Sindh Univ. Res. Jour. (Sci. Ser.) Vol. 49 (004) 797- 800 (2017)

http://doi.org/10.26692/sujo/2017.12.0060

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Periodic Measurements of CO_2 Emission Dynamics from Wheat Straw and It's Biochar Added to Soil

S. A. ABRO[++], M.A GADEHI, M. H. ODHANO, M. W. KALRO, S. MALLAH, G. S. UNAR, A. A. ABRO, S. A. MEMON

Department of Soil Science, Sindh Agriculture University, Tandojam

Received 24th November 2016 and Revised 10th June 2017

Abstract: To investigate the effects of direct incorporation of wheat straw (WS) and its biochar (WB) into loess soil a short-term laboratory incubation experiment was conducted. The purpose was to observe the comparative effects of (WS) and (WB) on carbon mineralization, CO_2 emission trends, cumulative production and Carbon C sequestration (Cseq). The (WS) and (WB) were applied four rates each at (0, 5, 10, 15 g/kg soil). The results revealed that wheat straw significantly increased CO_2emission rates and cumulative contrary to that biocharproduced from the wheat straw decreased CO_2 emissions. Moreover, only 1.3% of added Biochar C was respired where as 36% of added wheat straw C was decomposed. Wheat straw had high amount of labile C that enhanced greenhouse gas (GHG-C) and decreased Cseq. In contrast, (WB) had recalcitrant C that is why decreased (GHG-C) and increased Cseq. Therefore, it can be concluded that (WB) was very stable C source and could be better strategy to mitigate GHG-C emissions and sequester C in soils for long-term sustainability

Keywords: Wheat Straw, Carbon, Decomposition, Straw Derived Biochar

1. INTRODUCTION

Intensively grown long-term poorly managed wheat cultivation has led to the decreased soil organic carbon (SOC) stocks resulting in degraded soils with marginalized crop yield in North China. To cop up with this situation wheat crop stubble and straw (WS) leftover in fields is usually returned to soil to maintain SOC, improve soil fertility and enhance crop yield (Zhang *et al.*, 2008; Abro *et al.*, 2012). However (WS) is easily decomposable organic material that provides major substrate for CO_2 production resulting in global warming potential (Muhammad *et al.* 2007, Abro *et al.*, 2016). Biochar from pyrolysis of residues is stable carbon rich form of charcoal which can applied to crop lands as an amendment to improve soil carbon stocks, water holding capacity, reduce greenhouse gas emissions and enhance soil carbon sequestration (Lehman *et al.*, 2011; Laghari *et al.*, 2015).

Furthermore, contrasting chemical characteristics between wheat straw and it's derived biochar may lead to different for CO_2 emission and carbon sequestration (Cheng *et al.*, 2012; Hu *et al.*, 2014) There are some scientific contradictions that straw retuned to the soil is easily decomposed whereas C present in biochar is more stable could stay in soils for longer periods**.** some researchers reported a priming effect from soluble biochar C on native SOC decomposition (Luo *et al.* 2011; Jones *et al.* 2011) and others found a suppression effect of biochar addition on soil CO_2 production (Spokas *et al.* 2009) and a diminished priming effect after long-term incubation (Smith *et al.* 2010; Jones *et al.* 2011).

Soil carbon mineralization, CO_2 emission, and immobilization processes, induced by wheat straw and it's biochar application because soil greenhouse gas emissions and soil C and N transformation rates are strongly linked (Prayogo *et al.* 2014**;** Abro *et al.* 2016).

The impact of wheat straw and its biochar addition on CO_2 emission rates and the associated changes of soil organic carbon decomposition and transformation in agricultural soils are poorly understood particularly in our research area. In addition to the many studies on greenhouse gas emissions, studies on the comparative effect ofwheat straw andit's biochar application on CO_2 production soil C and transformation processes are needed. The impact of biochar application on soil C and N cycling in field conditions must be better understood before biochar is promoted for large-scale field application. The present study was conducted with following objectives a) determine carbon mineralization CO_2 emission rates from soil applied straw and straw derived biochar (b compare carbon sequestration as a result of straw and its biochar addition to a loess soil under controlled laboratory conditions.

