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Long-term effect of tillage systems, straw and green manure combinations on soil organic matter

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Abstract

Nowadays the priority in agriculture is given to the soil tillage systems which enable reduction of organic matter decomposition. Our investigation was aimed to assess the long-term impact of reduced intensity tillage systems, straw and green manure combinations on soil organic matter quantity and quality. Since 1999, a long-term field experiment has been done at the Experimental Station of Aleksandras Stulginskis University (former Lithuanian University of Agriculture) at 54º52′50″ N latitude and 23º49′41″ E longitude. The results presented in this paper were obtained in the 12th and 14th years of investigations. The soil of the experimental site is *Epieutric Endocalcaric Endogleyic Planosol*. Continuous long-term (12 and 14 years) straw application increased soil organic carbon (SOC) content by 9.3% and 12.0% compared with the plots without straw. Reduced tillage systems without primary tillage (shallow rotovating before sowing, catch cropping for green manure with rotovating, no-tillage) were even more effective. Compared with conventional ploughing, SOC increased by 19.4% to 33.9%. These tillage systems increased soil quality too, since SOC stratification ratio between 0–10 and 10–20 cm layers increased by 1.14 till 1.21. Reduced tillage systems with primary tillage (shallow ploughing and shallow loosening) had no effect both on SOC and stratification process in the soil. SOC pools over the experimental years tended to increase by 9.3% and 11.6% in the treatments of long-term application of straw compared with the plots without straw. No-tillage and catch cropping for green manure with rotovating compared with conventional ploughing significantly increased the pools of organic carbon by 31.7% to 33.3% in the plots without straw and by 28.9% to 32.7% in the plots with straw. Continuous straw application increased the quantity of mobile humus substances by 22.7% compared to the plots without straw. Straw in combination with catch crop for green manure incorporation and rotovating and no-tillage increased mobile humus substances by 53.2% and 58.8% compared with conventional ploughing. Only long-term application of straw increased the quantity of mobile humic acids by 40.6% compared with the plots without straw. The rate of mobile humic acids from total amount of mobile humus substances in the treatments without straw amounted to 39.8%, while with straw this content increased to 45.6%. Reduced tillage systems without primary tillage had no significant effect on mobile humic acids but tended to increase soil organic matter quality.

Key words: conventional and reduced tillage, mobile humic acids, no-tillage, soil organic carbon.

Introduction

Maintenance and improvement of soil quality in continuous cropping systems is critical to sustaining agricultural productivity and environmental quality. Oldeman (1992) estimated that 38% of all agricultural land has undergone anthropogenic soil degradation and defined soil degradation as the process which lowers the current and/or future capacity of soils to produce goods or services. Conversely, soil quality is referred to as the capacity of the soil to produce economic goods and services and to regulate the environment. The concept of "soil quality" recognizes soil organic matter as an important attribute that has a great deal of control over many of the key soil functions. Soil degradation in Lithuania occurs due to intensive agricultural and anthropogenic activity, therefore new investigations are necessary. Soil capacity as well as the crop productivity directly depends on soil degradation and pollution, which determine declining of soil organic matter and biological diversity.

Quantity of soil organic matter is an integral component of soil management strategy, generally increasing with higher mean annual precipitation, lower mean annual temperature, higher clay content, intermediate grazing intensity, higher crop residue inputs and cropping intensity (Kong et al., 2005; Majumder et al., 2007; Suproniene et al., 2011; Slepetiene et al.,

2013) and native vegetation. Several studies have found that conventional tillage is not only a high energy and labour consuming process, but it can also exert a negative impact on soil properties. Continuous soil mixing leads to increased nutrient leaching and therefore it becomes difficult to conserve soil fertility without high fertilizer input. However, other experiments gave controversial results showing that conventionally ploughed soil settles down until sowing time leaving no significant differences between tillage systems. Several studies have shown that no-tillage systems lead to higher soil organic carbon stocks compared to conventional tillage and also favour the formation of macro aggregates (Six et al., 2006). These circumstances increased research interest in soil management practices which may accumulate or partly reverse carbon losses from soil (Post, Kwon, 2000). Straw application and reduced tillage have both been reported to improve soil quality (Tripolskaja, Šidlauskas, 2010; Van Groenigen et al., 2010). However, several studies pointed that no-tillage and reduced tillage practices increase soil carbon contents in top soil (Ogle et al., 2005). Other investigators have found that carbon accumulation near the soil surface due to these practices might increase carbon losses at lower depths (Baker et al., 2007; Blanco-Canqui, Lal, 2008). On other hand, cereal straw is of renewed interest as a potential source of bioenergy. Export of biomass is a crucial and controversial point for agrosystem sustainability, especially in cropping systems with low content of soil carbon (Wilhelm et al., 2004; Lal, 2005), as we have the situation in Lithuania.

