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The impact of tillage intensity and meteorological conditions on soil temperature, moisture content and CO_2 efflux in maize and spring barley cultivation

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Abstract

With a worldwide increase in the use of sustainable tillage systems, it is important to ascertain their long-term effects on soil properties and greenhouse gas emissions. However, there are not many long-term experiments of this type, and they are conducted in very different climatic and soil conditions. To fill a knowledge gap in this field of study, a long-term, stationary field experiment was set up at Aleksandras Stulginskis University's Experimental Station (54°52′57 N lat., 23°50′51 E long.) in 1988. The current paper presents the experimental data from the 2015–2016 period. The soil of the experimental site is *Epieutric Endocalcaric Endogleyic Planosol* (*PL.gln-can-eup*) with a texture of loam on heavy loam. The topsoil layer's characteristics are as follows: pH_{KCL} 6.6–7.0, available phosphorus (P_2O_5) content 131.1–206.7 mg kg^{-1}, available potassium (K_2O) content 72.0–126.9 mg kg^{-1}, humus content 1.68%. This study set out to investigate the effects of long-term application of different tillage systems and meteorological conditions on soil temperature, moisture content and soil surface carbon dioxide (CO_2) efflux in the stands of maize and spring barley. The experiment included the following primary tillage methods differing in intensity: 1) conventional ploughing (CP) at a 23–25 cm depth (control treatment), 2) shallow ploughing (SP) at a depth of 12–15 cm, 3) deep cultivation (DC) at a depth of 23–25 cm, 4) shallow cultivation (SC) at a depth of 12–15 cm and 5) no tillage (NT) (direct drilling).

The findings of the study suggest that the soil surface CO_2 efflux depended on the amount of rainfall during the crop growing season. In a dry year 2016, the soil CO_2 efflux was lower than that in a wet year, the differences between the tillage treatments were more distinct, with the least flux being from the NT treatment. No significant differences among the tillage treatments were determined in a wet year 2015. The soil temperature depended on the tillage intensity and the weather conditions during the crop growing season. A lower soil temperature was recorded in the reduced tillage treatments compared with conventional tillage treatments. A negative strong correlation was established between the soil surface CO_2 efflux and soil temperature ($y = 13.93867 + 0.303x$; $r = -0.96$, $P < 0.05$). The tillage methods of different intensity did not have significant effect on the moisture content in the soil surface layer; however, in a dry year, the highest moisture content was determined in the no-tillage treatment, while in a wet year the differences were negligible.

Key words: maize, soil moisture, soil surface CO_2 efflux, soil temperature, spring barley, tillage.

Introduction

Recently, there has been increased worldwide interest in environmentally-friendly tillage systems, whose application not only saves energy resources but also impacts on soil hydro-physical and physical properties and greenhouse gas (particularly CO_2) emissions. Increasing CO_2 concentrations in the atmosphere together with other gases (CH_4 and N_2O) promote climate change (Brouder, Volenec, 2008).

It has been found that soil CO_2 loss is proportional to the volume of soil disturbed in the tillage operation (Reicosky, Archer, 2007). Feiza et al. (2010) have documented that soil CO_2 efflux is determined by the depth and intensity of mechanical tillage. Several reports have shown that ploughless tillage, as well as direct drilling, decreases soil CO_2 emission from the soil (Álvaro-Fuentes et al., 2008; Buragienė et al., 2015). The results of the studies on soil CO_2 efflux are discrepant and lack consistency (Vinten et al., 2002).

Mechanical tillage affects physical soil properties which are important for plant nutrient supply and soil air and moisture regime (Kouwenhoven et al., 2002). One of the solutions to the shortage of soil moisture is application of sustainable tillage systems (Riley, 2014).

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Soil temperature may vary during the crop growing season due to the canopy shading (Amos et al., 2005). Bergamaschi et al. (2004) have investigated the relationship between plant foliage development and tillage method. They compared direct drilling with conventional tillage and found that in the treatments of direct drilling the leaf density of plants was lower than that in conventionally tilled and sown treatments. The shade of plant leaves on the soil surface was different; therefore the temperature of soil surface was also uneven.

Based on the findings obtained by other researchers, it can be argued that the variation of soil temperature depends on the tillage intensity and environmental factors. Furthermore, thermal soil processes, which have a very strong influence on the growth of crops, are very closely related to the physical and mechanical properties of soil and plant residues. Paul et al. (2004) suggest that soil moisture and temperature are closely related values. Soil moisture can be controlled by soil and crop management practices of which the most important ones are proper crop rotation and tillage.

The current study was aimed to estimate the effects of long-term tillage of different intensity on soil surface efflux of carbon dioxide (CO_2), soil temperature and moisture.

