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Original Paper

Fertilization and carbon sequestration

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The effect of fertilization on the dynamic change of soil organic matter (SOM) in loamy Haplic Luvisol was studied. In 2008–2011, soil samples were taken from following treatments: 1. C – non-fertilized, 2. PR + NPK – plant residues together with NPK fertilizers, and 3. NPK – NPK fertilizers. The results showed that the content of soil organic carbon in water-stable micro-aggregates (SOC in WSA_{mi}) increased by 11% and by 13% in PR + NPK and NPK treatments, respectively. The ratios of SOC in WSA_{mi}/SOC in bulk soil in the NPK fertilized treatment and in PR + NPK were 14% and 4% higher than in the non-fertilized treatment, respectively. Overall the ratios of SOM in WSA/SOM in bulk soil were higher in macro-aggregates than micro-aggregates. In fertilized treatments, the statistical significant changes in dynamics of labile carbon in water-stable macro-aggregates (C_L in WSAma) and in WSAma 0.5–3 mm were observed. In fertilized treatments (PR + NPK and NPK) there were observed significant decrease of the C_L in WSAma. The ratios C_L in WSA_{mi} also WSA_{ma}/C_L in bulk soil decreased due to ploughed plant residues together with NPK fertilizers, the ratio of C_L in WSA_{ma}/C_L in soil decreased due to added only NPK fertilizers also.

Keywords: soil organic matter, water-stable aggregates, plant residues, soil management practices

1. Introduction

Increasing problems concerning the environmental quality in arable landscapes, and the long-term productivity of agro-ecosystems, have emphasized a need to develop and improve management strategies that maintain and protect soil function and resources. If a farmer wants to be successful, they must have a good knowledge of the soil and 'understand'it. Using the knowledge of chemistry and soil physics, one is able to design the proper soil management practices, ensuring its protection and sustainable production.

SOM is an important aspect of agricultural soil quality and soil ecology (Balashov and Buchkina, 2011; Gaida et al., 2013). SOM is a dynamic entity. The amount of organic matter in a given soil can increase or decrease depending on numerous factors including climate, vegetation type, nutrient availability, disturbance, land use, and management practices (Six and Jastrow, 2002). A stabilization and protection of SOM is controlled by the following mechanisms: association of SOM with clay minerals and Fe and Al oxides, sequestration into macro and micro pores of soil aggregates; and biochemical stabilization (Six et al., 2002; Chenu and Plante, 2006; von Lützov et al., 2008). Nevertheless, soil has a limited capacity of saturation by SOM within soil mineral matrix and aggregates (Eusterhues et al., 2003). Soil aggregation is not only an important process of carbon sequestration, but it is a key factor controlling the quality of arable soils, as it plays an important role in the formation of their optimal physical conditions. It can be affected by the whole complex of natural and anthropogenic influences. Of all the anthropogenic influences, fertilization has one of the greatest impacts. Fertilizers, in a broad sense, include all materials that are added to soils to increase the growth, yield, quality, or nutritive value of crops. Fertilizers may affect the soil and plant growth in a number of different ways (Millar et al., 1962).

The aim of this paper was to study how fertilization influences SOM dynamics. We compare the SOM in soil, as well as in water-stable aggregates (WSA), in a Haplic Luvisol subjected to ploughed plant residues, together with NPK fertilizer or NPK treatment during the years 2008–2011.

2. Material and methods

An experiment is situated at the Dolná Malanta (48o19'00" N; 18° 09' 00" E) where, in 1994, the Department of Plant Production of SAU Nitra established a long-term field experiment, which is still running. The experimental site location is to the east of Nitra city, on the Žitavská upland. The experimental area is flat, with a slight incline southwards. The geological substratum consisted of little previous rocks with high quantities of fine materials. Young Neogene deposits were composed of various

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clays, loams, sand gravels on which loess was deposited in the Pleistocene Epoch. Soil was classified according to World Reference Base for Soil Resources (WRB, 2006) as the loamy haplic Luvisol. Before the experiment the soil contained 360.4 g kg^{-1} of sand, 488.3 g kg^{-1} of silt and 151.3 g kg^{-1} of clay. Soil carbon content was 12.9 g kg^{-1}, while the cation exchange capacity was 147.18 mmol kg^{-1} and base saturation percentage was 92.6%. On average, the soil active pH was 6.96. The experimental site has a mean annual temperature of 9.8 °C, and a mean annual precipitation of 573 mm.

