosphatases and their activity was nearly twice higher compared to the conventional system during all studied period.

Activity of soil phosphatases have different optimal soil reaction and therefore are divided into acid and alkaline. Average values of acid phosphatase activity varied from 269 to 291 μg P $g^{-1}3$ h^{-1} in ecological farming and from 167 to 204 μg P g^{-1} 3 h^{-1} in conventional farming, which show 33% lower content of this enzyme in the conventional farming system. Average values of alkaline phosphatase activity varied from 258 to 288 μg P g^{-1} 3 h^{-1} in ecological farming and from 168 to 196 μg P g^{-1} 3 h^{-1} in conventional farming, which also show 33% lower content of this enzyme in the conventional farming system. Both phosphatases are associated with the hydrolysis of organic esters into inorganic phosphate and their values are higher under ecological management.

One of the most common soil enzyme that is strongly bound to soil organic matter is urease. Average values of soil urease activity varied from 0.54 to 0.56 mg $NH_4 \pm N$ g^{-1} 24 h^{-1} in ecological farming and from 0.19 to 0.43 mg NH_4^+ N g^{-1} 24 h^{-1} in conventional system, which show 43% lower content of this enzyme

Table 2. Average values and standard deviations (±) of selected soil physical and biochemical properties during research period (2014–2018)

Parameter	Farming system	Year				
		2014	2015	2016	2017	2018
Water content, %	Ecological	26.2 ± 1.1	26.9 ± 1.0	27.4 ± 1.2	26.8 ± 1.2	28.6 ± 1.1
	Conventional	24.6 ± 1.2	24.0 ± 1.3	21.8 ± 1.2	24.4 ± 1.1	24,6 ± 1.4
Organic C, %	Ecological	3.62 ± 0.2	3.40 ± 0.1	3.28 ± 0.2	3.44 ± 0.2	3.56 ± 0.1
	Conventional	1.45 ± 0.3	1.37 ± 0.2	1.30 ± 0.2	1.35 ± 0.1	1.33 ± 0.3
pH $CaCl_2$	Ecological	6.3 ± 0.1	6.6 ± 0.1	6.4 ± 0.1	6.5 ± 0.1	6.5 ± 0.1
	Conventional	6.3 ± 0.2	6.4 ± 0.1	6.1 ± 0.1	6.1 ± 0.3	6.2 ± 0.2
URE	Ecological	0.52 ± 0.01	0.48 ± 0.03	0.52 ± 0.04	0.56 ± 0.02	0.63 ± 0.02
	Conventional	0.21 ± 0.02	0.27 ± 0.02	0.26 ± 0.02	0.39 ± 0.04	0.37 ± 0.03
CAT	Ecological	1.30 ± 0.1	1.52 ± 0.2	1.36 ± 0.1	1.45 ± 0.1	1.65 ± 0.2
	Conventional	1.84 ± 0.2	1.70 ± 0.2	1.82 ± 0.3	1.79 ± 0.2	1.85 ± 0.2
$PHOS_{AC}$	Ecological	273 ± 4.3	281 ± 3.9	285 ± 4.4	286 ± 5.0	286 ± 4.9
	Conventional	181 ± 5.0	187 ± 4.8	171 ± 3.7	183 ± 4.5	198 ± 5.1
$PHOS_{AL}$	Ecological	263 ± 4.6	272 ± 3.8	276 ± 5.0	282 ± 4.9	283 ± 5.5
	Conventional	171 ± 3.6	173 ± 4.5	178 ± 5.1	190 ± 4.6	185 ± 5.2

URE—Urease (mg $NH_4^+ - N\,g^{-1}\,24\,h^{-1}$), CAT—Catalase (mL $O_2\,g\,min^{-1}$), $PHOS_{AC}$—acid phosphatase (μg P $g^{-1}\,3h^{-1}$), $PHOS_{AL}$—alkaline phosphatase (μg P $g^{-1}\,3\,h^{-1}$).