Materials and methods

Site and soil description and experimental design. A long-term stationary field experiment was set up in 1988 at the then Lithuanian Academy of Agriculture's (currently – Aleksandras Stulginskis University) Experimental Station (54°52′57 N lat., 23°50′51 E long.). The experiment was instigated by prof. A. Stancevičius. It was laid out in a six-course crop rotation. In 2000, on the initiative of prof. V. Bogužas the experiment was modified by including a direct drilling treatment, the crops grown were sugar beet (2001–2007), maize (2008–2015), spring barley (since 1988) and spring oilseed rape (2001–2015) and winter wheat (since 1988).

The soil of the experimental field has formed in the area of bottom moraine or bottom glacial deposits covered with glacial lacustrine sediments. The soil texture is loam on heavy loam, soil type is *Epieutric Endocalcaric Endogleyic Planosol* (*PL-gln-can-eup*) (WRB, 2014); the depth of arable layer is 23–27 cm. The topsoil (0–15 cm) characteristics were as follows: pH_{KCl} 6.6–7.0, available phosphorus (P_2O_5) content 131.1–206.7 mg kg^{-1}, available potassium (K_2O) content 72.0–126.9 mg kg^{-1}, humus content 1.68% (Avižienytė et al., 2013).

The plots of the experimental treatments were replicated four times. There were a total of 20 plots in which maize (2015) and spring barley (2016) were grown. The initial plot size was 126 m^2 (14 × 9 m) and sampling area was 70 (10 × 7) m^2. The plots of the experimental treatments were laid out in a randomized design. The protection zone of a plot was 1 m wide, and that between replications was 9 m wide. The following primary tillage methods were investigated: 1) conventional ploughing (CP) at a depth of 23–25 cm (control treatment), 2) shallow ploughing (SP) at a depth of 12–15 cm, 3) deep cultivation (DC) (chiselling) at a depth of 23–25 cm, 4) shallow cultivation (SC) (discing) at a depth of 12–15 cm and 5) no tillage (direct drilling) (NT).

The NT plots were sprayed with a herbicide Roundup (a.i. glyphosate 480 g L^{-1}, 4 L ha^{-1}) after the pre-crop harvesting. The experimental plots were tilled in late October. For ploughing, a plough PP-3-43 (Lithuania) with semi-helical shellboards, a chisel cultivator KRG-3.6 and a disc harrow Väderstad Carrier 300 (Sweden) were used. Pre-sowing tillage was performed with a complex cultivator KLG-3.6 (Lithuania). The crops were sown with a drill Väderstad Rapid 300C Super XL (Sweden). Mineral fertilizers were incorporated at sowing. The distance between rows in the strip was 12.5 cm. Maize was sown at a rate of 100 000 seeds ha^{-1} at a sowing depth of 6–7 cm. Weeds were controlled by one spray application using an Amazone UF-901 (UK) sprayer. Maize is a relatively new crop in Lithuania, therefore pests and diseases have weak impact on crop development. Maize was harvested by a Wintersteiger Delta plot combine (Austria). More detailed information on the methodology of the experiment is available in Avižienytė et al. (2013) and Romaneckas et al. (2015). Spring barley was sown at a rate of 5–6 million seeds ha^{-1} at a depth of 3.5 cm with 12.5 cm wide interrow spacings. The NPK fertilizers (16:16:16, 250 kg ha^{-1}) were used as placement application at a 4–4.5 cm depth. The crops were sprayed twice against weeds and three times against diseases and twice against pests using the following products: herbicide Mustang 0.7 l ha^{-1} (a.i. florasulam 6.25 g L^{-1}, 2.4-D 2-ethylhexyl 452.5 g L^{-1}), fungicide Bumper fungi 0.5 l ha^{-1} (a.i. propiconazole 250 g L^{-1}), herbicide Lontrel 160 g ha^{-1} (a.i. clopyralid 720 g kg^{-1}) and fungicide Amistar fungi 0.6 l ha^{-1} (a.i. azoxystrobin 250 g l^{-1}). The crop was additionally fertilized with ammonium nitrate (N_{68}) 200 kg ha^{-1} and urea 30 kg ha^{-1}.

Soil sampling and methods of analyses. In 2015, the soil surface carbon dioxide (CO_2) efflux (μmol m^{-2} s^{-1}) was measured in the 0–10 cm layer with an infra-red gas analyser LI-6400XT (LI-COR Inc., USA) (IRGA method). CO_2 efflux was carried out three times per growing season from June to August, 2015, at the same time of the day (from 10.00 to 15.00 hrs) and at the fixed locations in the field. Soil temperature and moisture were measured in not less than 10 spots of each harvested plot in the 0–10 cm topsoil layer by the false discovery rate (FDR) method (Yao et al., 2016) An electronic Delta-T device HH_2 moisture meter with a WET sensor (Delta-T Devices, UK) was used. The measurements were made three times per growing season.