In 2008–2011, twice a year (spring and autumn), the soil samples were taken from the depth 0–0.2 m from following treatments: C – non-fertilized, PR + NPK – plant residues ploughed to the soil together with NPK fertilizers, and NPK – added NPK fertilizers. The doses of fertilizers were: N 80 kg ha^{-1}, P (P_2O_5) 45 kg ha^{-1} and K (K_2O) 72 kg ha^{-1}. In 2008 in experimental plot was sown red clover (*Trifolium pratense* L.), in 2009 winter wheat (*Triticum aestivum* L.), in 2010 pea (*Pisum sativum* L. subsp. Hortense (Neitr.) and in 2011 maize (*Zea mays* L.).

Soil samples for the determination of SOM parameters as soil organic carbon content – SOC (Dziadowiec and Gonet, 1999) and labile carbon content – C_L (Loginow et al., 1987) in bulk soil were collected from each sampled zone (included all treatments of fertilization) and mixed to an average sample. Samples from the same sampled zones for the determination of SOM parameters in individual size fraction of WSA (SOC and C_L – according to above mentioned methods) were taken with the aid. Large clods were gently broken up along natural fracture lines, and samples were then air-dried at the laboratory temperature. Before the determination of WSA, all soil samples were sieved to provide a range of aggregate sizes (>7, 7–5, 5–3, 3–1, 1–0.5, 0.5–0.25, <0.25 mm). These size classes of air-dried aggregates were used for the determination of size classes of WSA by the Baksheev method (Vadjunina and Korchagina, 1986), while aggregates in size fractions more than 0.25 mm are macro-aggregates (WSA_{ma}) and less than 0.25 mm are micro-aggregates (WSA_{mi}). The share of macro-aggregates in size from 0.5 to 3 mm is important from the agronomical point of view.

The statistical treatment of the data was performed with the use of the Statgraphics Centurion XV.I (Statpoint Technologies, Inc., USA). Treatment differences (ANOVA) were considered significant at *P*-values <0.05 by the LSD multiple-range test. Non-linear regression analyses were performed to quantify the dynamic change of SOM in bulk soil as well as in WSA.

3. Result and discussion

Results from 2008 to 2011 were evaluated (Table 1). Overall, application of fertilizers did not significantly influence the SOC because a significant part of the SOC is formed from the stable fraction of organic matter and it has been turned over thousands of times over the years (Haynes, 2005; Richter et al., 2007; Šimanský et al., 2013). As presented in the results (Table 1), there was no significant change in the content of C_L due to fertilization. This is surprising because several previous studies demonstrate that labile C pools recover in shorter time frames than total SOC (Carpenter-Boggs et al., 2003; Dou et al., 2008; Šimanský, 2013). In the PR + NPK treatment, plant residues added to the soil together with NPK fertilizers increased (no significant, *P* >0.05) the SOC in soil, but the content of C_L was the same in comparison to the control (non-fertilized). On the other hand, in NPK by 4% compared with the control, there was decreased content of C_L in the soil. SOM can be sequestrate into macro and micro pores of soil aggregates (Six et al., 2000; von Lützov et al., 2008) therefore the next important objective of this study was to test the effect of fertilization on re-distribution of SOM in WSA. There were substantial differences (*P* ≤0.05) in SOC in the WSA (mainly in WSA_{mi}) between the fertilized treatments and the non-fertilized treatment. Tisdall and Oades (1980) and Kurakov and Kharin (2012) found greater concentrations of organic C in macro-aggregates than in micro-aggregates and suggested that it is due to decomposing roots and hyphae within macro-aggregates. Elliott (1986) suggested that macro-aggregates have elevated C concentrations because of the organic matter binding micro-aggregates into macro-aggregates and that this organic matter is "qualitatively more labile and less highly processed" than the organics stabilizing micro-aggregates. For the investigated period, the content of SOC in WSA_{mi} increased by 11% and 13% due to ploughed plant residues together with NPK fertilizers and only NPK fertilizers, respectively. In opposition to this, the results of Šimanský (2013) in Rendzic Leptosol showed a decrease of SOC in WSA_{mi} due to the application of higher doses of NPK (120 N kg ha^{-1}, 55 P kg ha^{-1} and 195 K kg ha^{-1}). In PR + NPK treatment, higher content of SOC by 5% and by 4% was observed in WSA_{ma} and WSA_{ma} size fractions from 0.5–3 mm, respectively. On the other hand in NPK, this trend was the opposite. Fertilizer use improves residue quantity and quality, but this does not necessarily increase SOC pool. However, fertilizers may also decrease SOC concentration in compared to unfertilized soil (Halvorson et al., 2002). Increased ionic concentration in fertilized soil can be the reason for the increase in susceptibility to clay dispersion. This also has a direct impact on the stability of aggregates decrease (Whalen and Chang, 2002), with subsequent decrease in SOC in aggregates because of its low physical protection. Overall, the C_L content decreased in WSA due to the application of NPK fertilizers. As presented by Neff et al. (2002), the availability of nitrogen from fertilizers