Literature survey is under-resourced while describing combinations of interactions of tillage intensity, the application of straw and catch crop growing for green manure on soil organic matter quantity and quality (Marcinkeviciene et al., 2013; Tripolskaja et al., 2014). With this aim in mind, the study was done in Lithuania on a drained clay loam on silty clay with deeper lying sandy loam. The study concluded that sustainable tillage significantly increased light fraction carbon content in the plough layer, and particulate organic matter carbon content in the topsoil layer, but reduced it in the bottom of plough layer as compared with that in the case of conventional tillage (Liaudanskienė et al., 2010). Agricultural management practice with cover crop in clay loam soil determined positive changes in the main humus quality indicator (Arlauskienė et al., 2010). According to Slepetienė and Slepetys (2005), shallow and minimum soil tillage systems resulted in significant humus content increases in the topsoil (0–10 and 10–20 cm). In both experiments in Lithuania on light loam soil with lower and higher application rates of mineral fertilizer in the 0–30 cm layer the content of humus in the minimum soil tillage systems significantly increased, and in the shallow tillage system did not differ significantly, compared to conventional deep tillage. In both experiments, the content of humus in the 0–10 and 10–20 cm soil layers in the shallow soil tillage system was significantly higher than in the 20–30 cm layer. In minimum tillage treatments, in both experiments mobile humic acids content increased within the whole 0–30 cm depth compared to conventional tillage (Slepetiene, Slepetys, 2005). Feiza et al. (2011) also confirmed that on both loam and sandy loam long-term no-tillage application resulted in a significant increase in carbon content in the upper soil layer.

Moreover, short term changes are usually small and not accurately measurable with the large background amounts of soil organic carbon. It may take several decades before new organic carbon equilibrium is reached following a change in management practices. Therefore, long-term agronomic studies are essential for determination of changes in soil organic carbon. The objective of our investigations was to assess the long-term impact of reduced intensity tillage systems, straw and green manure combinations on soil organic matter quantity and quality.

Material and methods

Since 1999, a long-term field experiment has been conducted at the Experimental Station of Aleksandras Stulginskis University (former Lithuanian University of Agriculture) at 54º52′50″ N latitude and 23º49′41″ E longitude. The soil of the experiment site is *Epieutric Endocalcaric Endogleyic Planosol* (*Endoclayic*, *Aric*, *Drainic*, *Humic*, *Episiltic*) according to WRB (2014), texture at 0–20 cm depth is silty medium loam (33.7% sand, 50.3% silt, 16.0% clay), at 20–40 cm depth – silty light loam (35.4% sand, 51.1% silt, 13.5% clay). A short crop rotation was introduced: winter wheat → spring barley → spring rape. The results presented in this paper were obtained in the 12^{th} and 14^{th} years of investigations, when winter wheat and spring rape were cultivated. According to two factor field experiment, the straw (factor A) was removed (R) from one part of the experimental field and on the other part of the field all straw yield was chopped and spread (S) at harvesting. As a subplot 6 different tillage systems (factor B) were investigated: conventional ploughing (CP) at 23–25 cm depth in autumn, shallow ploughing (SP) at 10–12 cm depth in autumn, shallow loosening (SL) with sweep cultivator and disc harrow at 8–10 cm depth in autumn, shallow rotovating (SR) at 5–6 cm depth before next crop sowing, catch cropping for green manure and rotovating (GMR) at 5–6 cm depth before next crop sowing, no-tillage (NT), direct drilling. Catch crop white mustard (*Sinapis alba* L.) for green manure was undersown on stubble only in GMR plots just after winter wheat and spring barley harvest. The primary tillage operations as well as seedbed preparation – harrowing was performed only in CP, SP and SL treatments. Glyphosate (Roundup) 4 l ha^{-1} was applied on demand in SR, GMR and NT treatment plots. Air seeder Rapid 300C ("Väderstad", Sweden) in all crops as well as in white mustard was used without any additional tillage implement. Crop rotation: spring rape → winter wheat → spring barley was arranged. For winter wheat complex fertilizer (N – 120 kg ha^{-1}, P_2O_5 – 55 kg ha^{-1} and K_2O – 110 kg ha^{-1}) was used before sowing and ammonium nitrate (N – 68 kg ha^{-1}) was added in spring. For barley we applied complex fertilizer (N – 50 kg ha^{-1}, P_2O_5 – 50 kg ha^{-1} and K_2O ha^{-1} – 50 kg ha^{-1}) before sowing and ammonium nitrate (N – 30 kg ha^{-1}) after emergence since 2001. For spring rape we used complex fertilizer (N – 44 kg ha^{-1}, P_2O_5 – 52 kg ha^{-1} and K_2O – 120 kg ha^{-1}) before sowing and ammonium nitrate (N – 60 kg ha^{-1}) after emergence. Weeds and fungi in crops were controlled using the same quantity and composition of appropriate herbicides, fungicides and insecticides for all treatments. The trials were replicated four times. The treatments were arranged using a split-plot design. The total size of each plot was 102 (6 × 17) m^2 and net size was 30.0 (2.0 × 15) m^2.