In 2016, measurements of the soil surface CO_2 efflux (μmol m^{-2} s^{-1}) were made using the IRGA method. A portable, automated soil gas flux system LI-8100A with a 8100-103 chamber, analyser LI-8100A (LI-COR Inc.) was used. In each record plot, in spring, rings 20 cm in diameter were installed into the soil in which, three measurements were made in each plot. CO_2 efflux was carried out three times per growing season from June to August, 2016, at the say time of the day (from 10.00 to 15.00 hrs) and at the fixed locations in the field. Soil moisture was measured by a sensor LI-8100-204 (LI-COR Inc.), soil temperature – by a sensor LI-8100-203 (LI-COR Inc.) included in the chamber control kit of the LI-8100A automated soil gas flux system (LI-COR Inc.).

Statistical analysis. The experimental data were processed using a two-factor analysis of variance (*ANOVA*) from the statistical software package *SYSTAT 10* (SPSS Inc., 2000; Leonavičienė, 2007). The significance of differences among the treatments was estimated by the least significant difference (LSD) test. The mutual causality of the investigated parameters was estimated by the correlation regression analysis method using the software *STAT ENG* (Raudonius et al., 2009; Raudonius, 2017). If there was a significant difference between a specific treatment and the control treatment, its probability level is indicated as follows: * – when $P \leq 0.050 > 0.010$ (differences are significant at 95% probability level), ** – when $P \leq 0.010 > 0.001$ (differences are significant at 99% probability level), *** – when $P \leq 0.001$ (differences are significant at 99.99% probability level).

Meteorological conditions. The climate of Lithuania is moderately warm, temperate transitioning from maritime to continental. Lithuania is in a cool temperate zone with moderately warm summers and moderately cold winters. According to the climate zoning, Kaunas region belongs to the Middle Lowland zone of Lithuania, the sub-region of the lower-reaches of the river Nemunas. Meteorological conditions are described using the data from Kaunas Meteorological Station (Figs 1 and 2).

In 2015, the thermal conditions of the maize growing season were close to the long-term average (Fig. 1). It was warmer than usual only in August and September. In August, the average monthly temperature was 20.3°C, which was 3.0°C higher compared to the long-term average. The temperature of September was 2.1°C above the long-term average.

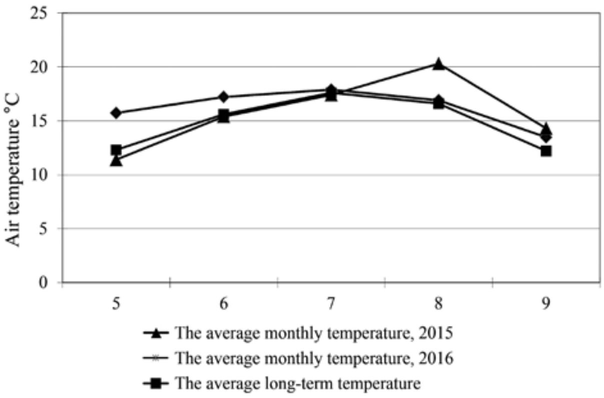


Figure 1. The air temperature during the crop growing season (Kaunas Meteorological Station)

In 2015, there was a deficit of moisture for maize development. The weather was more humid only in September. June and August were particularly dry (Fig. 2). In June, instead of the usual 77 mm rainfall, as little as 16.4 mm fell. The rainfall in August amounted to 6.9 mm, while the long-term average is 82 mm. Under such conditions, there was a lack of moisture not only for crops but also for soil microorganisms. Due to this, the activity of soil microorganisms was low and gas efflux from the soil was weak.

In 2016, the thermal conditions of the growing season of barley were closer to the long-term average, but May and June were warmer (Fig. 1). The average monthly temperature of May was by 3.4°C higher than the long-term average and that of June by 1.6°C. Unlike in 2015, in 2016 it was wetter than usual (Fig. 2). Only May and September were more arid; however, there was excess of moisture in the summer. Such conditions were conducive to the biochemical reactions occurring in the soil. July was particularly wet, with rainfall amounting to 160 mm, which was nearly twice as much as the normal rate.

