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THE EFFECT OF STRAW INCORPORATION INTO THE SOIL ON SOIL CARBON DIOXIDE EMISSION

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Abstract

In this study, straw was incorporated into different soil depth and then soil CO_2 emission was recorded for 45 days after the tillage operation. For this purpose, four treatments were investigated as bare soil surface (A), straw incorporated into 5 cm soil depth (B), straw incorporated into 10 cm soil depth (C), straw spreaded at the soil surface (D). Approximately, 0.5 kg straw was used per square meter. Soil carbon dioxide emission was recorded by mobile soil CO_2 flux system. Concomitantly, soil temperature, soil water evaporation and soil moisture was recorded.
According to results, soil CO_2 emission for A, B, C, and D treatments are 0.176, 0.213, 0.211 and 0.097 g CO_2 m^{-2} $h^{-1,}$ respectively. Soil temperature for A, B, C, and D treatments are 13.2°C, 13.2°C, 13.2°C and 13.3°C, respectively. Soil water evaporation for A, B, C, and D treatments are 2.24, 3.00, 2.40, and 2.01 g m^{-2} h^{-1}, respectively. Soil moisture for A, B, C, and D treatments are 16.7%, 18.4%, 18.3%, and 18.1%, respectively.
According to results, the least soil CO_2 emission was determined in D treatment. The highest soil CO_2 emission was determined for B and C treatments. Results showed that soil CO_2 emissions increased with the incorporating of straw into the soil.

Key words: *soil CO_2 emission, tillage, straw, greenhouse gasses*.

INTRODUCTION

Agricultural activities, use of fossil fuels, deforestation, rapid population growth, and the community's propensity to consume increased the amount of greenhouse gases (CO_2, NH_4 and N_2O). These gases have the greenhouse effect thereby resulting in global warming and climate changes. Soil CO_2 emissions varies depending on the types and number of equipment used in seed bed preparation. (Akbolat et al., 2004). Therefore, one of the scientific research topics in recent years is to reduce soil CO_2 emissions. Stubble burning, plow tillage and continuous production have very important role in the increase of soil CO_2 emission (Lal and Kimbele, 1997). Ball et al. (1999) reported that soil compaction, tillage and soil structure quality affect the transportation, production and consumption of CO_2 and N_2O gasses. Additionally, soil compaction and tillage are highly effective on gas movement in the soil affecting soil quality. In a sort term research, comparing the effect of 1 kPa and 6 kPa compression on soil CO_2 and N_2O emission, it was concluded that soil CO_2 and N_2O emission were reduced with the compaction (Ball et al., 2008). There is always a standard respiration on the soil as CO_2 of 0.5-10 mg m^{-2} day^{-1} in normal agricultural soil (Haktanır and Arcak, 1997).
The most important physical factors affecting gas emissions are soil temperature and humidity (Smith et al., 2003). Nitrate accumulation and microbial activity affect soil CO_2 emissions. Therefore, it affects the quality of the soil and the atmospheric environment (Calderon and Jackson, 2002). Tillage systems also show the intensity of the effects to the soil. In a study on tillage systems, the maximum CO_2 emissions were found in the conventional tillage system, followed by the reduced tillage system and no-till system (Akbolat et al., 2009). In one study, the effect of mixing the hay into the soil or leaving it on the soil surface was investigated on soil CO_2 emissions. 280 kg da^{-1} straw was used in the study. The test plot was irrigated every two days. According to the results of the research, it is reported that distribution of the straw to the soil surface reduced soil carbon dioxide emissions (Curtin et al., 1998).

It is understood from previous studies that the residues left on the soil surface or incorporated into the soil affect the decomposition, organic carbon accumulation and soil carbon dioxide emission. In this study, the effects of leaving straw on soil surface or burying with different depths of soil on soil CO_2 emission was investigated.

MATERIALS AND METHODS

The experiment was carried out at the Agricultural Research Station of the Faculty of Agriculture of Suleyman Demirel University in Isparta (37.75° N, 30.55° E). The experiment was conducted over a 45 days period in November and December 2015. The main soil properties of the experimental site for the depth of 0-30 cm were as follows: 33.9% sand, 22.3% clay, 1.7% soil organic matter, and pH 7.87 (Akgul and Basayigit, 2005).

Plots of 10 m x 2 m were used for each replication.