Soil sampling for evaluation of the soil organic carbon (SOC) and humus substances in soil was carried out in 2011 and 2013 in spring before the crop fertilization. Four soil samples were taken in each plot from 0–10 and 10–20 cm depth. Visible roots and plant residues were removed from soil samples by hand. Air-dried soil samples were crushed and sieved through a 2-mm sieve and homogeneously mixed. The content of SOC and mobile humic acids was determined by photometric procedure at the wavelength of 590 nm using the UV-VIS spectrophotometer Cary 50 ("Varian", USA) equipped with software, and glucose as a standard after wet combustion according to Nikitin (1999). Mobile humic substances were extracted by 0.1 M NaOH solution and determined according to Ponomariova and Plotnikova (1980). The extracted humic substances were separated into mobile humic and fulvic acid fractions by acidifying the extract to pH 1.3–1.5 using 0.5 M H_2SO_4 at 68–70°C and mobile humic acids were separated by filtering. Separated mobile humic acids were re-dissolved in 0.1 M NaOH solution, evaporated, oxidized and organic carbon content determined, using the same procedures as soil SOC. The content of mobile humic substances was determined by photometric procedure at the wavelength of 590 nm using the UV-VIS spectrophotometer Cary 50 equipped with software, and using glucose as a standard after the dichromate oxidation procedure according to Nikitin (1999) and Ponomariova and Plotnikova (1980). Soil bulk density for SOC calculation was investigated according to cylinder method one week after crop sowing. Undisturbed soil cores were obtained in 200 cm^3 cylinders at two locations within each plot from 0–10 and 10–20 cm depths with a double-cylinder coring device. Samples were oven-dried at a temperature of 105°C. The SOC pools were calculated according to the equation:

SOC pools = (SOC content of the soil × soil weight)/100,

where SOC pools is in Mg ha^{-1}, SOC content – g g^{-1} C, soil weight – Mg ha^{-1}.

Weather conditions can influence soil organic matter quantity and quality. Table shows rainfall and mean air temperature at the experimental site. Rainfall varied considerably between years. Vegetation of 2011 was semi humid in spring and too wet in summer. 2011 was wetter compared with the long-term mean, especially in July and August; the total amount of rainfall was 144 and 152 mm, respectively, or by 77% and 89% higher, compared to the multiannual mean. Higher than usual temperatures were observed in April, June and July; however, the temperatures nearly corresponded to average of many years. Vegetation period of 2013 was humid and similar to that in 2011; however, the temperature nearly corresponded to multiannual, except for May. By 46% and 98% higher than multiannual average rainfall was in July and September, respectively.

Table. Rainfall and temperature distribution during the vegetation period, 2011 and 2013

Month	Hydrological year					
	2011		2013		Multiannual	
	temperature °C	rainfall mm	temperature °C	rainfall mm	temperature °C	rainfall mm
March	0.10	10.60	3.90	9.50	−0.70	32.5
April	8.90	25.20	5.50	56.50	6.10	38.4
May	12.70	46.90	16.60	63.80	12.3	53.8
June	18.10	82.70	18.50	45.90	15.6	62.6
July	19.60	144.00	19.20	118.50	17.6	81.2
August	17.50	152.00	18.40	67.20	16.6	80.3
September	13.60	73.90	12.30	104.30	12.2	52.6
October	7.40	21.60	9.00	43.70	6.8	49.6
November	3.50	15.50	4.95	63.10	1.5	46.1