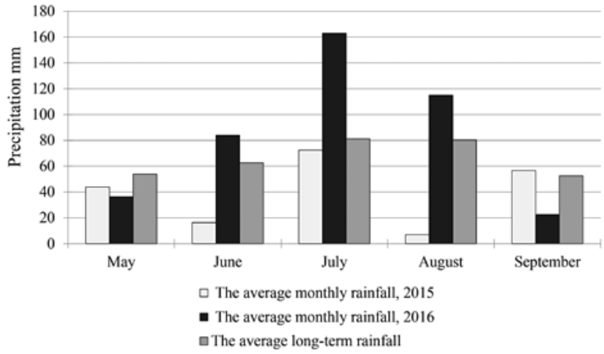


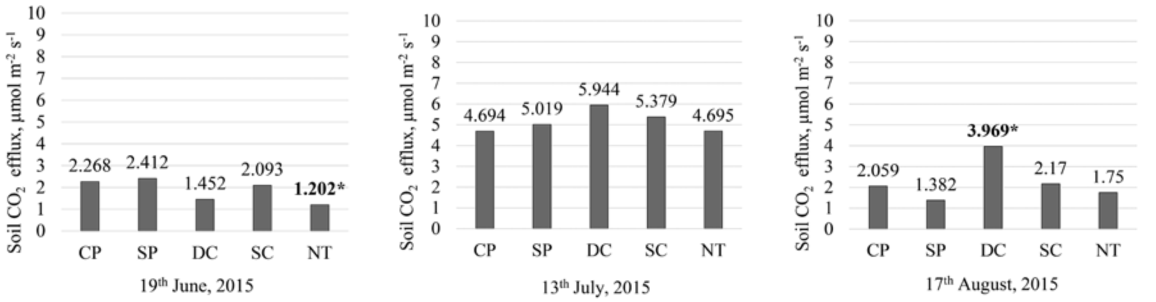
Figure 2. The amount of rainfall during the crop growing season (Kaunas Meteorological Station, Lithuania)

Results and discussion

Carbon dioxide (CO_2) efflux from the soil surface. During the tillage operations, the soil is disturbed, turned and mixed, its natural structure is destroyed; moreover, the soil CO_2 efflux is increased due to increased aeration (Al-Kaisi, Yin, 2005; Moussadek et al., 2011). Tillage implements that cultivate the soil more intensively and at greater depths exert stronger effect on soil CO_2 efflux (La Scala et al., 2001). In our experiment, in 2015 the lowest CO_2 efflux from the soil was recorded in the no tillage treatment; however, only on 19 June, 2015 the difference was significantly lower (1.9 times) compared with the conventional deep ploughing treatment (Fig. 3). In other differently tilled plots, most often there were found no significant differences compared with the conventional ploughing treatment. However, in the second half of maize growing season, gas efflux from deeply cultivated plots intensified, which at the end of the growing season became significantly the highest about 1.9 times. Similar findings were obtained by Steponavičienė (2017). CO_2 efflux from the soil increased in proportion to increasing tillage intensity. Thus, direct drilling into untilled or minimally tilled soil allows alleviation of the negative farming impacts on climate change and serves as an efficient means for soil fertility restoration and enhancement (Buragienė et al., 2015).

Rainfall, albeit scarce, strongly activates the intensity of soil carbon dioxide turnover (Curiel Yuste et al., 2003; Lee et al., 2004). Higher soil moisture content favours more intensive microbiological activity as well as higher oxygen consumption and carbon dioxide release (Buyanovsky, Wagner, 1998). The above mentioned authors suggest that CO_2 concentration was affected when the soil temperature was above +15°C. Our research supports their proposition, we established this trend because it was sufficiently warm and the amount of rainfall increased from the second ten-day period of June, which resulted in increased CO_2 efflux from the soil (Fig. 3).

Soil analysis in 2016 indicated that CO_2 efflux from the soil was higher compared with that in the dry year 2015. Tillage of different intensity did not have significant impact on the soil carbon dioxide fluxes. Nevertheless, during the entire experimental period, the soil CO_2 fluxes from the plots of the shallow ploughing

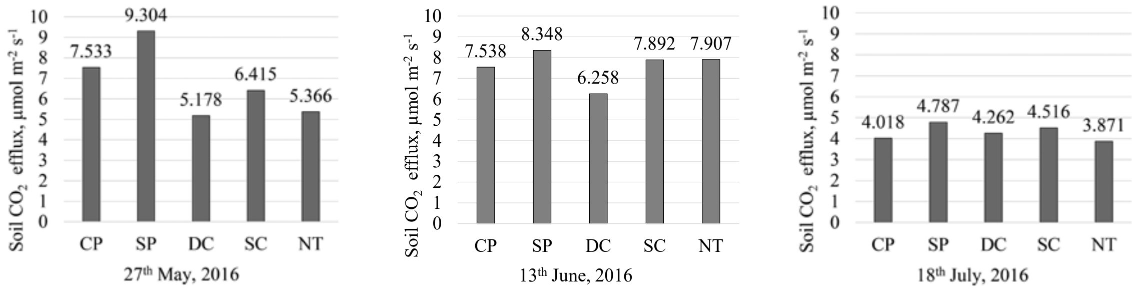


CP – conventional ploughing (control treatment), SP – shallow ploughing, DC – deep cultivation (chiselling), SC – shallow cultivation (discing), NT – no tillage (direct drilling); * – significant difference from the control treatment at 95.0% probability level