2. MATERIALS AND METHOD

Site characteristics and experimental design

The soil used in this incubation study was collected from Sanyuan County, Guanzhong Plain area, Shaanxi Province, Northwest China (N34°25′27.0″, E 108°04′22.1). Annual winter wheat and summer maize rotation is a major cropping system in this area. The mean annual temperature and precipitation are approximately 13.6°C and 656 mm, respectively. The soils were classified as Earth-cumuli-Orthic Anthrosols

[++]Corresponding authorabro.shaukat@gmail.com

SSRI, PARC, TandoJam, AAC, DSWT Laboratory Thatta @ Makli, NSTHRI, PARC, Thatta,,

AZRI, PARC, Umerkot,

Deptt Plant breeding & Genetics SAU Tandojam

Dr M A Kazi Institute of chemistry ,university of Sindh Jamshoro

according to Chinese Soil Taxonomy (CRG-CST, 2001). The texture of soil was clay loam with field water capacity of 300 g kg-1, pH 7.6, organic carbon of 9.2 g kg-1 and total nitrogen of 0.86 g kg-1. Wheat straw carbon was 42% and total nitrogen was 0.61%. Soil samples were collected from surface horizon (0 to 15 cm) using soil auger. The soil was air dried and kept in plastic bags. Visible plant residues such as roots and leaves were removed by hand. The soil was ground and sieved through 2 mm sieve and then stored for 5 days at 4°C. Wheat straw (including leaves and stems) was collected from the same field after the grain was harvested and taken to the laboratory, washed with distilled water and dried at 70°C. The maize straw was cut into small pieces (<1 cm), ground and mixed with the soil samples for incubation

Biochar: Biochar: used in the experiment was produced from wheat straw at the final temperature of approximately 400°C for almost 4 h. The biochar was ground and filtered through a 2mm sieve for the incubation experiment. Soilsspread across the Loess Plateau were collected from 0 cm to 20 cm horizons as test objects in the incubation experiment.

Incubation experiment: The experiment was set up using complete randomized design for 8 treatments replicated four times for the incubation experiment. The treatments were as follows: (wheat straw WSat four rates 0 control, 5 g kg^{-1}, 10 g kg^{-1} and 20 g kg^{-1}soil and wheat straw biochar WB four rates with 0 control,5 g kg^{-1}, 10 g kg^{-1} and 20 g kg^{-1} by weight (WS_0, WS_5, WS_{10}, WS_{20}, WB_0, WB_5, WB_{10}, WB_{20}, respectively). The ground straw was thoroughly mixed with soil, and then transferred into PVC pots (height 11 cm, inner diameter 250 mm) for an equivalent of 150 g soil to 1.25 g maize straw pot-1. Nitrogen as $(NH4)_2SO_4$ and phosphorus as KH_2PO_4 were applied to pots as water solution. Samples were slowly wetted with calculated amount of deionized water to maintain approximately designed moisture contents. The pots were then incubated at a constant temperature of 25°C for 50 days. After mixing the biochar with the soil at the designated amount, the soil was added into incubation pots, which were made of polyvinyl chloride tube (160 mm in diameter & 220 mm in depth). The bulk density of the soil was determined. For the soil, 1.3 g cm–3was chosen and 20 cm thick soil column was packed in 5 cm layers to achieve soil consistency for bulk density. All of the pots were regularly irrigated, and the water content was kept at 60% to 70% of the water holding capacity by adding water every 5 days.

CO_2-C determination

25 ml vial containing 10 ml of 1 M NaOH solution were placed on soil surface inside the pot to absorb CO_2. Pots were covered with polyethylene sheets and incubated in darkness at 25°C. Excess NaOH was titrated with 0.2 MHCl after precipitating carbonates with $BaCl_2$using phenolphthalein as indicator and subtracted from an amount titrated in control. All the pots were taken out and opened periodically, then aerated for few minutes. Soil water content was checked and adjusted by weighing and then distilled water was added, to maintain moisture levels. The CO_2 evolved was measured at 1, 2, 5, 8, 11, 14, 20, 24, 30, 36, 41 and 50^{th} day of incubation. At the end of incubation, soil samples were analyzed for SOC.