The straw was distributed homogeneously on the plot surfaces as 500 kg per decar, then treatment B was tilled 5 cm tillage depth, and treatment C was tilled 10 cm tillage depth by self-propelled rotary tiller. The straw was left on the plot surface at the fourth treatment (D). This treatment was not tilled. In the first treatment (A), no stubble was left on plot surface as control. Details of treatments are given in Table 1.

Table 1. Details of treatments

Treatments	Details
A	No straw on the soil surface, no-till soil
B	Straw was incorporated in to the 5 cm soil depth by rotovator
C	Straw was incorporated in to the 10 cm soil depth by rotovator
D	Straw was spreaded on to the soil surface, no-till soil

In situ soil respiration was measured using a CFX-2 soil CO_2 flux system (PP Systems, Hitchin, UK) consisting of integral CO_2 analyzer and H_2O sensor, soil respiration chamber, and soil temperature probe (Akbolat et al., 2009). Measurements of soil net CO_2 efflux are based on concentration differences between air entering and leaving the chamber and the flow rate under normal soil atmosphere exchanges, with an accuracy of better than 1% and 2% for CO_2 and H_2O concentrations, respectively.

Three recording were randomly taken at different locations from every plot. A soil CO_2 flux chamber was installed 1.5 cm deep into the randomly selected locations for the plots, and thus was isolated from the outer atmosphere.

The measurements were made on days 1, 2, 6, 9, 21 and 45 after the tillage. Amount of soil CO_2 emission are expressed in g CO_2 m^{-2} h^{-1} throughout the text. In addition, evaporation, and soil temperature, were concomitantly measured.

Soil samples taken from a soil depth of 0-20 cm were analyzed at 105°C for 24 hours, based on a gravimetric method for moisture content (Blake ve Hartge, 1986). A randomized complete block design with three replication was selected for the experiment.

RESULTS AND DISCUSSIONS

The data obtained in this study to determine the effect of straw left on the soil surface or incorporated into the soil on soil CO_2 emissions is given in Table 2.

The equal amount of straw was applied to all treatments. Straw was distributed homogenously on the replications as much as possible. According to data obtained (Table 2), minimum soil carbon dioxide emission was determined for D treatment, maximum soil carbon dioxide emission was determined for B and C treatments. The difference between B and C treatments was not significant.

The amount of carbon dioxide emissions was higher in the first days after the soil tillage, but decreased in later period (Figure 2a). The high level of emissions on the 6^{th} day after tillage was caused by rainfall in the days before the record. Soil evaporation (H_2O emission) which are effective on soil CO_2 emissions are parallel to soil carbon dioxide emissions.

The cumulative CO_2 emission evolution over the 45-day period is given in Figure 1. It can be seen that the highest soil CO_2 emission at the end of 45 days was determined for B treatment.

Table 2. Results obtained from the research

Treatments	Time after the tillage (days)						Mean
	1	2	6	9	21	45	
	Soil CO_2 emission (g CO_2 m^{-2} h^{-1})						
A	0.226^{ab}	0.169^{bc}	0.359^{a}	0.157^{ab}	0.083^{ab}	0.063^{ab}	0.176^{a}
B	0.259^{a}	0.264^{ab}	0.357^{a}	0.215^{a}	0.104^{ab}	0.083^{a}	0.213^{a}
C	0.302^{a}	0.314^{a}	0.285^{ab}	0.231^{a}	0.066^{b}	0.072^{ab}	0.211^{a}
D	0.114^{b}	0.086^{c}	0.138^{b}	0.057^{b}	0.144^{a}	0.044^{b}	0.097^{b}
	Soil evaporation (g H_2O m^{-2} h^{-1})						
A	$3.07a^{b}$	3.00^{b}	3.18^{b}	0.98^{b}	0.75^{ab}	2.43^{a}	2.24^{a}
B	3.98^{a}	4.59^{a}	4.13^{a}	0.98^{b}	0.77^{ab}	3.23^{a}	3.00^{b}
C	3.78^{a}	3.39^{b}	2.94^{bc}	1.36^{a}	0.73^{b}	2.20^{a}	2.40^{a}
D	1.96^{b}	3.23^{b}	2.33^{c}	0.58^{c}	1.09^{a}	2.86^{a}	2.01^{a}
	Soil temperature (^{o}C)						
A	10.4^{a}	10.6^{c}	9.1^{b}	15.9^{a}	17.3^{a}	15.5^{ab}	13.2
B	10.9^{b}	11.2^{a}	9.3^{b}	15.2^{b}	16.8^{b}	15.8^{a}	13.2
C	11.0^{b}	10.9^{b}	9.9^{a}	15.7^{a}	16.7^{b}	14.5^{b}	13.2
D	11.1^{b}	11.3^{a}	9.8^{a}	15.1^{b}	16.8^{b}	15.9^{a}	13.3

