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# Influx of $CO_2$ from Soil Incubated Organic Residues at Constant Temperature

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## Abstract

Temperature induced $CO_2$ from genotypic residue substances is still less understood**.** Two types of organic residues (wheat- maize) were incubated at a constant temperature (25˚C) to determine the rate and cumulative influx of $CO_2$ in laboratory experiment for 40 days. Further, the effect of surface and incorporated crop residues with and without phosphorus addition was also studied. Results revealed that mixing of crop residues increased $CO_2$-C evolution significantly & emission rare was 37% higher than that of control. At constant temperature, soil mixed residues, had higher emission rates $CO_2$-C than the residues superimposed. There was linear correlation of $CO_2$-C influxed for phosphorus levels and residue application ways with entire incubation at constant temperature. The mixing of organic residues to soil enhanced soil organic carbon levels and biomass of microbially bound N; however to little degree ammonium ($NH_4$-N) and nitrate $NO_3$-N nitrogen were decreased.

***Keywords:*** Temperature; Soil organic carbon; Microbial biomass; Mineral nitrogen.

## Introduction

Release of carbon dioxide form organic residues is largely affected by the atmospheric temperature. Depletion of soil organic carbon (SOC) from arable soils can be correlated with $CO_2$ emission and environmental degradation. The declining stocks of SOC require to be restored with returning crop residues in arable fields produced every year in large quantities. The agricultural soils have great potential to accentuate atmospheric carbon (C) through best agronomic organic amendments for increasing organic matter and managing environmental pollution. A large quantity of cereal crop residue is produced in north china that is being ploughed down to soil after crop harvest. Returning crop residues could be a strategy to increase SOC and prevent $CO_2$-C emission in the environmental [1]. However the nitrogen and Carbon mineralization rates & $CO_2$ emission of crop straw from the maize [2, 3] and wheat [4, 5] crops, of representing different substrate qualities, and at constant temperature under controlled conditions. is still not properly understood [6]. Further, it is observed that during directly returning residues to soil, some quantity of crop residue is pulverized into soil while still a large amount is also placed on top of soil. But the effect of residue placement on surface and subsurface addition with nutrient application on its C mineralization and $CO_2$ emission at constant temperature is still not been clearly known. Generally, owing to favorable environment like soil temperature, intense microbial activity, crop residues mixed with soil are decayed rapidly than surface applied residues [5]. A group of scientists observed a meager difference of the degradation of residues mixed or surface applied [7]. The decomposition rate of soil returned residues may be influenced by placement ways [5]. Application of fertilizers to soil is deemed to influence soil microbial activity and C mineralization of soil mixed residues [8]. Phosphorous (P) is a major element that activates microbial degradation of soil applied organic residues. Whether phosphorus enhances [9, 10] or reduces [11] residue C decomposition is still not completely understood. More clearly scientific information is a prerequisite for organic residue C mineralization returned to soil. In open fields it is difficult to estimate $CO_2$, whereas laboratory incubation offers controlled conditions to estimate microbial activities and simulates $CO_2$ emission rates to be measured [11]. Study aims to test the $CO_2$ release from wheat-maize crop residues at constant temperature. It was essential to determine the influence of P fertilizer application on residue C mineralization of wheat- maize residues. Therefore, we set objectives: to determine the variations in $CO_2$ emission kinetics of soil mixed and superimposed organic wheat-maize crop residues with and without P application at constant temperature under controlled environment. Assessing effect of addition of crop residues & P application on soil properties as SOC, microbial biomass nitrogen (MBN) & mineral nitrogen.

## Materials and Methods

### *Soil and crop residue sample collection*

In this experiment the soil samples (0–15 cm) were collected from, Sanyuan County, near Yangling Shaanxi Province, Northwest China. Major cropping pattern is annual winter wheat and summer maize rotation in this area. The temperature 13.6°C and precipitation 656 mm are recorded, as annual means, respectively. The soil classification declared as Earth-cumuli-Orthic-Anthrosols with clayey loam texture. Other soil residue parameters are given in Table 1. The air dried soil was then placed in plastic bags. Then soil was ground and sieved through 2 mm sieve and thereafter stored for 5 days at 4°C. Wheat and maize residue was collected from the same field after grain harvest. The residues were was washed with distilled water and dried at 70°C in laboratory. The crop residues was cut into small pieces (< 1 cm), ground and mixed with soil samples for incubation.