Table 3. Correlation coefficients (r) between selected biological and physicochemical indices under ecological and conventional farming systems

Parameter	Farming system	Water content	Organic C	pH $CaCl_2$
URE	Ecological	ns	0.85^{++}	0.56^{+}
	Conventional	ns	0.62^{++}	ns
CAT	Ecological	ns	-0.63^{+}	ns
	Conventional	ns	ns	ns
$PHOS_{AC}$	Ecological	ns	0.84^{++}	0.62^{+}
	Conventional	0.68^{+}	0.83^{++}	0.79^{+}
$PHOS_{AL}$	Ecological	ns	0.62^{+}	0.86^{+}
	Conventional	ns	0.78^{+}	0.75^{+}
H	Ecological	ns	0.63^{+}	0.66^{+}
	Conventional	ns	ns	0.56^{+}
R	Ecological	ns	0.64^{+}	0.75^{+}
	Conventional	ns	ns	0.78^{+}

$^{+}p < 0.05$, $^{++}p < 0.01$, ns—no significance.
URE—Urease, CAT—Catalase, PHOSAC—Acid phosphatase, PHOSAL—Alkaline phosphatase, H—Shannon diversity index, R—Richness.

in the conventional farming system. Activity of soil urease during the research period showed minimal variation that might be explained that increasing amount of organic matter protects the natural supply of this enzyme that was also shown in the previous studies [3, 39].

Average values of soil catalase ranged from 1.20 to 1.82 mL O_2 g min^{-1} in ecological farming and from 1.50 to 2.05 ml O_2 g min^{-1} in conventional farming system. Although activity of this enzyme is quite stable in soils as other soil enzymes, our study showed 17% higher content of soil catalase in the conventional managed fields. In the previous studies, it has been reported that catalase is not related to the amount of microorganisms and content of organic carbon in soil ecosystem [40, 41]. Our study showed that there is an inverse significant relationship between activity of soil catalase and organic matter content.

It is known that there is a strong relationship between soil organic matter and enzyme activities [38] and between microbial indices and soil reaction [36]. These relationships were also shown in our study (Table 3). The most significant correlation with the

Table 4. Analysis of variance of biological parameters

Parameter	Source of variability	df	F-value	Significance
URE	Year	4	21.85	++
	Locality	1	488.57	++
CAT	Year	4	0.38	ns
	Locality	1	102.43	++
PHOS_{AC}	Year	4	5.49	++
	Locality	1	3350.65	++
PHOS_{AL}	Year	4	125.93	++
	Locality	1	17218.39	++
H	Year	4	519.96	++
	Locality	1	11019.83	++
R	Year	4	237.76	++
	Locality	1	629.60	++

URE—Urease, CAT—Catalase, PHOSAC—Acid phosphatase, PHOSAL—Alkaline phosphatase, H—Shannon diversity index, R—richness.

microbial indicators was observed with the content of soil organic matter and these results corresponded with several authors [38, 42]. Also, a statistically significant effect of experimental years and localities on all observed soil microbial indices were confirmed by analysis of variance (Table 4).

Despite the fact, that most soil parameters are influenced by soil management, many authors [3, 38, 43] reported that biological indices (microbial biomass, enzyme activities, soil respiration, nitrogen mineralization) respond more quickly to management and land use. Therefore, Microbial biomass C and activity of soil enzymes are to be considered as more sensitive indicators of soil quality and health compared to chemical and physical properties [44]. Soil microbiota exist in the labile fraction of soil organic matter involved in the energy and nutrient cycling. Therefore, microbial attributes may respond more quickly to changes in management practices or environmental disturbances compared to physical and chemical properties [45]. Analysis of soil composition showed that the samples from ecological and conventionally managed fields differed greatly in their biochemical content. It is well known that the availability of organic compounds directly influences the composition and activity of soil microbial communities [46]. Our study demonstrated that ecologically managed soils exhibited greater biological activity (soil enzymes, functional diversity) compared to the conventionally managed soils, agreeing with the other studies [47, 48].

CONCLUSIONS

Microorganisms have one of the basic roles in soil autoregulation processes and soil enzymes can control degradation and synthetic biochemical processes. It is known that soil fertility is conditioned by its biological activity. From the biological characteristics, the activity of soil enzymes, soil respiration, the size of the microbial biomass, the structure of the microbial community is most often used to evaluate the quality and health of the soil.

The two farming systems (ecological and conventional) studied at farm level in north-east of Slovakia has pointed out interesting differences on soil quality. Organic amendments and low input system significantly affected soil microbial and chemical properties by increasing microbial activity and soil functional diversity. They can represent a set of sensitive indicators of soil quality and health that can early detect the environmental disturbances in soil ecosystem.

This study also highlights the importance of organic agroecosystems that have a positive impact on the development of biological and chemical parameters in soil ecosystems. This research also contributes to the knowledge about the complex and particular microbial activity and diversity found under two different farming management and show the distribution of microbial functional groups within these ecosystems. This study also brings the view that soil chemical indices directly influence the activity and diversity of microbial communities that are key components of nutrient cycling in soil ecosystem.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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