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DETERMINATION OF SOME MICROBIAL ACTIVITY IN SOIL MANAGED WITH STUBBLE BURNED-UNBURNED, TRADITIONAL AND NO-TILLAGE SYSTEMS

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Abstract

Most of farmers in Turkey have been burning wheat stubble every June or July to prepare their field for second crops. It is believed that as a result of stubble burning, soil is becoming more productive and healthy. Stubble burning may be caused some yield benefits for short-term but in long-term it is caused degradation on soil quality. The purpose of this research was to determine the effects of stubble burning on microbial activity of soil under traditional tillage and no-tillage system. In accordance with this purpose, some microbial analyses have been followed in soils. Soil respiration rate (CO_2 formation), dehidrogenase enzyme activity (DHA) and microbial biomass carbon content (MBC) were analysed according to Isermayer (1952), Thalman (1967) and Ohlinger (1993), respectively. Results revealed that soil microbial activity was lower in the stubble burned and conventional tillage (SBCT) applied plots. In this plot, as a mean values CO_2 formation, DHA and MBC determined as 14.6 mg C 100 g^{-1} 24h^{-1}, 193 μg TPF 10 g^{-1} 24h^{-1} and 25.6 mg C 100 g^{-1}, respectively. These values were 16.9, 309.3 and 19.5 in conventional tillage (SCT) plots whereas 15.4, 620.6 and 11.0 in no tillage (NT) plots. In general, DHA was the most influenced factor among the other biologic activity indicators determined.

***Key words**: stubble burning, CO_2, microbial activity, soil quality, soil tillage systems.*

INTRODUCTION

Microbial activities drives directly affect the functioning and sustainability of soil ecosystems. Soil microbial activity (SMA) was effected by different tillage system including agricultural practices, and stubble burning. Stubble burning decreases in fertile agricultural lands and loses sustainable fertility of soils. Stubble burning is an improper agricultural practice applied every year in June-July in Turkey, as a routine and seriously damages the long-term aspects of soil fertility (Kılıç et al., 2013). The ways in which these operations are implemented affect the physical and chemical properties of the soil, which in turn affect soil microorganisms (Coşkan and Doğan, 2011). Burning of crop residue on the soil surface reduces soil micro-organisms and increased soil pH. This is an increase of soluble salts from the soil. Burning stubble and straw decreased soil organic matter. In addition, the amount of water and fat soluble compounds and hemic acids show a downward trend (Hesammi et al., 2014). Soil tillage methods have complex effects on physical, chemical and biological properties of soil. Because of the changing physical and chemical properties of soil by soil tillage methods, the biological properties of soil may also change. Actually these changes are indirect results of tillage. Changed physical and chemical soil properties by soil tillage methods effect the parameters directly related with soil microbial activities such as organic matter, soil humidity, temperature and ventilation as well as the degrees of interaction between soil mineral and organic matter. As a result of these effects, significant differences can be observed in the population of microbial activities in soil (Kladivko, 2001; Lavelle, 2000; Wardle, 1995; Saggar et al., 2001; Coşkan et al., 2010; Walker et al., 1986). People burn stubble because it improves weed control and creates easier passage for seeding equipment. But unfortunately the practice of burning stubble has recently declined due to concerns about soil erosion and loss of soil organic matter. In addition burning is damaged to other important soil properties (Clark et al., 1999; Coşkan and Doğan, 2011; Rasmusen et al., 1980).