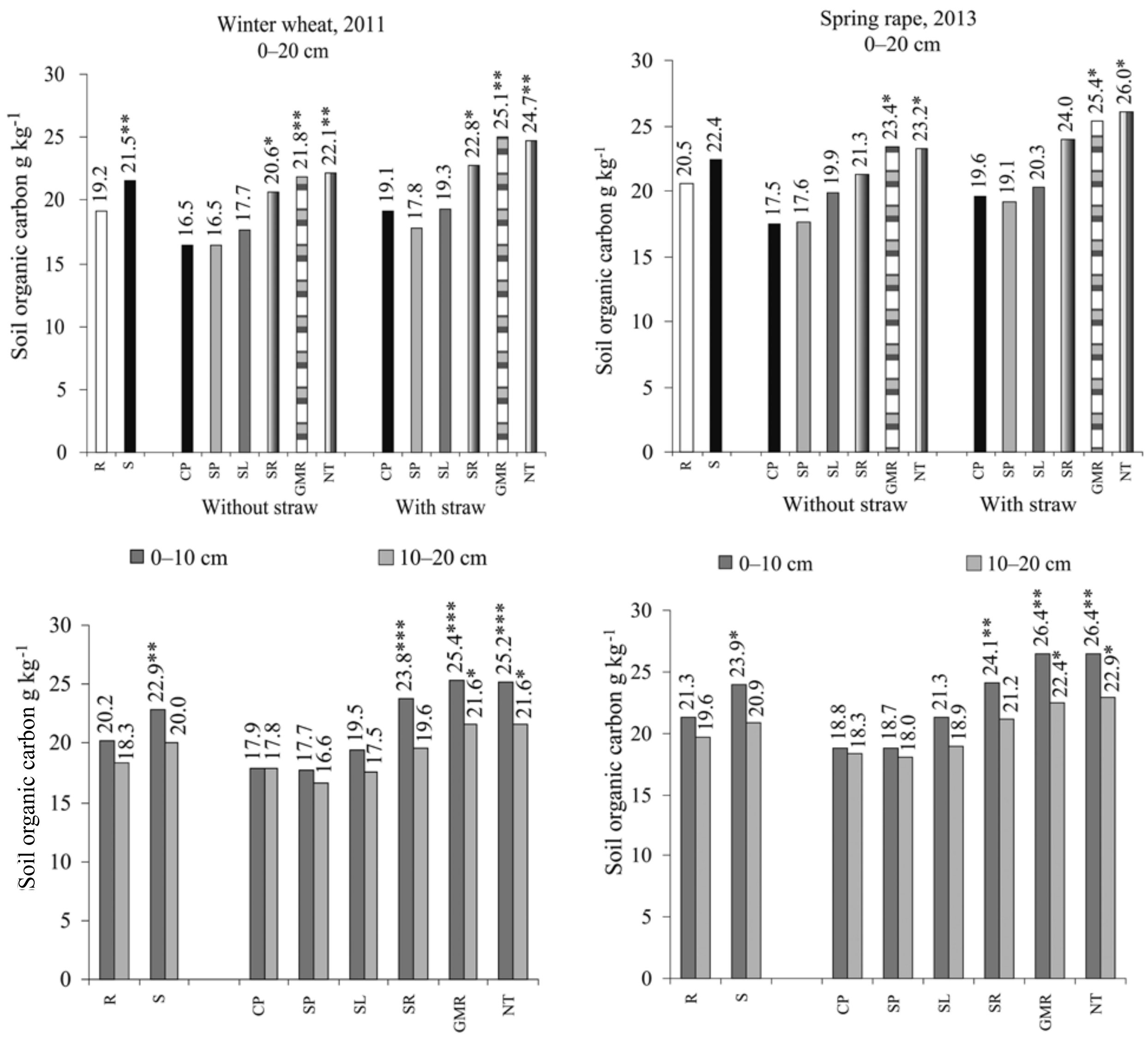
Experimental data was evaluated using analysis of variance (* – $P \leq 0.05$, ** – $P \leq 0.01$, *** – $P \leq 0.001$) based on a two-factorial split-plot design model (statistical package *SYSTAT*, procedure *GLM*). Comparisons of differences *vs* control (without straw – for factor A, conventional ploughing – for factor B) were undertaken, Fisher LSD test was used. No factorial interaction was found and therefore the results are presented as average for each factor.

Results and discussion

The results obtained after 12 and 14 years from the beginning of the field experiment indicated a positive effect of straw incorporation and reduced tillage systems on soil organic carbon content (Fig. 1). Continuous long-term straw application significantly increased SOC. Compared with the plots without straw this content was by 9.3% and 12.0% higher in 2011 and 2013, respectively in 0–20 cm soil depth.

