QUANTITY AND QUALITY OF SOIL ORGANIC MATTER IN ECOLOGICAL AND INTEGRATED FARMING SYSTEM

KVANTITA A KVALITA PÔDNEJ ORGANICKEJ HMOTY V EKOLOGICKOM A INTEGROVANOM SYSTÉME HOSPODÁRENIA

Erika TOBIAŠOVÁ

Department of Soil Science, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra, e-mail: Erika.Tobiasova@uniag.sk

ABSTRACT

Impact of farming system on the quantity and quality of soil organic matter was studied. The experiment was situated on Haplic Luvisol of Research – experimental base of Slovak University of Agriculture Dolná Malanta, where over a period of 5 years soil samples from ecological (ES) and integrated (IS) farming system were collected. In period of 5 years, on average higher contents of total organic carbon (TOC) and total nitrogen (NT) were in ES (1.219%; 1382 mg.kg^{-1}) than in IS (1.121%; 1262 mg.kg^{-1}). TOC content in the ES was on the level of variants with application of farmyard manure, while in the IS it was on the level of non-fertilized variants. The highest contents of TOC and non-labile carbon (C_{NL}) were recorded in 2010 when the previous crops were alfalfa (*Medicago sativa*) and pea (*Pisum sativum*). Higher content of C_{NL} was in the ES than in the IS. A positive linear relationship between the amounts of precipitation per year and during the vegetation was observed not only between TOC contents (r = 0.914, $P < 0.05$ and r = 0.971, $P < 0.01$), but also C_{NL} contents (r = 0.880, $P < 0.05$ and r = 0.952, $P < 0.05$). The most stabilized humus substances were in 2007, when the highest average temperature per year and during the vegetation was recorded. In 2010, the lowest amounts of extracted humus substances were recorded, with domination of humic acids. Their stability, however, on the base of colour coefficients of humus substances and humic acids were the lowest from all years. The humus substances were more stabilized in the IS than in the ES.

Key words: farming system, Haplic Luvisol, soil organic matter

DETAILED ABSTRACT IN NATIVE LANGUAGE

Práca sa zaoberá vplyvom systému hospodárenia na kvantitu a kvalitu pôdnej organickej hmoty. Experiment bol situovaný na hnedozemi Výskumno-experimentálnej báze SPU Malanta, kde v perióde 5 rokov boli odoberané pôdne vzorky z ekologického (ES) a integrovaného (IS) systému hospodárenia. V obidvoch systémoch hospodárenia boli zahrnuté varianty hnojené maštaľným hnojom a nehnojené varianty. V ES bol zaznamenaný v časovej perióde 5 rokov v priemere vyšší obsah celkového organického uhlíka (TOC) (1,219 %) a celkového dusíka (1382 mg.kg^{-1}) ako v IS (1,121 % a 1262 mg.kg^{-1}). Obsah TOC sa v ES pohyboval na úrovni variantov hnojených maštaľným hnojom, kým v IS to bolo približne na úrovni nehnojeného variantu. Najvyššie obsahy TOC a nelabilného uhlíka (C_{NL}) boli zaznamenané v roku 2010, kedy boli predplodinami lucerna siata (*Medicago sativa*) a hrach siaty (*Pisum sativum*). Vyšší obsah frakcie C_{NL} bol v ES ako v IS. Pozitívna lineárna závislosť medzi množstvom zrážok za rok ako aj počas vegetácie bola zaznamenaná nielen medzi obsahom TOC (r=0,914; P<0,05 a r=0,971 P<0,01), ale aj C_{NL} (r=0,880; P<0,05 a r=0,952; P<0,05). Najstabilnejšie humusové látky boli v roku 2007, kedy bola zaznamenaná najvyššia priemerná teplota za rok aj za vegetáciu. V roku 2010 boli zaznamenané najnižšie množstvá vyextrahovaných humusových látok, pričom dominovali humínové kyseliny. Ich stabilita však na základe farebných kvocientov humusových látok a humínových kyselín bola najnižšia zo všetkých rokov. V ES boli humusové látky menej stabilizované ako v IS.