Data analysis: All data in the research were recorded and classified using Microsoft Office Excel 2003. Data were analyzed by two-way ANOVA, and differences in means were compared by the least significant difference test at P<0.05. All statistical analyses were conducted with SPSS 16.00 (for windows),

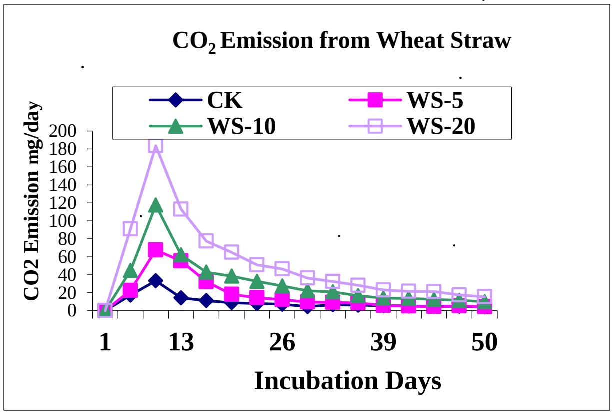
Table 1. Physico-chemical Characteristics of Soil, Straw and Biochar

Properties	Soil	straw	Biochar
Clay	18.6		
Silt	46.4		
Sand	38.8		
C %	0 .5	46	69
N%	0.15	1.00	0.3
Ash	6. 7	13.83	

3. RESULTS &DISCUSSION

1. CO_2 (mg /day) emission rates from wheat Straw and it's biochar

Both in straw and biochar amended soils initially CO_2 emissions rates were higher and declined thereafter. Similar trends were observed for both straw and biochar carbon mineralization and greenhouse gas emissions for microbial respiration CO_2 influx dynamics **(Fig. 1).** The control (zero levels) for both straw and biochar had lowest CO_2 emissions rates. This may be attributed to the microbial attack ad respiration to early stages of both straw and biochar carbon decomposition. There were about 36 % (p<0.001) increase in the CO_2 emissions rates with the application of wheat straw in our incubation experiment and results are in agreement with the results found by (Abro *et al.*, 2016). However, CO_2 emissions rates of biochar were almost half of that of straw amended treatments. Similar results are achieved by (Hu *et al.*, 2014; Abro*et al.*, 2016). CO_2 emissions rates fluctuated across WB and WS treatments with a tendency to be high at higher application rates. With WB small peaks in CO_2 emission rates were visible during incubation periods compared to wheat straw. The results are in agreement with the results found by (Thammasom *et al.*, 2016). This was positively related to the increasing rates of both straw and biochar adoption. There were no significant interactions between wheat straw and its biochar additions on CO_2 emission rates (**Fig. 1**).



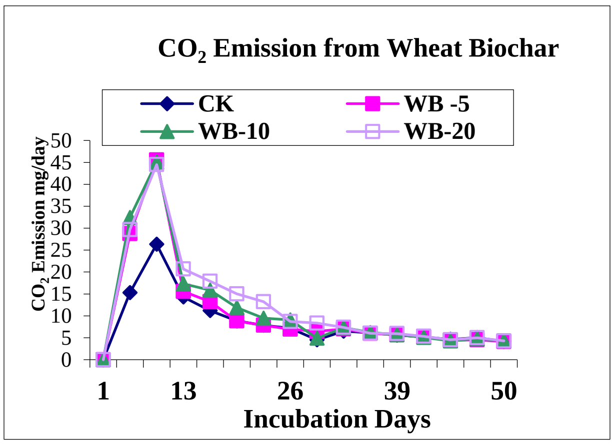


Fig. 1. Dynamics of CO_2 emission trendsfrom wheat straw and it's biochar incubated with soil form all treatments for incubationexperiment

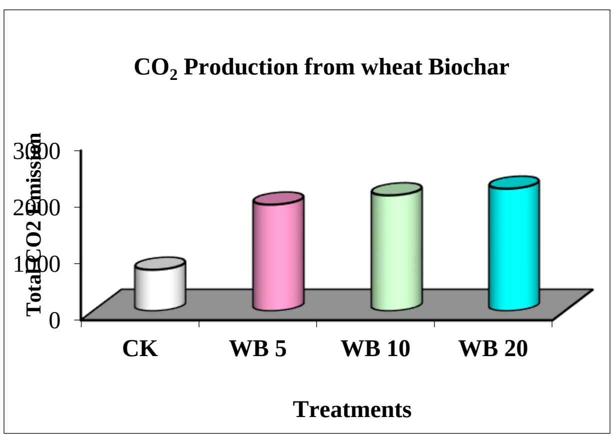


Fig. 2, Cumulative CO_2 flux from wheat straw and it's biochar incubated with soil from all treatments in incubation experiment