MATERIALS AND METHODS

A long-term field experiment was carried out from 2006 to 2012. In this research, it was evaluated the effects of three different tillage practices on some biological activities of an alluvial and clay soil of southern Turkey during the sixth years of a wheat–soybean–wheat crop sequence. This research was carried out in a long term experiment field area in Çukurova Region in south of Turkey (Figure 1). Soil type is alluvial, clay texture and calcareous. Research area has typical Mediterranean climate. Research tillage variants were Stubble burned and conventional tillage (SBCT: Burning the stubble; Plowing, 30-33 cm, Disk horrow, 13-15 cm, and 2 times; Packing, 2 times; Wheat planting with a universal planter, 4 cm), with stubble conventional tillage (SCT: Chopping the residues Plowing (30-33 cm) Disk horrow;13-15 cm and 2 times. Packing 2 times. Wheat planting with a universal planter 4 cm) and no tillage with direct seeding (NTDS: Chopping the residues; Herbicide application; Wheat seeding with direct seeder, 4 cm) system. After six years study period soil samples were collected from three field replications in June at three different depths (0-5 cm; 5-10 cm; 0-10 cm) and prepared to microbial analyses (Figure 2). All analytical results were calculated on the basis of oven-dried (105^0C) weight. Biological activities were evaluated in summer. CO_2 analyses were done by titration method which CO_2 was captured by $Ba(OH)_2$ and remaining BaOH titrated by HCl (Isermayer, 1952). Dehydrogenase enzyme activity (DHA) was determined according to Thalman (1956). Microbial biomass carbon (MBC) content was
determined by fumigation-extraction method (Ohlinger, 1993). Completely randomized design was used, obtained results were statistically analysed via MSTAT-C pocket software and ranged with Duncan multiple range test.

RESULTS AND DISCUSSIONS

Effect of different tillage applications on soil respiration rate (CO_2 production) is presented in Table 1. The effect of tillage application on CO_2 production was not statistically significant ($p>0.05$). Close values were observed from all three tillage systems. Among the all values, CO_2 formation varied between 12.0 (NTDS 0-10 cm) to 17.6 (SCT 5-10 cm) mg CO_2 100 g^{-1} $24h^{-1}$.

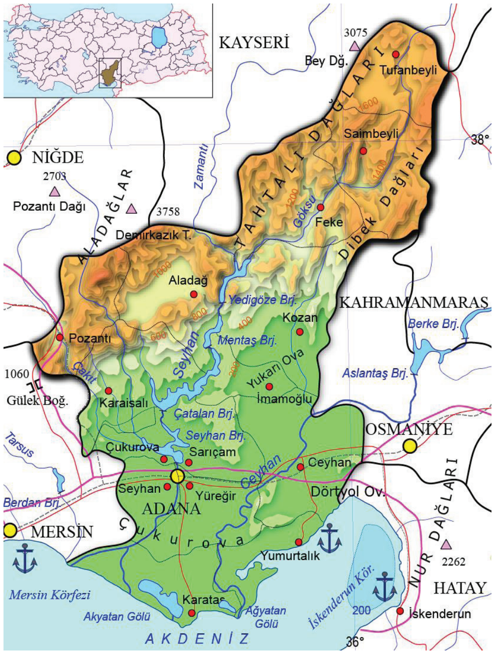

Figure 1. Geographic location of research Area (http://cografyaharita.com, 2017)

Figure 2. Taken soil samples in burning field areas

Table 1. Effect of different soil tillage applications on CO_2 produce (mg/100 g. ds. 24 h.) in soil

Soil Tillage	Depth (cm)	CO_2 (mg/100 g ds 24 h)	
With stubble conventional tillage (SCT)	0-5	16.4	b-d
	5-10	17.6	b-d
	0-10	16.7	b-d
	Average	**16.9**	**A**
Stubble burned and conventional tillage (SBCT)	0-5	16.5	b-d
	5-10	14.2	b-d
	0-10	13.0	Cd
	Average	**14.6**	**A**
No tillage with direct seeding (NTDS)	0-5	14.0	b-d
	5-10	20.2	a-d
	0-10	12.0	D
	Average	**15.4**	**A**
Average Depth (cm)	0-5	**15.6**	**A**
	5-10	**17.3**	**A**
	0-10	**13.9**	**A**