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Table 1 Contents of soil organic and labile carbon in bulk soil, in water-stable aggregates and their rations

Treatment	SOC in g kg^{-1}	C_L in mg kg^{-1}	SOC in WSA in g kg^{-1}			C_L in WSA in mg kg^{-1}			SOC in WSA/SOC in bulk soil			C_L in WSA/C_L in bulk soil		
			WSA_{mi}	WSA_{ma}	WSA_{ma} 0.5–3	WSA_{mi}	WSA_{ma}	WSA_{ma} 0.5–3	WSA_{mi}	WSA_{ma}	WSA_{ma} 0.5–3	WSA_{mi}	WSA_{ma}	WSA_{ma} 0.5–3
C	12.5a	1783a	9.90a	12.8a	12.8a	1616a	1862a	1836a	0.80a	1.03a	1.02a	0.91a	1.04a	1.03a
PR + NPK	13.3a	1783a	11.0b	13.5b	13.3a	1616a	1875a	1843a	0.83a	1.03a	1.01a	0.91a	1.05a	1.03a
NPK	12.4a	1719a	11.2b	12.4a	12.1a	1584a	1773a	1722a	0.91a	1.00a	0.98a	0.92a	1.03a	1.00a

SOC – soil organic carbon, C_L – labile carbon, SOC in WSA – soil organic carbon in water-stable aggregates, C_L in WSA – labile carbon in water-stable aggregates, WSA_{mi} – water-stable micro-aggregates, WSA_{ma} – water-stable macro-aggregates, WSA_{ma} 0.5–3 – water-stable macro-aggregates in size fraction from 0.5 to 3 mm, C – control, PR + NPK – plant residues ploughed to the soil together with NPK fertilizers, NPK – added NPK fertilizers,
Different letters between columns (a, b) indicate that treatment means are significantly different at $p \leq 0.05$ according to LSD multiple-range test

Table 2 Dynamics of soil organic and labile carbon in bulk soil in individual treatments of fertilization

Treatment	Crops	Red clover (2008)		Winter wheat (2009)		Pea (2010)		Maize (2011)		Polynomial model	R^2	Probability
	time of sampling	spring	autumn	spring	autumn	spring	autumn	spring	autumn			
						SOC						
C		12.6	12.6	12.3	12.2	11.9	12.9	12.0	13.6	$y = 0.07x^2 - 0.57x + 13.3$	0.481	n.s.
PR + NPK		11.5	14.3	12.6	14.5	11.9	12.0	16.0	13.2	$y = -0.02x^2 + 0.33x + 12.2$	0.092	n.s.
NPK		11.6	11.9	11.8	13.0	11.7	12.6	14.1	12.1	$y = -0.03x^2 + 0.44x + 11.1$	0.311	n.s.
						C_L						
C		1474	2205	1800	1848	1980	2002	1232	1724	$y = -28.1x^2 + 224.7x + 1489$	0.248	n.s.
PR + NPK		1395	1530	1800	2138	2036	2700	1317	1351	$y = -73.2x^2 + 673.6x + 619$	0.551	0.05
NPK		1418	1485	1710	1822	2019	2216	1523	1556	$y = -42.6x^2 + 417.6x + 926$	0.634	0.05

SOC – soil organic carbon, C_L – labile carbon, C – control, PR + NPK – plant residues ploughed to the soil together with NPK fertilizers, NPK – added NPK fertilizers, n.s. – non-significant.