Kľúčové slová: hnedozem, systém hospodárenia, pôdna organická hmota

INTRODUCTION

In agriculture, the increased interest is aimed to the soil organic carbon content as the main indicator of soil quality (Smith, 2005). Increasing of organic substances inputs by the way of farming system is a key role of carbon content increasing (Janzen et al., 1992). Soil organic matter is one of components, which is changed by soil management system (Dębska et al., 2009; Dębska et al., 2010; Robinson et al., 1994; Šimanský and Zaujec, 2009). By reducing its content, the soil productivity also decreases (Bauer and Black, 1994). Intensive agricultural systems change the properties of organic matter and support carbon losses (Ding et al., 2002). Sustainable systems lead to the preservation of organic matter (Batjes, 1998). Farming systems significantly affect not only the quantity, but also the quality of soil organic matter (Tobiašová, 2010). Schjőnning et al. (2007) recorded changes in their quality after 5 to 6 years. In short-term, nutrient cycles, especially labile forms of soil organic matter play important role (Tisdall and Oades, 1982). Labile components are degraded within a few weeks or months, but stabile can remain in the soil for years or even decades (Theng et al., 1989). Stabile organic components in soil are represented by humus substances and significantly affect the soil properties and productive ability of soil (Galantini and Rosell, 2006). Transformation processes of soil organic matter in arable land are during the year affected not only by the temperature and moisture (Fierer and Schimel, 2002), but also by inputs of organic matter into the soil through the vegetation (Campbell, 1978) and organic fertilizers (Marriott and Wander 2006; Zaujec and Šimanský, 2006). The aim of this study was to assess the impact of farming system on the quantity and quality of soil organic matter.

MATERIALS AND METHODS

Research – experimental base of SUA is a part of the territory, which is located in the lower part of Selenec river basin and its tributaries belonging to the middle part of Nitra river basin. It is located east of the city of Nitra on Žitava hilly land (Hrnčiarová, 2001). The geological substrate consists of little permeable rocks with a high proportion of fine-grained material. Young neogene sediments consist of various clays, loams, sands and gravels, on which in the Pleistocene, loess sediments were deposited (Hrnčiarová and Miklóš, 1991). Soil type is Haplic Luvisol. Basic soil characterics of studied locality were described by Tobiašová and Šimanský (2009). Climatic region is warm, very dry, lowland, with the length of periods with air temperature above 5ºC 237 days (Linkeš et al., 1996). The average sum of annual precipitation is 540 mm, and the average annual temperature is 9.6ºC (Špánik et al., 2002). The altitude of this locality is 170 m n. m.

The experiment included two farming systems on arable land: ecological (ES) and integrated (IS). Overall, crop rotation structure in the ES includes: 33.3% of cereals, 16.7% of legumes, 16.7% of root crops, and 33.3% of forage, and the percentage proportions of crops in the IS are: 50% of cereals, 16.7% of legumes, 16.7% of root crops, and 16.7% of forage. In both farming systems, fertilized variant (O) and non-fertilized variant (OR) are included. In the fertilized variant of the IS, inorganic fertilizers are used in doses, which are determined according to the balance method, and farmyard manure is applied to silage maize in dose of 40 $t.ha^{-1.}$ In the ES, farmyard manure is applied in the same dose to silage maize, but additional nitrogen is provided through the symbiotic fixation. In both farming systems, soil tillage is based on the tillage with elements of minimizing (Tobiašová and Šimanský, 2009).

The soil samples were collected to a depth of 0.3 m in spring. They were dried in a room temperature, and after drying, they were grinded and homogenized. In soil samples, following chemical parameters were determined: the total organic carbon (TOC) according to Tyurin method in Nikitin modification (Orlov and Grišina, 1981), the group composition of humus substances according to method Belčikova – Kononova (Kononova and Belčikova, 1962), the labile carbon (C_L) by $KMnO_4$ oxidation (Loginov et al., 1987) and the total nitrogen according to Kjeldahl method (Peterburskij, 1963). The lability of carbon (L_C) was calculated according to Blair et al. (1995).

The differences between variants were assessed with the Tukey test at a significance level $P < 0.05$. Correlation analysis was used to determine mutual relationships. Significant correlation coefficients were tested at $P < 0.05$ and $P < 0.01$.

RESULTS AND DISCUSSION

The quantity of soil organic matter was influenced mainly by the management systems and the fertilization (tab. 1). In the period of 5 years, on average higher content of total organic carbon was recorded in the ES than in the IS. Marriott and Wander (2006) showed on a higher ability of organic farming systems to maintain soil organic matter content comparable to the systems with supply of manure and compost. Its content in the ES was approximately at the level of variants with application of farmyard manure, while in the IS, it was at the level of non-fertilized variants. Overall, the highest contents were recorded in 2010, when the previous crops mainly alfalfa and pea were. These plants are characterized not only by the large source of crop residues (Jurčová and Bielek, 1997), but also root exudates Jurčová (1990), and they also participate on nitrogen fixation.