Cumulative-CO_2Production

Wheat straw addition increased CO_2 emission; however, biochar addition did not affect CO_2 emission rates. CO_2 emission from both wheat straw and wheat biochar was linearly correlated with increasing rates of straw and biochar. However similar trends were observed for all treatments (**Fig. 2**). It was noticed that for straw treatments why was no significant difference between rates applied. However, the biochar added soils CO_2 was the application rates of biochar had variability.

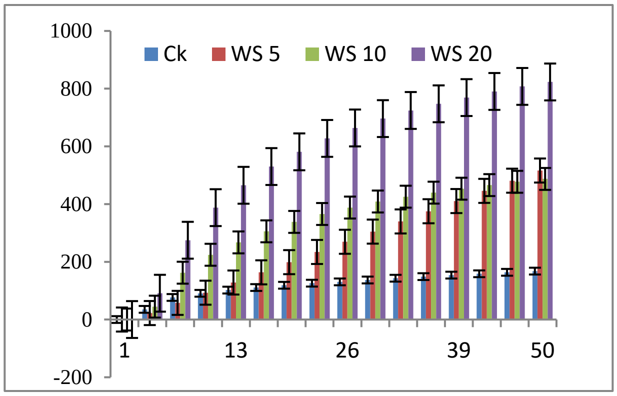
More over biochar application substantially limited carbon mineralization thus reducing greenhouse gas emission to the environment thereby enhancing carbon sequestration. These results potentially suggest that biochar application should be increased to mitigate global warming climate change and sustained crop production. Substrate inputs from wheat straw and biochar and soil physical conditions (e.g., soil moisture content and pH) are main controlling factors on soil C mineralization (Yu *et al.* 2013, Abro*et al.*, 2012).

The application of biochar has the potential to be a management strategy for C sequestration in the soil. While for the immobilization of NO_3^- and leaching losses in the soil, direct incorporation of wheat straw is a better choice. Therefore, the advantages and disadvantages of direct incorporation of wheat straw and its biochar should be assessed before straw management decisions are made. The implication from this study is that converting wheat straw into biochar has multiple benefits as to reduced greenhouse gas emissions and increased soil C storage in the form of stable biochar C when the biochar is applied to the soil.

Correlation Of $Co_2$with Incubation Time

There was a linear correlation between CO_2 emission and incubation time for both biochar ad straw (**Fig 3**). The results in agreement with the results found by (Abro *et al.*, 2012 and Abro *et al.*, 2016). Cheng*et al.* (2012) reported that straw application rather than biochar CO_2 emissions was increased incubation experiment. Considered the increased soil carbon storage after biochar application and enhanced CO_2 release by wheat straw application, biochar application should provide substantial benefits to C sequestration in soil compared with application of wheat straw only (Begum *et al.*, 2014).

When carbon inputs exceed carbon output than soil carbon sequestration occurs. in present study biochar increased carbon sequestration with increasing application rates while wheat straw decreased soil carbon sequestration. The decreased soil carbon sequestration was probably due to high carbon mineralization and greenhouse gas emission. Whereas the increased carbon sequestrations form WB was due to chemical recalcitrant of biochar applied to the soil. These results are in agreement with the research work.



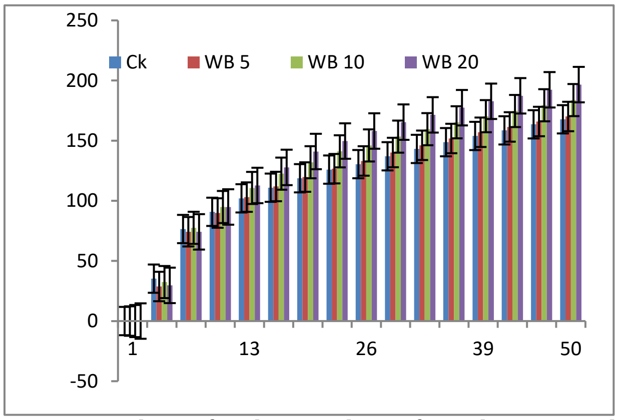


Fig. 3. Correlation of total CO_2 production from wheat straw and it's biochar incubated with soil for entire incubation time