The DHA results are presented in Table 1. Effects of applications on dehydrogenase enzyme activities were statically important ($p<0.05$). The highest value was determined as 632 µg TPF/10 g ds 24 h in no tillage with direct seeding (NTDS) plots soils in depth of 0-10 cm. The lowest value of the table is 165 µg TPF/10 g ds 24 h which was determined in SBCT plots in soil depth of 0 - 5 cm. Dehydrogenase enzyme activity (DHA) results, belong to stubble conventional tillage (SCT) soil, higher than stubble burned and conventional tillage (SBCT) soil's value however the highest DHA value was found in No tillage with direct seeding (NTDS) soils. Long-term no tillage may enhance soil C sequestration and alter soil C and N dynamics and this case may increase to microbial activities especially enzyme activities. Soil dehydrogenase enzymes are one of the main components of soil enzymatic activities. DHA is very important and sensitive indicator for biochemical mechanisms in the soil. DHA is responding natural and anthropogenic disturbances very quickly. In a research by Doğan (2012), it was investigated the effect of genetically modified (GM) tobacco plants (pcVChMTIIGFP), used in phytoremediation purposes, and different heavy metals applications (Cd: 0, 0.5, 1, 2, 4; Zn: 0, 100,200, 400, 800; Cu: 0, 50, 100, 200, 400 mg kg^{-1}) on microbial activity in root zone soil. According to the above mentioned research results of Cd, Zn and Cu experiments DHA values with non-GM (SR-1 non-transgene) were found higher than GM plants (pcV-ChMTIIGFP)'s DHA (µg TPF/10 g kt) values. However in the same research, CO_2 and MBC values weren't effected negatively as much as DHA were. Most of similar research show that DHA very sensitive to both natural and anthropogenic disturbances and show a quick response to the induced changes (Kumar et al., 2013; Dick, 1994; Doğan, 2012). Thus, soil enzyme activity like DHA is very important parameter to determine biological activity.

Table 2. Effect of different soil tillage applications on Dehydrogenase enzyme activity (DHA) (µg TPF/10 g ds 24 h)

Soil Tillage	Depth (cm)	Dehydrogenase enzyme activity (DHA) (µg TPF/10 g ds 24 h)	
With stubble conventional tillage (SCT)	0-5	247	D
	5-10	365	b-d
	0-10	317	Cd
	Average	**309.3**	**B**
Stubble burned and conventional tillage (SBCT)	0-5	165	D
	5-10	170	D
	0-10	244	D
	Average	**193.0**	**B**
No tillage with direct seeding (NTDS)	0-5	599	a-c
	5-10	631	a-c
	0-10	632	a-c
	Average	**620.6**	**A**
Average Depth (cm)	0-5	337	A
	5-10	388	A
	0-10	398	A

Microbial biomass carbon (MBC) content (mg C kg^{-1}) were given in Table 3. Tillage systems had no significant impacts ($p<0.05$) on MBC content at any soil depth. Minimum and maximum values (mg C kg^{-1}) of MBC in Table 3 are 10.82 in NTDS soils (5-10 cm) and 21.42 in SCT soils (0 - 5 cm). With stubble conventional tillage (SCT) MBC results were found higher than others tillage applications. However no tillage with direct seeding (NTDS) MBC results were determined lower than other applications. According to this results MBC wasn't effected different tillage applications. In a similar study by Wright et al. (2005) which was carried out to investigate the impacts of tillage on soil C and N sequestration and microbial C and N dynamics of corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.)

cropping sequences after 20 years of management. They found no effect to tillage systems on MBC significantly.

Table 3. Effect of different soil tillage applications on microbial biomass carbon (MBC) (mg C kg^{-1})

Soil Tillage	Depth (cm)	Microbial biomass carbon (MBC) (mg C kg^{-1})	
With stubble conventional tillage (SCT)	0-5	21.42	a
	5-10	16.29	a
	0-10	20.85	a
	Average	**19.52**	**A**
Stubble burned and conventional tillage (SBCT)	0-5	16.50	a
	5-10	11.77	a
	0-10	19.14	a
	Average	**15.80**	**A**
No tillage with direct seeding (NTDS)	0-5	11.24	a
	5-10	10.82	a
	0-10	10.82	a
	Average	**10.96**	**B**
Average Depth (cm)	0-5	16.38	**A**
	5-10	12.96	**A**
	0-10	16.94	**A**

Ammonium (NH_4-N) results were given Table 4. Soil NH_4-N concentrations were not impacted by tillage and did not vary with soil depth. Minimum and maximum NH_4-N concentrations are determined 3.85 mg kg^{-1} (0-10 cm) and 6.40 mg kg^{-1} (0 - 5 cm) in SCT soils respectively.