Reduced tillage systems without primary tillage (SR, GMR, NT) were more effective than reduced tillage systems with primary tillage (SP, SL) and than conventional ploughing (CP) as well (Fig. 1). In the plots without straw in 2011, compared with the conventional ploughing, shallow rotovating significantly increased SOC content in 0–20 cm soil layer by 24.8%, green manure application and rotovation – 32.1%, no-tillage – 33.9%. The same tendencies were obtained in 2013; SOC content was higher 21.7, 33.7 and 32.6 %, respectively. Shallow ploughing and shallow loosening had no significant effect.

Higher SOC content was obtained in plots with straw than without straw in the same tillage systems (Fig. 1). In 2011 and 2013, in shallow rotovating plots this index was higher 19.4% and 22.4%, in the plots



Notes. Differences significant at * – $P \leq 0.05 > 0.01$, ** – $P \leq 0.01 > 0.001$ and *** – $P \leq 0.001$; Fisher LSD test *vs* control. R – without straw (control for factor A), S – with straw, CP – conventional ploughing (control for factor B), SP – shallow ploughing, SL – shallow loosening, SR – shallow rotovating before sowing, GMR – catch cropping for green manure and rotovating before sowing, NT – no-tillage.

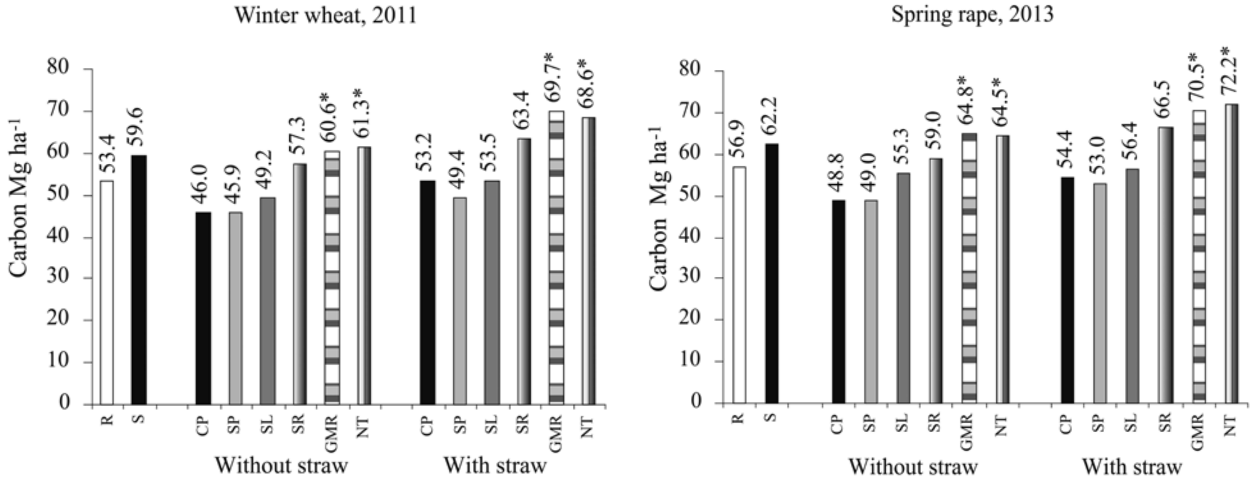
Figure 1. Soil organic carbon content in different depth, 2011 and 2013

with green manure application and rotovation 31.4% and 29.6%, and in no-tillage plots 29.3% and 32.7% compared with conventional ploughing. Shallow ploughing and shallow loosening had a similar effect as conventional ploughing.