Figure 3. The effect of tillage of different intensity on the soil surface (0–10 cm) carbon dioxide (CO_2) efflux under maize (2016)

treatment tended to increase (Fig. 4). The effects of the other reduced tillage methods on CO_2 fluxes from the soil were uneven. On 27 May, when the measurements were made, the air temperature was high and there was little rainfall (Figs 1 and 2). As a result, in cultivated and untilled plots, the CO_2 efflux from the soil was 1.2–1.6 times, insignificantly lower compared with that occurring from the conventionally tilled soil.

The weather conditions have a marked impact on CO_2 efflux from the soil (Feizienė, Kadžienė, 2008; Buragienė et al., 2011). In our study, we established that in the middle of spring barley growing season, 13 June, 2016, the CO_2 efflux from the soil largely depended on soil temperature. With increasing soil temperature, the CO_2 efflux increased as well ($y = 13.94 + 0.30x$; $r = -0.96$, $P < 0.05$). A very strong correlation was established between the average monthly air temperatures of the crop growing period and CO_2 efflux in 2015 ($y = -166.69 + 19.19x - 0.53x^2$; $r = 0.91$, $P \leq 0.01$) and in 2016 ($y = 0x^2 \times 8.96$; $r = 0.78$, $P \leq 0.01$). With increasing average daily temperature, the soil CO_2 efflux increased; however, when the average daily temperature rose above 18°C, the intensity of soil CO_2 efflux started to decline. A strong and moderately strong correlation was identified between the monthly amount of rainfall during the crop growing season and soil CO_2 efflux in 2015 ($y = 1.66 \times 1.01^2x$; $r = 0.70$, $P \leq 0.01$) and in 2016 ($y = 26.31 - 0.36x + 0.001x^2$; $r = 0.61$, $P \leq 0.05$). With increasing amount of rainfall, CO_2 efflux increased as well; however, when the temperature rose above 20°C and the amount of rainfall decreased by 6.9 mm (increased evaporation), the CO_2 efflux decreased. In July 2016, the CO_2 efflux from the plots, in which tillage methods alternative to conventional ploughing had been applied, was 1.1–1.2 times higher. The lowest CO_2 efflux was measured from the untilled soil. The differences were not significant.



Explanations under Figure 3

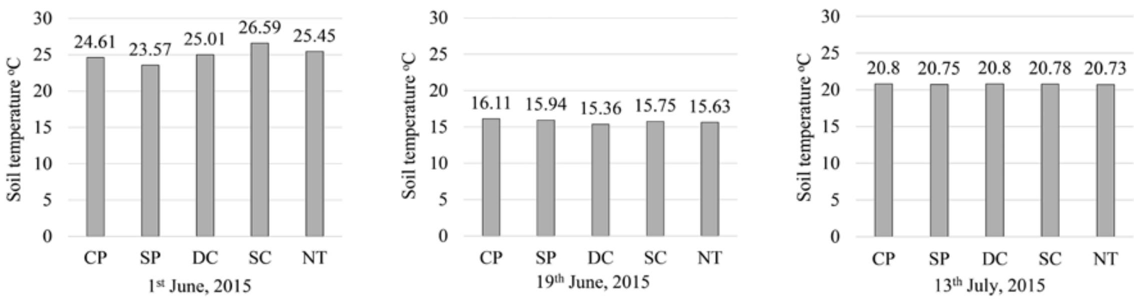
Figure 4. The effect of tillage of different intensity on the soil surface (0–10 cm) carbon dioxide (CO_2) efflux under spring barley (2016)

Summarizing the results of these investigations, it can be maintained that the intensity of CO_2 efflux from the soil was largely dependent on the weather conditions during the crop growing season and the peculiarities of tillage.

Soil temperature. Soil temperature exerts effect on many important processes occurring in nature (Lehnert et al., 2014). There has been found a relationship between soil temperature and CO_2 and NO_2 efflux: with increasing soil temperature, the efflux of these gases into the atmosphere increase as well. Thus, this effect becomes a positive feedback in the climate system (Haei et al., 2013; Lu, Xu, 2014; Albergel et al., 2015). The changes in soil temperature and evaporation are conditioned by the heat efflux in it. The latter are determined by the thermal capacity of a specific soil and the thermal conductivity. The soil thermal properties are most dependent on soil bulk density, organic matter content, soil texture and moisture content. The mineral part of the soil is characterised by a low thermal capacity, but it has a higher thermal conductivity than water, therefore dry soils can warm up more quickly and cool faster than wetter soils (Hillel, 1991). Heat turnover in the soil depends on the meteorological conditions, its thermal conductivity, thermal capacity, moisture content and other soil characteristics. One of the main factors influencing the thermal process in the soil is tillage and soil surface coverage with various crops or their residues (Buragienė et al., 2015).