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Table 3 Dynamics of soil organic and labile carbon in water-stable aggregates in individual treatments of fertilization

Treatment	Crops	Red clover (2008)		Winter wheat (2009)		Pea (2010)		Maize (2011)		Polynomial model	R^2	Probability
	time of sampling	spring	autumn	spring	autumn	spring	autumn	spring	autumn			
SOC in WSA_{mi}												
C		7.90	14.5	8.70	10.7	8.60	9.50	8.90	10.7	$y = 0.02x^2 - 0.23x + 10.6$	0.014	n.s.
PR + NPK		6.30	11.0	13.3	17.6	8.90	11.5	8.80	10.7	$y = -0.41x^2 + 3.7x + 4.6$	0.345	n.s.
NPK		15.8	7.80	11.2	14.1	10.4	10.2	9.80	10.0	$y = 0.07x^2 - 1.06x + 14.2$	0.197	n.s.
SOC in WSA_{ma}												
C		10.7	14.0	13.5	15.6	12.4	12.4	11.1	13.0	$y = -0.16x^2 + 1.37x + 10.7$	0.252	n.s.
PR + NPK		11.5	15.3	14.1	17.6	11.9	13.4	12.1	12.4	$y = -0.21x^2 + 1.68x + 11.3$	0.307	n.s.
NPK		9.90	11.0	13.8	14.5	11.0	11.9	14.5	12.5	$y = -0.13x^2 + 1.51x + 8.9$	0.337	n.s.
SOC in WSA_{ma} 0.5–3												
C		9.70	13.8	13.6	16.4	12.2	12.3	11.4	12.6	$y = -0.24x^2 + 2.11x + 9.2$	0.345	n.s.
PR + NPK		10.4	14.4	14.2	18.5	10.9	13.4	12.1	12.3	$y = -0.26x^2 + 2.28x + 9.8$	0.266	n.s.
NPK		10.6	10.7	13.3	12.8	10.5	12.2	14.7	12.3	$y = -0.04x^2 + 0.70x + 10.1$	0.286	n.s.
C_L in WSA_{mi}												
C		1710	1620	1642	1631	1508	1688	1665	1464	$y = -1.08x^2 - 7.89x + 1679$	0.253	n.s.
PR + NPK		1800	1440	1699	2385	1575	1654	1175	1199	$y = -37.21x^2 + 257.8x + 1405$	0.466	n.s.
NPK		1485	1890	1215	1980	1800	1575	1350	1373	$y = -23.95x^2 + 184.8x + 1363$	0.251	n.s.
C_L in WSA_{ma}												
C		1782	1841	1545	1800	1928	1967	1549	1772	$y = -5.41x^2 + 47.02x + 1699$	0.030	n.s.
PR + NPK		1892	1947	1961	2453	1895	1878	1501	1469	$y = -37.39x^2 + 265.13x + 1635$	0.689	0.05
NPK		1920	1844	2070	1941	1826	2089	1565	1642	$y = -17.67x^2 + 118.59x + 1779$	0.500	0.05
C_L in WSA_{ma} 0.5–3												
C		1917	1755	2025	1935	1777	1929	1592	1761	$y = -7.91x^2 + 43.19x + 1844$	0.320	n.s.
PR + NPK		1845	1875	1823	2400	1774	1920	1662	1443	$y = -33.01x^2 + 246.94x + 1573$	0.561	0.05
NPK		1549	1860	1463	1755	1770	2040	1522	1816	$y = -7.13x^2 + 87.04x + 1512$	0.114	n.s.

SOC in WSA – soil organic carbon in water-stable aggregates, C_L in WSA – labile carbon in water-stable aggregates, WSA_{mi} – water-stable micro-aggregates, WSA_{ma} – water-stable macro-aggregates, WSA_{ma} 0.5–3 – water-stable macro-aggregates in size fraction from 0.5 to 3 mm, C – control, PR + NPK – plant residues ploughed to the soil together with NPK fertilizers, NPK – added NPK fertilizers, n.s. – non-significant

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Table 4 Dynamics of rations soil organic and labile carbon in water-stable aggregates to soil organic and labile carbon in bulk soil in individual treatments of fertilization