Mentioned significant differences of SOC were even higher in 0–10 cm soil layer (Fig. 1). Compared with conventional ploughing in 2011 and 2013 in this top layer organic carbon content increased in reduced tillage systems without primary tillage: SR, GMR, NT treatments – by 28.2% and 33.0%, 40.4% and 41.9%, 40.4% and 40.8%, respectively. However, in 10–20 cm layer these effects were lower 10.1% and 15.8%, 21.3% and 22.4%, 21.3% and 25.1%, respectively. It shows SOC stratification processes in reduced tillage systems without primary tillage. Organic carbon increase in this layer can be explained by slower crop residue decomposition with long-term soil disturbance minimization. SOC stratification ratio between 0–10 and 10–20 cm layers established from 1.14 till 1.21 in shallow rotovating, green manuring with rotovating and no-tillage treatments. According to Franzluebbers (2004), tilled soils have a more uniform distribution of soil organic matter (SOM) compared with a highly stratified distribution of SOM with no-tillage. Straw placement is very important to the depth of soil organic matter distribution in profile, because plant residues contribute greatly to subsequent SOM formation. Surface SOM is essential to crust formation, conservation of nutrients, water infiltration, erosion control, and some other important soil functions. Therefore, stratification ratio of soil organic carbon (concentration in the 0–5 cm soil layer divided by that deeper in the soil profile) has been suggested as an indicator of soil quality in different agroecological zones (Franzluebbers, 2002). As was pointed, stratification is a better soil quality indicator of the improvement induced by conservation management than content of SOC. In general, whatever the soil and climatic conditions are, high stratification ratios would indicate good soil quality, as ratios >2 are not frequently found in degraded soils (Franzluebbers, 2002). It can be agreed with Franzluebbers (2002), who suggested that more research on stratification ratio of various SOM fractions is needed to test the applicability of using stratification ratio as a soil quality indicator in different agroecological zones, especially in soils with low SOC.

SOC results from our field experiments agree with the findings of other researchers, which explain different tillage management impact on total soil organic carbon content. Actually, the basic sources of SOC are organic residues, straw, green and farmyard manure (Tripolskaja, Šidlauskas, 2010; Kwiatkowska-Malina, 2011; Marcinkeviciene et al., 2013; Tripolskaja et al., 2014), content of SOC depends upon soil used (Mikučionienė, 2010; Liaudanskienė et al., 2013; Mikučionienė, Aleinikovienė, 2013; Slepetiene et al., 2013), soil can be characterized by differences in organic carbon stability. Thereby, straw must be used as readily available and effective carbon recourse on farms, especially on crop production farms.

Tillage systems and straw application had significant effect on soil organic carbon pools in 0–20 cm soil layer as well (Fig. 2). Long-term straw application increased SOC pools by 5.3 and 6.2 Mg ha^{-1} that is by 9.3% and 11.6% compared with the plots without straw (Fig. 2).



Explanations under Figure 1

Figure 2. Soil organic carbon pools in 0–20 cm soil layer in 2011 and 2013

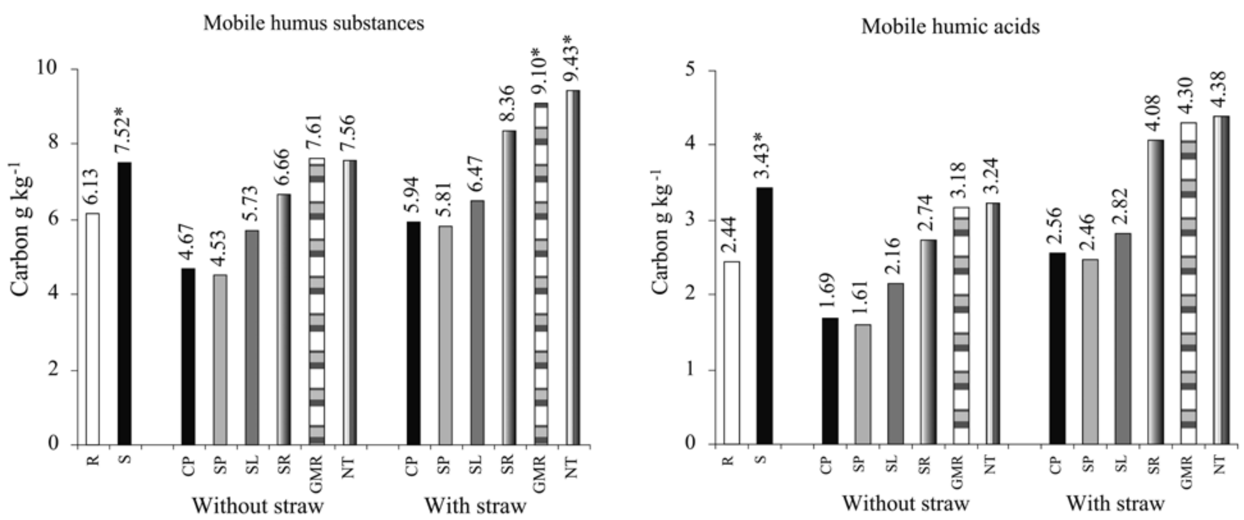
Low intensity tillage systems without primary tillage were more effective for SOC pools than straw application (Fig. 2). In the plots without straw long-term catch cropping for green manure with rotovating before sowing and no-tillage significantly increased pools of organic carbon by 14.6 and 15.3 Mg ha^{-1} in 2011 and 16.0 and 15.7 Mg ha^{-1} in 2013, respectively, compared with conventional ploughing. In the plots with straw, these pools in 2011 increased by 16.5 and 15.4 Mg ha^{-1} and in 2013 – by 16.1 and 17.8 Mg ha^{-1}, respectively. Shallow rotovating had only insignificant tendency to increase SOC pool in both without and with straw plots and in 2011 and 2013. Shallow ploughing and shallow loosening had no effect on carbon pools compared with conventional ploughing both with straw removed or chopped and spread in 2011 and 2013.