It has been documented (Morote et al., 1990; Salton, Mielniczuk, 1995; Calderon, Jackson, 2002;

Al-Kaisi, Yin, 2005) that ploughless tillage and direct drilling into untilled soil, due to the higher amount of plant residues on the soil surface left, do not allow the soil to rapidly warm up during the first stages of the growing season. In our experiment, the tested tillage methods of different intensity did not have significant effect on soil temperature (Fig. 5). Contrary to what the above researchers suggest, in our experiment, during the first measurement carried out on 1 June, 2015 there were observed incidents of most warmed up topsoil layer (26.59°C) in the plots of shallow cultivation and no-tillage treatments. The temperature of the soil surface was higher than that during other measurements because it was warm and very dry – low moisture content in the soil accelerated its warming up.



Explanations under Figure 3

Figure 5. The effect of tillage of different intensity on soil temperature in 0–10 cm layer under maize (2015)

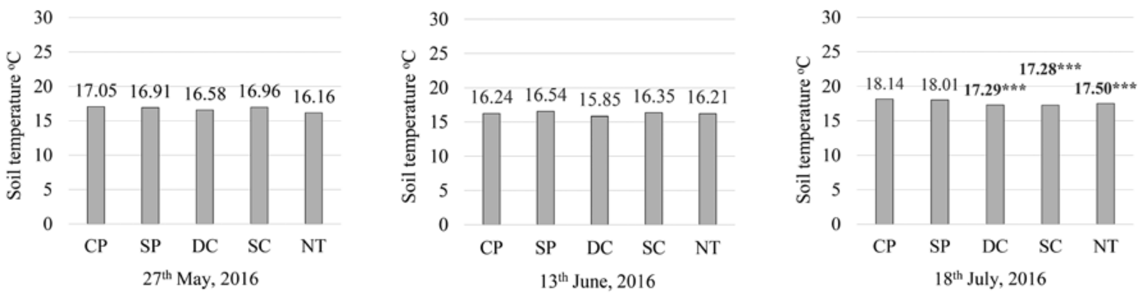
During the second measurement conducted on 19 June, 2015, the air temperature was not high; therefore the soil had not warmed up. The soil temperature in the reduced tillage plots and untilled plots was only inappreciably lower (from 0.17°C to 0.75°C), compared with that in the plots of conventional deep ploughing treatment.

Research evidence suggests that in the soil disturbed by tillage implements, there appear more air gaps through which ambient air temperature is more rapidly transferred into the soil. In the case of direct drilling application, plant residues that are left on the soil surface inhibit warming up of the topsoil layer when the ambient temperature increases, and when the temperature goes down, conversely, they do not allow the soil to rapidly cool down (Calderon, Jackson, 2002; Al-Kaisi, Yin, 2005). Our study supports this proposition. Rainfall that occurred in July cooled down the soil, although average daily temperature was higher. Measurements made on 13 July, 2015 showed that in the plots of no-tillage treatment, shallow ploughing treatment and shallow cultivation treatment soil temperature was lower than that in the plots of conventional ploughing treatment. Soil temperature in the plots of deep cultivation treatment was the same as in the control treatment.

In the second experimental year (2016), during the first measurements, it was found that the methods of different primary tillage did not have significant effect on soil surface temperature, although the amount of plant residues differed several times (Avižienytė et al., 2015) (Fig. 6). In 2016, in the second ten-day period of May, there fell considerable amount of rainfall (31.3 mm) and the air temperature was not high (on average 12.55°C). At the beginning of the third ten-day period of May, the amount of rainfall decreased but the temperature remained similar. For these reasons, the soil temperature was lower. Measurements made on 27 May, 2016 did not show significant differences. In the reduced tillage treatments, the soil temperature was very similar to that in the plots of conventional ploughing treatment.

During the second measurement conducted on 13 June, 2016, the soil temperature in shallow ploughing and shallow cultivation treatments was slightly higher (0.11–0.30°C) than in the control treatment. During the third measurement conducted on 18 July, 2016, significant differences were established among the tillage treatments. Significantly lower soil temperature was measured in the plots tilled using non-inversion methods and in the untilled plots. Mechanical soil cultivation, which disturbs and loosens the soil, promotes its faster drying and warming up (Hillel, 1991). This was corroborated by the results of our research.