Treatment	Crops	Red clover (2008)		Winter wheat (2009)		Pea (2010)		Maize (2011)		Polynomial model	R^2	Probability
	time of sampling	spring	autumn	spring	autumn	spring	autumn	spring	autumn			
C		0.63	1.15	0.71	0.88	0.72	0.74	0.74	0.79	$y = -0.003x^2 + 0.02x + 0.80$	0.042	n.s.
PR + NPK		0.55	0.77	1.06	1.21	0.75	0.96	0.55	0.81	$y = -0.03x^2 + 0.27x + 0.39$	0.393	n.s.
NPK		1.36	0.66	0.95	1.08	0.89	0.81	0.70	0.83	$y = 0.10x^2 - 0.13x + 1.27$	0.324	n.s.
SOC in WSA_{ma}/SOC in bulk soil												
C		0.85	1.11	1.10	1.28	1.04	0.96	0.93	0.96	$y = -0.02x^2 + 0.16x + 0.80$	0.474	n.s.
PR + NPK		1.00	1.07	1.12	1.21	1.00	1.12	0.76	0.94	$y = -0.01x^2 + 0.10x + 0.93$	0.462	n.s.
NPK		0.85	0.92	1.17	1.12	0.94	0.94	1.03	1.03	$y = -0.01x^2 + 0.09x + 0.81$	0.234	n.s.
NPK		0.85	0.92	1.17	1.12	0.94	0.94	1.03	1.03	$y = -0.01x^2 + 0.09x + 0.81$	0.234	n.s.
SOC in WSA_{ma} 0.5–3/SOC in bulk soil												
C		0.77	1.10	1.11	1.34	1.03	0.95	0.95	0.93	$y = -0.02x^2 + 0.21x + 0.68$	0.507	0.05
PR + NPK		0.90	1.01	1.13	1.28	0.92	1.12	0.76	0.93	$y = -0.02x^2 + 0.15x + 0.80$	0.382	n.s
NPK		0.91	0.90	1.13	0.98	0.90	0.97	1.04	1.02	$y = -0.002x^2 + 0.02x + 0.91$	0.117	n.s
C_L in WSA_{mi}/C_L in bulk soil												
C		1.16	0.73	0.91	0.88	0.76	0.84	1.35	0.85	$y = 0.02x^2 - 0.14x + 1.14$	0.144	n.s
PR + NPK		1.29	0.94	0.94	1.12	0.77	0.61	0.89	0.89	$y = 0.02x^2 - 0.21x + 1.43$	0.565	0.05
NPK		1.05	1.27	0.71	1.09	0.89	0.71	0.89	0.88	$y = 0.01x^2 - 0.12x + 1.25$	0.303	n.s
C_L in WSA_{ma}/C_L in bulk soil												
C		1.30	0.84	1.15	1.05	0.92	1.04	1.27	0.95	$y = 0.01x^2 - 0.09x + 1.23$	0.083	n.s
PR + NPK		1.36	1.27	1.09	1.15	0.93	0.70	1.14	1.09	$y = 0.02x^2 - 0.25x + 1.64$	0,.614	0.05
NPK		1.26	1.24	0.90	0.99	0.95	0.89	1.02	1.14	$y = 0.02x^2 - 0.24x + 1.51$	0.787	0.01
C_L in WSA_{ma} 0.5–3/C_L in bulk soil												
C		1.30	0.80	1.13	1.05	0.90	0.96	1.29	1.02	$y = 0.01x^2 - 0.13x + 1.27$	0.145	n.s
PR + NPK		1.32	1.23	1.01	1.12	0.87	0.71	1.26	1.07	$y = 0.03x^2 - 0.25x + 1.59$	0.486	n.s
NPK		1.09	1.25	0.86	0.96	0.88	0.92	1.00	1.17	$y = 0.02x^2 - 0.20x + 1.36$	0.547	0.05

SOC in WSA/SOC in bulk soil – ratio of soil organic carbon in water-stable aggregates to soil organic carbon in bulk soil, C_L in WSA/C_L in bulk soil – ratio of labile carbon in water-stable aggregates to labile carbon in bulk soil, WSA_{mi} – water-stable micro-aggregates, WSA_{ma} – water-stable macro-aggregates, WSA_{ma} 0.5–3 – water-stable macro-aggregates in size fraction from 0.5 to 3 mm, C – control, PR + NPK – plant residues ploughed to the soil together with NPK fertilizers, NPK – added NPK fertilizers, n.s. – non-significant

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can increase the rate of decomposition of labile organic substances. The ratio of SOC in WSA/SOC in bulk soil was evaluated, and the ability of carbon sequestration to exist inside of soil aggregates was recorded (Table 1). In the non-fertilized treatment (control), the ratios of SOC content in WSA_{mi} to that in soil was 0.80% in the PR + NPK treatment 0.83% and 0.91% in the NPK treatment. The ratios of SOC in WSA_{mi}/SOC in bulk soil in the NPK fertilized treatment and in PR + NPK were 14% and 4% higher than in the non-fertilized treatment, respectively. These results demonstrated that all treatments of fertilization had a rather high ability to the sequestration of SOC from bulk soil to WSA_{mi} compared to non-fertilized treatment. The results of Šimanský and Kováčik (2014) also confirmed the fact that water-stable micro-aggregates can be one of the most important storage for retention of SOM due to fertilization of soils. However, as is shown in Table 1, overall, the ratios of SOC in WSA/SOC in bulk soil were higher in macro-aggregates than micro-aggregates. This means that higher C sequestration was in WSA_{ma}, but fertilization did not have any effect on the increase of it in WSA_{ma}. The ratios of C_L in WSA/C_L in bulk soil to that in soil, followed the same trends (P >0.05) as the ratios of SOC in WSA to that in soil with the lowest values in the WSA_{mi} and the highest in WSA_{ma} in all treatments.