that only 1.8-1.9% biochar was mineralized while 43-45% straw carbon was mineralized when applied to applied to soil (Bruun and El-Zehery, 2012). As a result of that, biochar application has been proposed as a potential means to offset CO_2 emissions derived from fossil fuel use. In this study, biochar application increased OC but did not change soil CO_2 emission. The small or complete lack of effects of biochar on soil C mineralization rates was also observed in some short-term studies (Wu *et al*.,2013). The biochar produced from the wheat straw through a slow pyrolysis process had contrasting effects on CO_2 emission, cumulative flux of $CO_2$when compared with the wheat straw.

REFERENCES:

Abro, S A., H. Shah, A. Abro, G. Q. Shar (2016) Kinetics of Microbial Carbon mineralization from soil Incubated Agro-Wastes. SU R J 48 (2) 335-338

Abro. S. A., Q. Hussain and U. Singh (2012) Carbon dioxide emissions from maize straw incubated with soil under various moisture and nitrogen levels J Chem Soc. Pak 34 1 22-27

Begum N., C. Guppy, D. Herridge, G. Schwenke (2014) Influence of source and quality of plant residues on emissions f N_2O and CO_2 from a fertile, acidic Black Vertisol. BiolFertil Soils 50:499–506.

Bruun S. El-Zehery, (2012) Biochar effect on mineralization of organic matter PesqueAgropeso, Brass, 47 661-671.

Cheng Y, Z. Cai, J. Wang (2012) Wheat straw and its biochar have contrasting effects on inorganic N retention and N_2O production in a cultivated Black Chernozem. BiolFertil Soils 48:941–946.

Emner, J. M. M.A. Tabatabai, (1972). Use of an ammonia electrode for determination of ammonia in Kjedahl. Analysis, 3: 159–165.

Hu Ya-Lin, Feng-Ping Wu, X. S. Chang (2014) Wheat straw and its biochar had contrasting effects on soil C and N cycling two growing seasons after addition to a Black Chernozemic soil planted to barley BiolFertil Soils 50:1291–1299.

Jones, D. L, D.V. Murphy, M. Khalid. W. Ahmad, T.H. Deluca (2011) Short-term biochar-induced increase in soil CO_2 release is both biotically and abiotically mediated. Soil BiolBiochem 43:1723–1731.

Laghari, M., M.S. Mirjat, Z. Hu, S. Fazal, (2015). Effects of biochar application rate on sandy desert soil properties and sorghum growth. Catena, 135, 313-320.

Lehmann, J., M.C. Rillig, J. Thies, D. Crowley, (2011). Biochar effects on soil biota – A review. Soil Biology and Biochemistry, 43(9), 1812-1836.

Muhammad S, R. G. Joergensen, T. Mueller T. S. Muhammad (2007) Priming mechanism: soil amended with crop residue. Pak J Bot 39:1155–1160.

Nelson, D.W. and L.E. Sommers, (1982). Total carbon, organic carbon and organic matter. In: Page, A.L., R.H. Miller and D.R. Keeney (eds.), Methods of Soil Analysis Chemical and Microbiological Properties Part 2, pp: 534–580. Soil Science Society of America, Madison, Wisconsin, USA.

Prayogo C., J.E. Jones, J. Baeyens, G. D. Bending (2014) Impact of biochar on mineralization of C and N from soil and willow litter and its relationship with microbial community biomass and structure. BiolFertil Soils 50:695–70.

Smith, J. L, H. P. Collins, V.L. Bailey (2010) The effect of young biochar on soil respiration. Soil BiolBiochem 42:2345–2347.

Spokas K. A, W. C. Baker. D.C. Reicosky (2009) Impacts of woodchip biochar additions on greenhouse gas production and sorption/degradation of two herbicides in a Minnesota soil. 77:574–581

Wu F., Z, Jia. S. Wang, S. X. Chang, A. Start (2013) Contrasting effects of wheat straw and its biocharon greenhouse gas emissions and enzyme activities in a Chernozemic soil. BiolFertil Soils 49:555–565.