Table 4. Effect of different soil tillage applications on NH_4^+-N (mg/kg) concentrations

Soil Tillage	Depth (cm)	NH_4^+-N (mg/kg)	
with stubble conventional tillage (SCT)	0-5	6.40	A
	5-10	4.48	ab
	0-10	3.85	ab
	Average	4.91	A
Stubble burned and conventional tillage (SBCT)	0-5	4.25	ab
	5-10	4.09	ab
	0-10	5.43	ab
	Average	4.59	A
No tillage with direct seeding (NTDS)	0-5	4.25	ab
	5-10	4.31	ab
	0-10	4.48	ab
	Average	4.35	A
Average Depth (cm)	0-5	4.97	A
	5-10	4.30	A
	0-10	4.59	A

The effects of different soil tillage applications on Nitrate (NO_3^--N) concentrations were given Table 5. With stubble conventional tillage (SCT) was effected on Nitrate (NO_3^--N) concentrations significantly ($p<0.05$) in 0-5 cm depth. SCT caused to higher Nitrate (NO_3^--N) concentrations results. However according to general average results tillage wasn't effect to this parameter significantly. Table 5 values changed between 2.65-7.35 mg kg^{-1}.

Table 5. Effect of different soil tillage applications on NO_3^--N (mg/kg) concentrations

Soil Tillage	Depth (cm)	NO_3^--N (mg/kg)	
with stubble conventional tillage (SCT)	0-5	7.35	a
	5-10	3.17	c-e
	0-10	4.32	b-l
	Average	4.95	A
Stubble burned and conventional tillage (SBCT)	0-5	2.65	e
	5-10	5.69	ab
	0-10	3.82	b-e
	Average	4.05	A
No tillage with direct seeding (NTDS)	0-5	2.65	e
	5-10	4.35	a-c
	0-10	3.17	c-e
	Average	7.11	A
Average Depth (cm)	0-5	4.22	A
	5-10	4.40	A
	0-10	3.77	A

General effect of different soil tillage and soil depth on CO_2 production (mg/100 g kt 24 h), DHA enzyme activities (µg/10 g kt 24 h) and MBC content (mg C /kg ds) were given Figure 3. According to Figure 3 CO_2 value in with subble conventional tillage (SCT) is higher than others tillage soils and values of soil in 5 - 10 cm depth is higher than the other soil depths values. DHA enzyme activities to determined in no tillage with direct seeding (NTDS) soils are higher than others tillage soils. The highest DHA activities were found in 0 - 10 cm depth of soil. The highest MBC value is determined in with stubble conventional tillage (SCT) soils.

No tillage applications increase organic matter levels in surface soil layers (Alvear et al., 2005; Crovetto, 1996). So that biological activity has been found to be higher in soils under no tillage management than other tillage management (Bolinder et al., 1999). Also, under NT management with crop residues over the soil, an increased activity of some enzymes has been found, mainly acid phosphomonoesterase, arylsulphatase, dehydrogenase, urease and b-glucosidase (Alvear et al., 2005; Mullen et al., 1998).