The organic matter is represented by the labile and stabile fractions. Contents of non-labile carbon copy the contents of total organic carbon. Their highest contents were recorded also in 2010, indicating not only higher inputs of organic matter into the soil, but also their higher stability. Stabile organic substances in soil are also naturally resistant to the microorganisms activity, or they are physically protected by adsorption in aggregates (Theng et al., 1989; Tobiašová, 2011).

Table 1 Assessment of selected factor influences on carbon parameters

Factor	TOC	C_L [g.kg^{-1}]	C_{NL}	L_C	NT [mg.kg^{-1}]	C:N
Year						
2006	11,570 a	1,841 ab	9,724 a	0.191 a	1,212 a	9.62 b
2007	11,340 a	2,088 ab	9,262 a	0.225 b	1,096 a	9.86 b
2008	11,000 a	1,748 a	9,254 a	0.189 a	1,456 b	7.30 a
2009	11,200 a	1,719 a	9,489 a	0.181 a	1,682 b	6.91 a
2010	13,410 b	2,146 b	11,261 b	0.190 a	1,164 a	12.03 c
Farming system						
ES	12,190 b	1,992 a	10,200 b	0.195 a	1,382 b	8.90 a
IS	11,210 a	1,825 a	9,396 a	0.195 a	1,262 a	9.39 a
Crop rotation						
5	11,670 a	1,855 a	9,818 a	0.190 a	1,332 a	9.12 a
7	11,730 a	1,962 a	9,778 a	0.200 a	1,312 a	9.17 a
Fertilization						
O	11,230 a	1,783 a	9,447 a	0.189 a	1,201 a	9.75 b
OR	12,180 b	2,033 b	10,149 b	0.201 a	1,443 b	8.54 a

ES – ecological farming system, IS – integrated farming system, 5 – crop rotation on plot 5, 7 – crop rotation on plot 7, O – non-fertilized variant, OR – fertilized variant, TOC – total organic carbon, C_L- labile carbon, C_{NL} – non-labile carbon, L_C – lability of carbon, NT – total nitrogen, C:N – ratio of carbon to nitrogen. Different letters (a, b, c) between factors show statistically significant differences (P<0.05) – Tukey test.

In this case, the reason can be also the physical stabilization of organic substances, which became the cement between the mineral particles in soil aggregates, making them resistant against further microorganisms activity. To their higher stabilization in the previous year, lower amount of precipitation per year and their lowest amount during the vegetation, compared to other years contributed. Also, the average temperature per vegetation was the highest in 2009.

Table 2 Tendency of dependences between carbon fractions and selected factors

	Linear	r	Logarithmic	r
TOC and P py	y = 0.1355x - 966.04	0.914^{+}	y=1648.3Ln(x) - 14817	0.908^{+}
TOC and P pvg	y = 0.1403x - 1249.9	0.971^{++}	y=1711.2Ln(x) - 15633	0.966^{++}
C_{NL} and P py	y = 0.1512x - 861.55	0.880^{+}	y=1534.6Ln(x) - 13479	0.871^{+}
C_{NL} and P pvg	y = 0.1595x - 1170.1	0.952^{+}	y=1625.6Ln(x) - 14542	0.946^{+}

	Power-law	r	Exponential	r
TOC and P py	$y = 2E\text{-}07x^{2.3366}$	0.880^{+}	$y = 64.101e^{0.0002x}$	0.887^{+}
TOC and P pvg	$y = 5E\text{-}13x^{3.6546}$	0.960^{++}	$y = 11.286\ e^{0.0003x}$	0.964^{++}
C_{NL} and P py	$y = 2E\text{-}06x^{2.1558}$	0.837	$y = 75.626\ e^{0.0002x}$	0.847
C_{NL} and P pvg	$y = 7E\text{-}12x^{3.4475}$	0.933^{+}	$y = 13.669e^{0.0003x}$	0.940^{+}

TOC- total organic carbon, C_{NL}- non-labile carbon, P – precipitation, py – per year, pvg – per vegetation period

Positive linear relationships between the amount of precipitation per year and during the vegetation were recorded not only with total organic carbon content, but also with its non-labile fraction (tab. 2). The relationship, between the carbon content and the amount of water in the soil, was recorded by several authors (Alvarez and Lavado, 1998; Burke et al., 1989; Cassman et al., 2002). Higher carbon content of non-labile fraction was in the ES than in the IS.