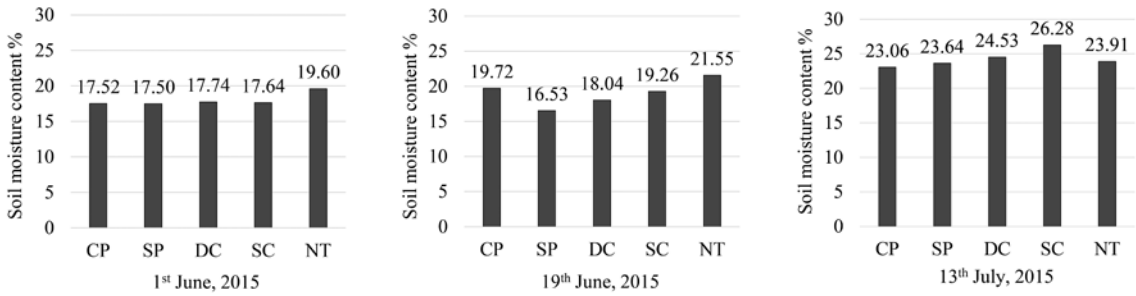
Soil moisture. Crops need moisture during the entire growing season. Different tillage methods are important for soil moister and air regime. They influence the formation of the biological potential of crops, and thus the yield. The climatic conditions are usually responsible for different moisture content in separate



Explanations under Figure 3

Figure 6. The effect of tillage of different intensity on soil temperature in 0–10 cm layer under spring barley (2016)

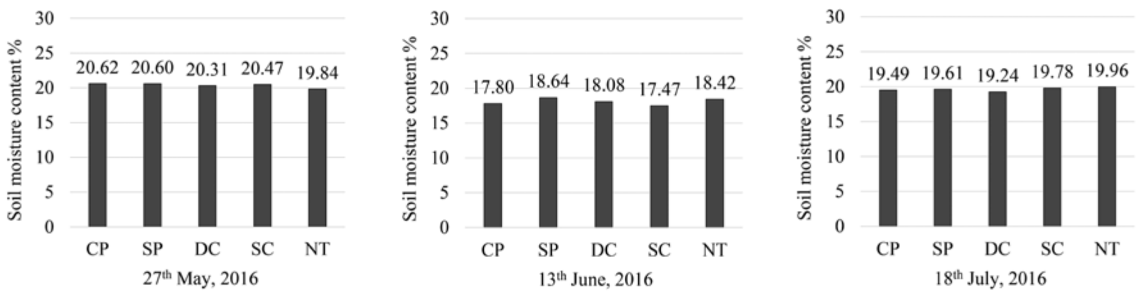
years (Steduto et al., 2007). Jemai et al. (2013) found that sustainable soil cultivation longer preserves the moisture needed for plants to emerge and grow. Similar results were obtained in our previous studies (Romaneckas et al., 2011; 2012; 2015). Unlike in the present studies, in 2015, the different tillage methods did not have a significant influence on the moisture content of the soil surface (Fig. 7). During the first measurement, from the third ten-day period of May to the first ten-day period of June it was very dry. This is reflected in the results of our study, the soil moisture content (volume) varied from 17.50% to 19.60%. The highest soil moisture content was recorded in the untilled soil. In the first and second ten-day periods of June, there was as little rainfall as 2 mm; therefore during the second measurement conducted on 19 June, 2015 similar trends were identified to those established during the first measurement. The highest moisture content (21.55%) was measured in the plots of direct drilling treatment.



Explanations under Figure 3

Figure 7. The effect of tillage of different intensity on the soil moisture content (volume) in 0–10 cm layer under maize (2015)

In 2016, the crop growing season was characterised by excessive moisture, therefore the results obtained that year differed from those obtained in the year with a dry growing season 2015 (Fig. 8). All reduced tillage methods negligibly reduced (0.02–0.78 percentage points) soil moisture content. Buragienė et al. (2015) obtained comparable results, they argue that such results might have been influenced by a densified layer, commonly referred to as "plough pan" created by a plough. Moisture filtrated more slowly through it, and therefore its excess accumulated in the plough layer. In 2016, the amount of rainfall that fell during the period from 1 to 18 July amounted to as much as 118.5 mm. The results of second and third measurement showed not significant differences. Meanwhile the highest soil moisture content incidents were recorded in the no-tillage treatment; however, in general, the soil moisture content was not high.



Explanations under Figure 3

Figure 8. The effect of tillage of different intensity on soil moisture content (volume) in 0–10 cm layer under spring barley (2016)

The soil CO_2 flux is highly dependent on rainfall and temperature fluctuations. It decreased when there was a shortage of moisture (2015) as well as when there was excess of moisture and lower temperatures (2016).