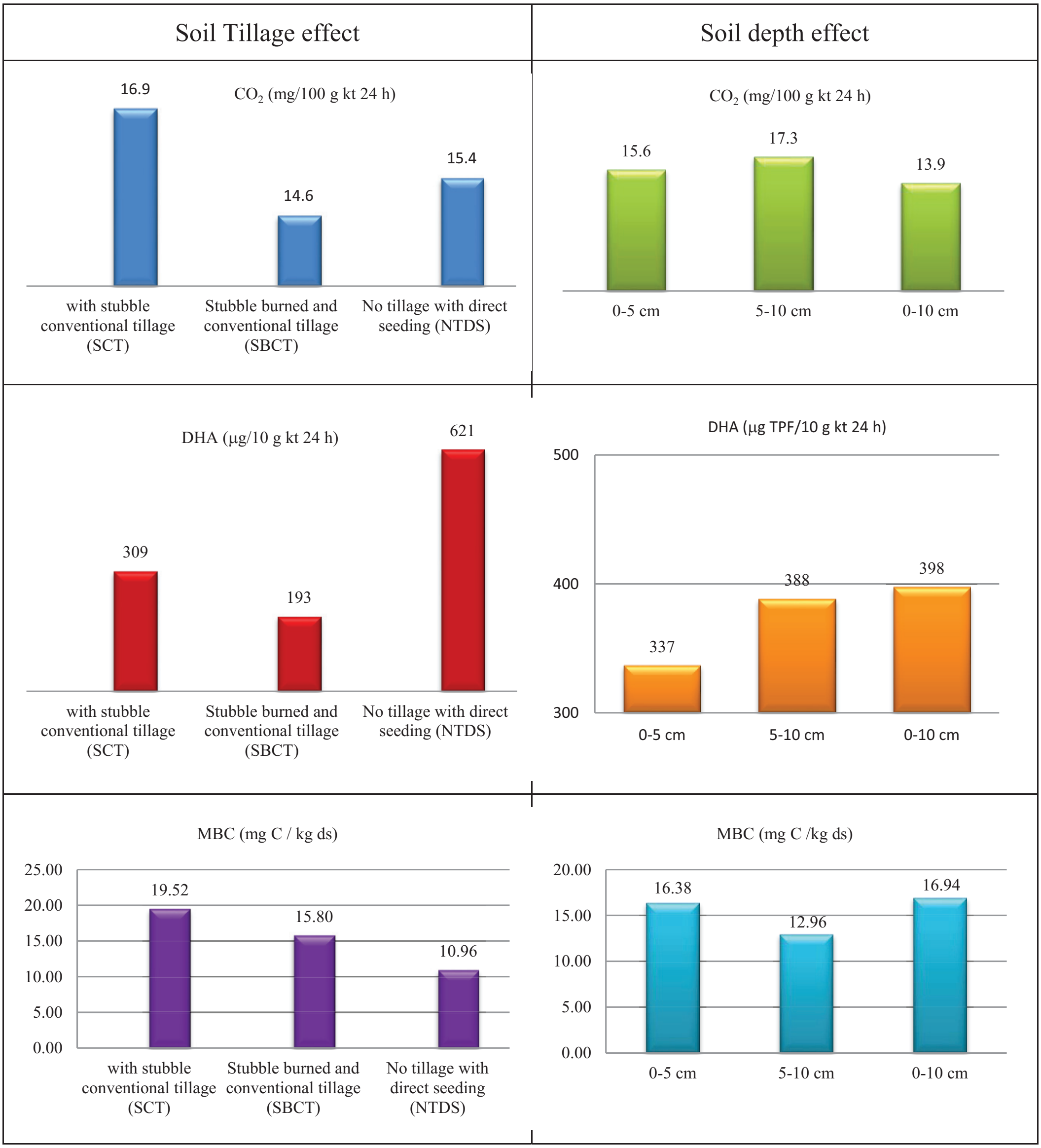

Figure 3. General effect of Different soil tillage applications and soil depth on CO_2 (mg/100 g kt 24 h), DHA (mg/10 g kt 24 h) and MBC (mg C/kg ds)

CONCLUSIONS

During to six years management in Cukurova Region's alluvial and clay soils in south of Turkey, some soil biological properties were effected from different soil tillage applications and stubble burning. Especially soil DHA enzyme activities were affected negatively from both different tillage and stubble burning. Soil respiration rate and MBC content of soil weren't effected the different tillage applications and burning as DHA enzyme activities. However six years term may not to be enough for a long-term research period. Although short term study, even this research is given effective results of soil microbial activities especially DHA activities. Stubble burning and intensive tillage damage to soil microbial activities which soil microbial activity effects to soil quality and productivity. Soil quality can be defined as its capacity to work properly within ecosystem boundaries to maintain biological productivity, environment quality and also to promote plant and animal health (Doran and Parkin, 1994; Alvear et al., 2005). Microbial biomass (MBC exc.) and soil enzymes (DHA exc.) have been suggested as potential indicators of soil quality because of their relationship to soil biology, ease of measurement, rapid response to changes in soil management (different tillage) and high sensitivity to temporary soil changes originated by management and environment factors (Marx et al., 2001; Jime´nez et al., 2002; Alvear et al., 2005). Initially because of micro damage of burning problems don't occur short-term periods. This micro damages are became grave soil problem year after year if no action is taken. Serious researches should be done to prevent stubble burning and protect to soil sustainability and quality.

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