The total organic carbon content is an indicator for a longer period. If we want to assess the impact of farming system on arable land, it can be at least a period of one crop rotation. If we found out, after several years, that there are losses of soil organic matter, the return to the conditions at the beginning can be more difficult, perhaps sometimes impossible. For this reason, as more appropriate parameter seems labile carbon content. In 2010, the labile carbon had the highest proportion as well. Alfalfa produces, during its vegetation, a huge amount of root exudates. These are substances that are easy available sources of food for soil organisms, thus we consider them for a source of labile carbon. Rhizodeposition is the main source of labile carbon for the activity of heterotrophic microorganisms (Hütsch et al., 2002). Legumes also participated in atmospheric nitrogen fixation, which consequently in 2009 resulted in higher nitrogen content in soil. Higher inputs of nitrogen into the soil were reflected also in the narrowest C: N ratio. The rate of nitrogen decomposition is higher than the rate of carbon decomposition, which resulted in the expansion of C: N ratio (Gregorich et al., 2003). Narrower C: N ratio assumes higher intensity of transformation processes of organic substances in soil. Rovira and Vallejo (2002) assume that soil organic matter quality is decreasing with increasing of intensity of decomposition processes. This was also reflected in other quality parameters of organic substances in soil. In 2010, the lowest amounts of extracted humus substances were recorded, but humic substances were dominated, and thus the ratio of carbon of humic acids to carbon of fulvic acids refers to the highest quality of humus in that year (tab. 3).

Table 3 Assessment of selected factor influences on soil organic matter quality

Factor	C_{HS}	C_{HA} [%]	C_{FA}	C_{HA}:C_{FA}	Q_{HS}	Q_{HA}
Year						
2006	74.26 c	38.77 b	35.49 b	1.11 b	4.79 b	4.04 b
2007	35.47 a	19.13 a	19.11 a	1.01 b	3.21 a	2.58 a
2008	54.74 b	17.50 a	37.03 b	0.48 a	5.67 d	4.54 c
2009	38.70 a	19.87 a	18.83 a	1.06 b	5.11 bc	4.04 b
2010	34.34 a	18.61 a	15.73 a	1.22 b	5.45 cd	4.67 c
Farming system						
ES	46.86 a	22.08 a	25.08 a	0.92 a	4.96 b	3.98 a
IS	48.14 a	23.47 a	25.39 a	1.03 b	4.73 a	3.96 a
Crop rotation						
5	48.70 a	23.26 a	25.35 a	1.01 a	4.94 b	4.01 a
7	46.31 a	22.29 a	25.12 a	0.94 a	4.75 a	3.94 a

ES – ecological farming system, IS – integrated farming system, 5 – crop rotation on plot 5, 7 – crop rotation on crop 7, C_{HS} – carbon of humus substances, C_{HA} – carbon of humic acids, C_{FA} – carbon of fulvic acids, C_{HA}:C_{FA} – ratio of carbon of humic acids to carbon of fulvic acids, Q_{HS} – colour coefficient of humus substances, Q_{HA} – colour coefficient of humic substances. Different letters (a, b, c, d) between factors show statistically significant differences (P<0.05) – Tukey test.

Their stability, however, based on the colour coefficients of humus substances and humic acids, was the lowest of all years. The most stabile humus substances, as well as humic acids, were also in 2007, when the highest average temperature per year and during the vegetation was recorded. The results of Martin et al. (1998) also show on higher degree of humification of humic acids of warmer areas.

The humus substances in the ES were less stabilized, because in crop rotation of this farming system, higher proportion of forages was and this contributed to the higher proportion of labile carbon coming from root exudates. Legume crop residues are often decomposed faster than the cereal, because of narrower C: N ration in cereal residues (Primavessi, 1984). Narrower C: N ratio is the result of higher intensity of transformation processes, and thus a higher content of labile carbon. Legumes participate not only on nitrogen fixation, but also contribute to the increasing of nitrogen availability (Vieira et al., 2007). The nitrogen content was higher in the ES than in the IS. Crop rotation with the proportion of leguminous plants has important impact on soil organic carbon sequestration (Bhattacharyya et al., 2009), which content was also higher in the ES.

CONCLUSION

On the whole, higher content as total organic carbon both total nitrogen, was in the ES than in the IS. Higher quality of soil organic matter, however, was recorded in the IS than in the ES. Differences, which were recorded in years, are the result as crops both basic climatic characteristics, especially precipitation per year.