Conclusions

1. Soil carbon dioxide (CO_2) efflux mainly depended on the amount of rainfall during the crop growing season. In a dry year, the soil CO_2 efflux was lower than that in a wet year and the differences among the tillage treatments were more distinct. Most often, the lowest gas efflux was measured in no-tillage treatment. In a wet year, no significant differences among the tillage treatments were identified.

2. Soil temperature in 0–10 cm layer significantly depended on the intensity of tillage and the weather conditions during the crop growing season. In most cases, a lower soil temperature was measured in the soil of reduced tillage treatments compared with conventionally ploughed plots. A strong negative correlation ($y = 13.93867 + 0.303x$; $r = -0.96$, $P < 0.05$) was established between the soil CO_2 efflux rate and the soil temperature.

3. Tillage methods of different intensity did not have significant effect on the soil surface moisture. However, in a dry year, the soil of no-tillage treatment was found to have the highest moisture content, while in a wet year, the differences were negligible.

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Žemės dirbimo intensyvumo ir meteorologinių sąlygų įtaka dirvožemio temperatūrai, drėgmei ir CO_2 emisijai kukurūzų bei vasarinių miežių pasėliuose

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Santrauka

Pasaulyje plintant tvaraus žemės dirbimo sistemoms yra svarbu išsiaiškinti jų ilgalaikę įtaką dirvožemio savybėms ir šiltnamio efektą sukeliančių dujų emisijai. Tokio tipo ilgalaikių eksperimentų nėra daug, be to, jie atlikti esant labai nevienodoms klimato ir dirvožemio sąlygoms. Tuo tikslu Aleksandro Stulginskio universiteto Bandymų stotyje (540 52′57. 7″, 230 50′3.51″) nuo 1988 m. pradėtas vykdyti ilgalaikis stacionarus lauko eksperimentas. Straipsnyje pateikti 2015–2016 m. tyrimų duomenys. Eksperimento lauko dirvožemis yra giliau glėjiškas pasotintasis palvažemis (PLb-g4), kurio granuliometrinė sudėtis – priemolis ant sunkaus priemolio. Viršutinio armens sluoksnio pH_{KCl} – 6,6–7,0, judriojo fosforo (P_2O_5) – 131,1–206,7 mg kg^{-1}, judriojo kalio (K_2O) – 72,0–126,9 mg kg^{-1}, humuso – 1,68 %. Eksperimento tikslas – įvertinti ilgalaikio skirtingo žemės dirbimo įtaką dirvožemio temperatūrai, drėgniui ir anglies dioksido (CO_2) emisijai kukurūzų bei vasarinių miežių pasėliuose. Tirti skirtingo intensyvumo pagrindiniai žemės dirbimo būdai: 1) tradicinis arimas 23–25 cm gyliu (kontrolinis – palyginamasis variantas), 2) seklus arimas 12–15 cm gyliu, 3) gilus purenimas 23–25 cm gyliu, 4) seklus purenimas 12–15 cm gyliu, 5) nedirbta žemė (tiesioginė sėja į neįdirbtą dirvą).

Tyrimų duomenimis, CO_2 emisijos intensyvumas priklausė nuo kritulių kiekio vegetacijos metu. Sausais metais CO_2 emisija buvo mažesnė nei drėgnais, o skirtumai tarp žemės dirbimo variantų buvo ryškesni – dažniausiai mažiausias dujų emisijos intensyvumas buvo iš nedirbtos žemės. Drėgnais metais esminiai skirtumai tarp žemės dirbimo variantų nenustatyti. Dirvožemio temperatūra priklausė nuo žemės dirbimo intensyvumo ir meteorologinių sąlygų augalų vegetacijos metu. Taikant supaprastintus žemės dirbimo būdus daugeliu atvejų nustatyta žemesnė dirvožemio temperatūra nei tradiciškai artuose laukeliuose. Tarp CO_2 emisijos intensyvumo ir dirvožemio temperatūros nustatytas stiprus neigiamas ryšys ($y = 13.93867 + 0.303x$; $r = -0{,}96$, $P < 0{,}05$). Skirtingo intensyvumo žemės dirbimo būdai neturėjo esminės įtakos dirvožemio paviršinio sluoksnio drėgniui, tačiau sausais metais didžiausias drėgmės kiekis buvo nustatytas nedirbtoje žemėje; drėgnais metais skirtumai buvo nežymūs.

Reikšminiai žodžiai: CO_2 emisija, dirvožemio drėgmė, dirvožemio temperatūra, kukurūzai, vasariniai miežiai, žemės dirbimas.