According to Fabrizzi et al. (2003), increased carbon storage under no-tillage is mostly attributed to higher particulate organic carbon contents in the upper few cm of the soil profile, which according to Six et al. (2002) intervenes in the stabilization of macro aggregates, leading to a slower macro aggregate turnover under no-tillage compared to conventional ploughing. The study done in a the 4-year crop rotation confirmed that organic and organic-mineral fertilization systems as well as the crop plants in the rotation increased carbon pools (Mikučionienė, Aleinikovienė, 2013). Thus, the carbon pools in top layer also depend on tillage systems, residues and root quantity, catch crops and the composition or level of fertilizers. Therefore the carbon accumulation in mineral soil could be increased, the CO_2 emissions could be reduced and the negative effect of climatic changes could be decreased.

The quantity of mobile humus substances depended on tillage practice, straw and green manure management as well (Fig. 3).The application of straw significantly increased the content of mobile humus substances by 1.39 g kg^{-1} C in 0–20 cm soil layer compared to the plots without straw.

Tillage systems had significant effect on the content of mobile humus substances only in the plots with straw application (Fig. 3). Green manure incorporation with rotovating and no-tillage increased mobile humus substances by 3.16 and 3.49 g kg^{-1} C compared with conventional ploughing. Other soil tillage treatments (SP, SL and SR) had no significant effect both straw removed and chopped as well spread.

The mobile humic acids in evaluated soil layer accounted for about 35–49% of the total amount of mobile humus substances. The quantity of mobile humic acids increased only in the plots of long-term application of straw by 0.99 g kg^{-1} compared with the plots without straw (Fig. 3). Herewith straw increased quality of soil organic matter also. Mobile humic acids accounted for 39.8% of the total amount of mobile humus substances in the treatments without straw, while with the application of straw increased this rate till 45.6%. Reduced tillage systems had no significant effect on mobile humic acids but tended to increase SOM quality. Mobile humic acids in the treatments without straw with primary soil tillage



Explanations under Figure 1.

Figure 3. Mobile humus substances and mobile humic acids in 0–20 cm soil layer in 2013

(CP, SP and SL) amounted to 35.5–37.7% and with straw – 42.3–43.6% from the total amount of mobile humus substances. These proportions in treatments without primary tillage (SR, GMR and NT) increased by 41.1–42.9% and 46.4–48.8%, respectively. This agrees with the data of other researchers that the content of mobile humic substances depended on the soil tillage method and soil layer (Slepetiene, Slepetys, 2005). The highest content 0.76 and 0.78 g kg^{-1} of mobile humic acids accumulated in the soil under minimum soil tillage and two mineral fertilization levels in 0–10 cm soil layer. The residue of plants or green and farmyard manure had positive effect on mobile humic acids (Arlauskienė et al., 2010; Mikučionienė, 2010). It has been indicated that in different organic and organic-mineral fertilization systems mobile humic acids accumulate (0.20–0.35 g kg^{-1} C) in the top layer; moreover, the biomass of cover crops not only increases the content of mobile humic acids, but also are essential for plants and soil microorganisms as nutrient and energy potential.

Conclusions

1. Continuous straw application for 12 and 14 years from the beginning of the field experiment increased soil organic carbon (SOC) in 0–20 cm depth by 9.3% and 12.0% compared with the plots without straw. Long-term application of reduced tillage systems without primary tillage (shallow rotovating before sowing (SR), catch cropping for green manure with rotovating before sowing (GMR) and no-tillage (NT)) were even more effective. Compared with conventional ploughing (CP), SOC increased by 19.4% to 33.9%. In this way tillage systems soil quality increased too, since SOC stratification rate occurs between 0–10 and 10–20 cm layers. Reduced tillage systems with primary tillage (shallow ploughing (SP) and shallow loosening (SL)) had no effect both on SOC and stratification process in the soil.