Dynamics of SOC and C_L are presented in Tables 2–4. The content of SOC in bulk soil had no significant (P >0.05) increase in all treatments. Results clearly highlighted the effect of time of sampling in spring and autumn as well as plant influence, especially in labile carbon dynamics in fertilized treatments than in non-fertilized treatment. From the point of view of time sampling, the highest contents of SOC and C_L were determined in autumn than spring (Table 2). It can be connected with gradual increase of biomass in bulk soil. The effect of plants on changes of SOC and C_L in all treatments is best described by the second polynomial model (based on R^2). The highest statistical significant increase of C_L in bulk soil was identified in autumn, after the cultivation of peas in treatments with ploughed crop residues together with NPK, as well as in only NPK treatment. Miller et al. (2011) presented that green manure legumes such as pea, improved the availability of nutrients in the soil. The resulting increase in residue production also contributes to SOC (Lal, 2008). Intensification of crop rotation is also a key aspect to the observations of increased SOC levels, and may therefore increase organic C input to the soil (Halvorson et al., 2002). The dynamic changes of SOC in WSA were not significant (Table 3), however, in PR + NPK the SOC in WSA_{mi} increased slightly, but the SOC in WSA_{ma} and WSA_{ma} 0.5–3 mm slightly decreased. According to the results of Triberti et al. (2008) continuous additions of organic materials led to a SOC build up at rates 0.16–0.26 t SOC ha^{-1} year^{-1}. This slow accumulation, which represented less than 10% of added organic C, can be explained by the great amount of C that annually leaves the soil to other sinks (Richter et al., 2007). Diametrically different situations were in NPK treatment. There were observed slight decreases of SOC in WSA_{mi} and slight increases of SOC in WSA_{ma}. In fertilized treatments, the statistical significant changes in dynamics of C_L in WSA_{ma} and in WSA_{ma} 0.5–3 mm were observed. In PR + NPK there were observed significant decreases because in 2008, the C_L in WSA_{ma} was 1892 mg kg^{-1} and in 2011 its content was only 1469 mg kg^{-1}. The same trends were in WSA_{ma} 0.5–3 mm as well as in the treatment with added NPK fertilizers. A possible reason for the decrease of C_L in WSA_{ma} is the newly formed bonds between more labile organic substances and mineral components (Santos et al., 1997) with physical protection against a microbial attack (Krol et al., 2013). There were no significant changes in dynamics of the ratio SOC in WSA/SOC in bulk soil (Table 4). In PR + NPK treatment, the ratio of SOC in WSA_{mi}/SOC in bulk soil increased, however, the ratio of WSA_{ma}/SOC in bulk soil decreased. The opposite trends were in NPK treatment as well as in PR + NPK without statistical significance (Table 4). The ratios of C_L in WSA_{mi} and also WSA_{ma}/C_L in bulk soil, decreased due to ploughed plant residues together with NPK fertilizers (statistical significant). Also the ratio C_L in WSA_{ma}/C_L in soil statistical significant decreased due to added only NPK fertilizers. All these trends best expressed the polynomial model.

4. Conclusions

The results underscore the importance of fertilization in relation with carbon sequestration, mainly in water-stable macro-aggregates, especially in arable Haplic Luvisol and its meaning is emphasized in this study. Whereas the content of SOM, mainly as a result of the application of crop residues together with NPK fertilizers were slightly increased, there is a potential of increase of C sequestration (especially labile carbon) in a water-stable macro-aggregates, which is definitely one way for the elimination of CO_2 released from the soil to the atmosphere. Water-stable macro-aggregates are able to retain C, so in this regard it will be necessary to pay further attention to their stability. Application of only NPK fertilizers to soil had negative effect, which means that this alternative, from the view of sustainable farming, is not correct for the future. Significant differences in the dynamics of labile carbon in water-stable aggregates indicated the validity of their use as a sensitive indicator of the quality of the soil environment under different fertilization. This information is very important for farmers, because on this basis, they can optimize soil management practices in arable soils, and avoid environmental degradation due to the application of only mineral fertilizers to the soil.

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