According to the results, total soil carbon dioxide emission for A, B, C and D treatments after the 45 days were 36.3, 47.9, 41.5, and 26.0 g m^{-2} day^{-1} respectively. These results are in accordance with Curtin et al. (1998). There was no significant difference between the soil temperatures depending on treatments. Soil temperature in all treatments was low in the first 6 days and increased in the following days. But the recent rise in temperature has not been effective on soil CO_2 emissions. Comparisons of treatments of soil temperatures can be seen in Figure 2b. It is possible to say that the change in soil temperature is related to the climatic condition. Soil evaporation depending on the treatments is given in Figure 2c. Although there was a difference in soil evaporation between the B treatment and the others at the first stage, this difference was significantly reduced after the 6th day. It is expected to be more evaporated in the C treatment because of the deeper soil tillage than the other treatments. But the expectation has not been realized. Soil moisture amount as a function of time is given Figure 2d. Soil moisture is highly effective on soil CO_2 emissions. For this reason, soil moisture values have been determined in parallel with CO_2 emission records. Soil moisture for all treatments was found quite high on days of 6th and 9th. It can be said that the soil CO_2 emission increases especially on the 6th day depending on the soil moisture content.

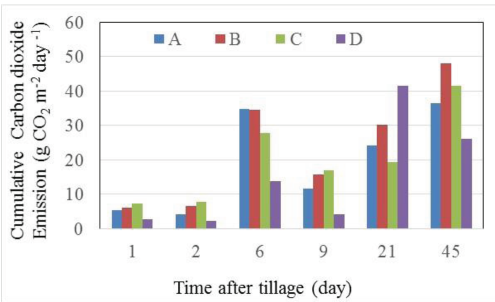

Figure 1. Cumulative soil CO_2 emission

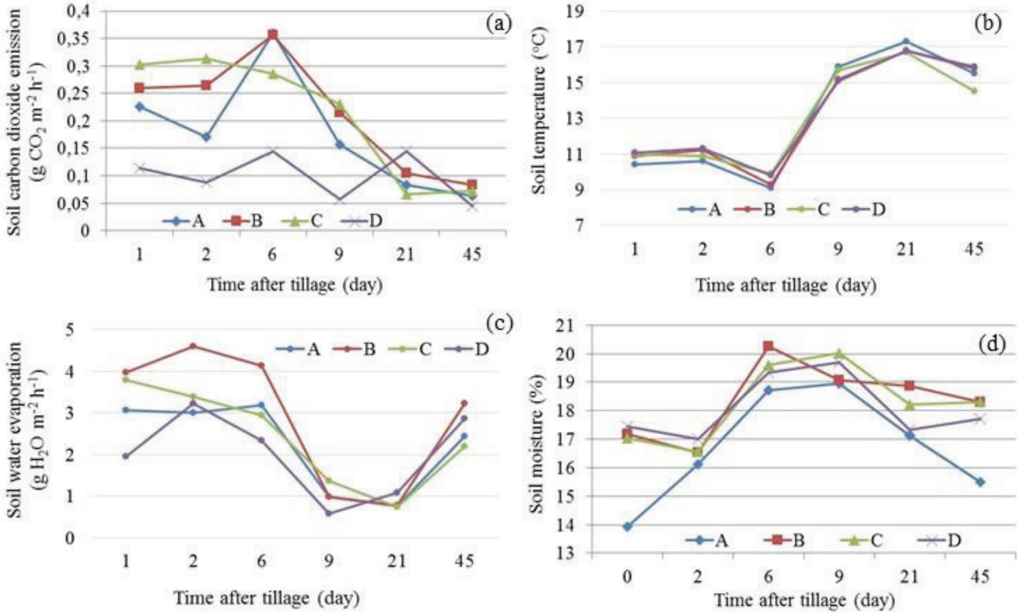

Figure 2. Soil carbon dioxide emission (a), soil temperature (b), soil water evaporation (c), and soil moisture content (d)

CONCLUSIONS

According to the results of the research, it was determined that incorporating straw into soil increased soil CO_2 emissions. In addition, less CO_2 emissions were determined on the soil surface covered with straw than the bare soil surface treatment. For this reason, it has been determined by the study that plant wastes should not be incorporated into the soil and left on the soil surface in order to reduce evaporation and CO_2 emissions from soil.

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