ACKNOWLEDGEMENTS

This project was supported by the Scientific Grant Agency of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences (VEGA No 1/0513/12 a 1/0300/11).

REFERENCES

Alvarez, R., Lavado, R.S., (1998) Climate, organic matter and clay content relationships in the Pampa and Chaco soils, Argentina. Geoderma 83, 127-141.

Batjes, N.H., (1998) Mitigation of atmospheric CO_2 concentrations by increased carbon sequestration in the soil. Biol. Fertil. Soils 27, 230-235.

Bauer, A., Black, A.L., (1994) Quantification of the effect of soil organic matter content on soil productivity. Soil Sci. Soc. Am. J. 58, 185-193.

Bhattacharyya, R., Prakash, V., Kundu, S., Srivastva, A.K., Gupta, H.S., (2009) Soil aggregation and organic matter in a sandy clay loam soil of the Indian Himalayas under different tillage and crop regimes. Agric. Ecosys. Environ. 132, 126-134.

Blair, G.J., Lefroy, R.D.B., Lisle, L., (1995) Soil carbon fractions, based on their degree of oxidation, and the development of a Carbon Management Index for agricultural systems. Austr. J. Agric. Res. 46, 1459-1466.

Burke, I.C., Yonker, C.M., Parton, W.J., Cole, C.V., Flach, K., Schimel, D.S., (1989) Texture, climate, and cultivation effects of soil organic matter content in U.S. grassland soils. Soil Sci. Soc. Am. J. 53, 800-805.

Campbell, C.A., (1978) Soil organic carbon, nitrogen and fertility. In: M., Schnitzer, S.U., Khan (1978) Soil organic matter. Developments in Soil Science 8. Amsterdam: Elsevier Scientific, p.p. 173-271.

Cassman, K., Dobermann, A., Walters, D.T., (2002) Agroecosystems, nitrogen use efficiency and nitrogen management. Ambio. 31 (2), 132-140.

Dębska, B., Banach-Szott, M., Dziamski, A., Gonet, S.S., (2010) Chromatographic characteristics (HPLC, HPSEC) of humic acids of soil fertilised with various organic fertilisers. Chemistry and Ecology 26, 49-57.

Dębska B., Szombathová N., Banach-Szott M., (2009) Properties of humic acids of soil under different management regimes. Polish Journal of Soil Science 42, 131-138.

Ding, G., Novak, J.M., Amarasiriwardena, D., Hunt, P.G., Xing, B., (2002) Soil Organic Matter Characteristics as Affected by Tillage Management. Soil Sci. Soc. Am. J. 66, 421-429.

Fierer, N., Schimel, J.P., (2002) Effects of drying-rewetting frequency on soil carbon and nitrogen transformations. Soil Biol. Biochem. 34, 777-787.

Galantini, J., Rosell, R., (2006) Long-term fertilization effects on soil organic matter quality and dynamics under different production systems in semiarid Pampean soils. Soil Till. Res. 87, 72-79.

Gregorich, E.G., Beareb, M.H., Stoklasa, U., St-Georgesa, P., (2003) Biodegradability of soluble organic matter in maize-cropped soils. Geoderma 113, 237–-252.

Hrnčiarová, T., (2001) Ekologická optimalizácia poľnohospodárskej krajiny (modelové územie Dolná Malanta) (Ecological optimization of agricultural land – model territory – Dolná Malanta). VEDA SAV. Bratislava.

Hrnčiarová, T., Miklós, L., (1991) Morphometric indices interpretation of water and material motion dynamics illustrated on the example Dolná Malanta. Ecology 10, 187-221.

Hütsch, B.W., Augustin, J., Merbach, W., (2002) Plant rhizodeposition - an important source for carbon turnover in soils. J. Plant Nutr. Soil Sci. 165, 397-407.

Janzen, H.H., Campbell, C.A., Brandt, S.A., Lafond, G.P., Townley-Smith, L., (1992) Light fraction organic matter in soils from long-term crop rotations. Soil Sci. Soc. Am. J. 56, 1799-1806.

Jurčová, O., (1990) Koreňové a pozberové zvyšky rastlín ako súčasť bilancie pôdnej organickej hmoty (Root and aboveground crop residues as a part of soil organic mater balance). In: Humusové látky - Aktiní složka systému půda- rostlina. Praha: VÚRV, p.p. 36- 41.