2. SOC pools tended to increase by 9.3% and 11.6% in the treatments of long-term application of straw compared with the plots without straw. Reduced intensity tillage systems without primary tillage were even more effective. Compared with conventional ploughing, no-tillage practise and catch cropping for green manure with rotovating before sowing significantly increased pools of organic carbon by from 31.7% to 33.3% in the plots without straw and by 28.9% to 32.7% in the plots with straw.

3. The quantity of mobile humus substances in 0–20 cm soil layer was increased by continuous straw application by 22.7% compared to the plots without straw. Straw in combination with catch crop for green manure incorporation and rotovating and no-tillage increased mobile humus substances by 53.2% and 58.8% compared with conventional ploughing. Long-term straw application had positive effect on the quality of soil organic matter also. Compared with the plot without straw it increased the quantity of mobile humic acids by 40.6%. Mobile humic acids accounted for 39.8% of the total amount of mobile humus substances in the treatments without straw, while in the long-term straw application treatments they accounted for 45.6%. Reduced tillage systems without primary tillage had no significant effect on the quantity of mobile humic acids but tended to increase soil organic matter quality.

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Žemės dirbimo sistemų, šiaudų ir žaliosios trąšos derinių ilgalaikis poveikis dirvožemio organinei medžiagai

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Santrauka

Per pastaruosius du dešimtmečius padidėjus dirvožemio degradacijos mastams pirmenybė teikiama toms žemės dirbimo ir dirvožemio derlingumo palaikymo priemonėms, kurios leidžia sumažinti organinės medžiagos skaidymą ir padidinti jos sankaupas dirvožemyje. Tyrimų tikslas – nustatyti įvairaus intensyvumo žemės dirbimo, šiaudų ir žaliosios trąšos derinių ilgalaikį poveikį dirvožemio organinės medžiagos kiekiui bei kokybei. Lauko eksperimentas vykdomas Aleksandro Stulginskio universiteto (anksčiau – Lietuvos žemės ūkio universiteto) Bandymų stotyje nuo 1999 m., straipsnyje pateikti 12-ais ir 14-ais tyrimų metais gauti rezultatai. Nuolatinis tręšimas šiaudais dirvožemio organinės anglies kiekį padidino 9,3 ir 12,0 %, palyginus su dirva be šiaudų. Mažiausio intensyvumo žemės dirbimo sistemos be rudeninio dirbimo (seklus ražienų įterpimas prieš sėją, seklus baltųjų garstyčių tarpinio pasėlio įterpimas prieš sėją, tiesioginė sėja į neįdirbtą ražieną), palyginus su tradiciniu arimu, dirvožemio organinės anglies kiekį padidino nuo 19,4 iki 33,9 %. Pagerėjo ir dirvožemio kokybė, nes dirvožemio organinės anglies kiekis 0–10 cm sluoksnyje, palyginus su 10–20 cm sluoksniu, padidėjo nuo 14 iki 21 %. Tręšimas šiaudais padidino dirvožemio organinės anglies sankaupas – palyginus su šiaudais netręšta dirva, nustatyta 9,3 ir 11,6 % sankaupų didėjimo tendencija. Seklus baltųjų garstyčių tarpinio pasėlio įterpimas prieš sėją ir tiesioginė sėja į neįdirbtą ražieną, palyginus su tradiciniu arimu, organinės anglies sankaupas padidino nuo 31,7 iki 33,3 % dirvoje be šiaudų ir nuo 28,9 iki 32,7 % dirvoje su šiaudais. Nuolatinis tręšimas šiaudais mobiliųjų humuso medžiagų kiekį padidino 22,7 %, o tręšimo šiaudais derinimas su sekliu baltųjų garstyčių tarpinio pasėlio įterpimu prieš sėją ir tiesiogine sėja į neįdirbtą ražieną – 53,2–58,8 %. Mobiliųjų huminių rūgščių kiekį padidino tik ilgalaikis nuolatinis tręšimas šiaudais, palyginus su dirva be šiaudų – 40,6 %. Mobiliųjų huminių rūgščių dalis nuo visų mobiliųjų humuso medžiagų kiekio dirvoje be šiaudų siekė 39,8 %, o dirvoje su šiaudais šis santykis padidėjo iki 45,6 %. Mažiausio intensyvumo žemės dirbimo sistemos be rudeninio dirbimo neturėjo esminės įtakos mobiliosioms huminėms rūgštims, bet turėjo tendenciją gerinti dirvožemio organinės medžiagos kokybę.

Reikšminiai žodžiai: dirvožemio organinė anglis, mobiliosios huminės rūgštys, tradicinis, tausojamasis ir nearminis žemės dirbimas.