Jurčová, O., Bielek, P., (1997) Metodika bilancie pôdnej organickej hmoty a stanovenie potreby organického hnojenia (Method of soil organic mater balance and the determination of organic fertilizers necessity). VÚPÚ. Bratislava.

Kononova, M.M., Belčikova, N.P., (1962) Uskornnyje metody opredelenija sostava gumusa minerálnych počv. Počvovedenije 10, 75-87.

Linkeš, V., Pestún, V., Džatko, M. (1996) Príručka pre používanie máp bonitovaných pôdno- ekologických jednotiek (Príručka pre bonitáciu poľnohospodárskych pôd) (Guide for use of evaluted soil - ecological units - Guide for agricultural land evaluation). VÚPÚ. Bratislava.

Loginov, W., Wisniewski, W., Gonet, S.S., Ciescinska, B., (1987) Fractionation of organic carbon based on susceptibility to oxidation. Pol. J. Soil Sci. 20, 47-52.

Marriott, E.E., Wander, M.M., (2006) Total and Labile Soil Organic Matter in Organic and Conventional Farming Systems. Soil Sci. Soc. Am. J. 70, 950-959.

Martin, D., Srivastava, P.C., Ghosh, D., Zech, W., (1998) Characteristics of humic substances in cultivated and natural forest soils of Sikkim. Geoderma 84, 345-362.

Orlov, D.S., Grišina, L.A., (1981) Praktikum po chimiji gumusa. IMU. Moscow.
Peterburskij, A., (1963) Praktikum po agronomičeskoj chimiji Izd. Seľskochozjajstvennoj literatury, žurnalov a plakatov. Moskva.
Primavessi, A., (1984) Manejo Ecológico del Suelo, El Ateneo, Buenos Aires.
Robinson, C.A., Cruse, R.M., Kohler, K.A., (1994) Soil management. In: J.L., Hatfield, Karlen, D.L. (1994) Sustainable agriculture systems. Boca Raton: Lewis Publ., p.p. 109-134.
Rovira, P., Vallejo, V.R., (2002) Labile and recalcitrant pools of carbon and nitrogen in organic matter decomposing at different depths in soil: an acid hydrolysis approach. Geoderma 107, 109-141.
Schjőnning, P., Munkholm, L., Elmholt, S., Olesen, J. E., (2007) Organic matter and soil tilt in arable farming: Management makes a difference within 5-6 years. Agriculture Ecosystems & Environment 122, 157-172.
Smith, P., (2005) An overview of the performance of soil organic carbon stocks: influence of direct human-induced, indirect and natural effects. Eur. J. Soil Sci. 56, 673-680.
Šimanský, V., Zaujec, A. (2009) Suitable parameters for soil organic matter changes evaluation in agro-ecosystems. Folia Oecologica 36, 50-57.
Špánik, R., Repa, Š., Šiška, B. (2002) Agroklimatické a fenologické pomery Nitry (Agroclimatic and phenological conditions in Nitra). SPU. Nitra.
Theng, B.K.G., Tate, K.R., Sollins, P., (1989) Constituents of organic matter in temperate and tropical soils. In: D.C., Coleman et al. (1989) Dynamics of soil organic matter in tropical ecosystems. Honolulu: H. University of Hawaii Press.
Tisdall, J.M., Oades, J.M., (1982) Organic matter and water stable aggregates in soils. J. Soil Sci. 33, 141-163.
Tobiašová, E., (2011) The effect of organic matter on the structure of soils of different land use. Soil Till. Res. 114, 183-192.
Tobiašová, E., (2010) Pôdna organická hmota ako indikátor kvality ekosystémov (Soil organic mater as an indicator of ecosystem quality). SPU. Nitra.
Tobiašová, E., Šimanský, V., (2009) Kvantifikácia pôdnych vlastností a ich vzájomných vzťahov ovplyvnených antropickou činnosťou (Quantification of soil properties and their relations influenced by anthropic activities). SPU. Nitra.
Vieira, F.C.B., Bayer, C., Zanatta, J.A., Dieckow, J., Mielniczuk, J., He, Z.L., (2007) Carbon management index based on physical fractionation of soil organic matter in an Acrisol under long-term no-till cropping systems. Soil Till. Res. 96, 195-204.
Zaujec, A., Šimanský, V., (2006) Vplyv biostimulátorov rozkladu rastlinných zvyškov na pôdnu štruktúru a organickú hmotu pôdy (Influence of bio-preparates for plant residue decomposition on soil structure and organic mater in soil). SUA. Nitra.