***Table 1.*** **Some selected properties of soil and maize straw used for incubation.**

| | Texture | WHC % | pH | OC/ g/kg | TN g/kg | CN ratio | Straw C % |
|---|---|---|---|---|---|---|---|
| **Soil** | Clayey Loam | 30 | 7.3 | 9.2 | 0.86 | 10.6 | |
| **Wheat** | | | | | 0.41 | | 44 |
| **maize** | | | | | 0.61 | | 42.3 |

### ***Soil organic carbon (SOC)***

SOC concentration was determined using dichromate $H_2SO_4$-$K_2Cr_2O_7$ wet oxidation method of Walkley and Black [12].

### ***Microbial biomass nitrogen (MBN)***

MBN was measured by chloroform fumigation extraction method [13]. A 40 g sample of moist soil was split into two portions shaken at 250 rev/min with 100 ml $K_2SO_4$ and filtered. Organic N in 0.5 mol/L $K_2SO_4$ extracts was measured by Dohrman DC 80. Soil MBN was estimated from the relationship between organic carbons extracted from fumigated and subtracted from non fumigated soil samples.

### ***Soil inorganic nitrogen ($NO_3$ & $NH_4$)***

Inorganic 0.5 M $K_2SO_4$ extractable $NH_4$ N & $NO_3$ N nitrogen were determined by colorimetry (Automated chemistry analyzer) only in extracts from the non-fumigated soil samples at 660 and 545 nm, respectively.

### ***Treatmental design***

A treatment plan with three-factorial design was formulated with five replicates (each 5th replication as control) in factorial arrangement of 8 treatments. Each treatment is denoted as $WSI_P$, $WSI_0$, $WSS_P$, $WSS_0$ $MSI_P$, $MSI_0$, $MSS_P$, and $MSS_0$. It indicates (wheat straw incorporated into soil with and without P applied, wheat straw surface applied with and without P. Maize straw incorporated into soil with & without P and maize straw surface applied on soil with and without P applied. Phosphorus was applied at two levels with and without addition. In one set of treatments crop residue was incorporated into soil where as in other set, residues mixture was superimposed. The amount 0.961 g per pot of crop residues was applied. The residue ground was mixed with soil then filled into plastic jars (11cm, dia. 250 mm inner dia) at amount of 120 g soil and 0.950 g wheat and maize residue while in other set just superimposed on soil surface in plastic jars. The residue amount applied was chosen to simulate field conditions of the 5 t DM $ha^{-1}$. Then for achieving bulk density of 1.3 Mg $m^{-3}$ soil residue mixture was manually compacted. Afterwards distilled water was sprayed on surface of soil to obtain desired moisture content of 80% of F C for optimum C decomposition. Total weight of pot was recorded for latter adjustments of the moisture content. Fertilizer N as $(NH_4)_2SO_4$ and fertilizer P as $K_2HPO_4$ were applied as water solution in all the pots uniformly. The soil residue mixture filled pots were then transferred in chamber of incubation at constant room temperature 25°C for 40 days. During entire period of incubation accumulated $CO_2$ was trapped and recorded using alkali absorption method.

### *Data analysis & interpretation*

Data were obtained as treatment means and were analyzed using two way analysis of variance (ANOVA) by statistical package SPSS 16.00 (Windows) & Microsoft excel, 2003. Differences in mean values were considered significant at $P < 0.05$.

## Results and Discussion

### *Influx of $CO_2$ from soil incubated residues*

In this study we tried to investigate the $CO_2$ emission kinetics of C & N mineralization of soil mixed and superimposed wheat-maize crop residues. Data analysis showed that higher rates of $CO_2$ were recorded with P applied $S_IWP_1$ treatment, which was 10.24, 21.23 and 33.21% higher than rest of P applied treatments, irrespective of residue application method. However with no P applied ($S_1MP_0$) treatment evolved more $CO_2$ (Table 2). At constant temperature both P levels and residue soil placement ways had linear correlation with total $CO_2$-C evolved for entire incubation period. Both method of residue application and P fertilizer dose had linear co relationship with time (incubation) for $CO_2$-C influx. It was observed that method of organic residue addition had positive influence on $CO_2$ influx from both types of soil incubated residues C mineralization. It was reported that total $CO_2$ influx was greater in soil residue mixed pots than the crop residues, superimposed on the soil surface [5]. Whereas Lou at al., [14] revealed no significant variation in C decomposition of residues thoroughly mixed with soil and superimposed. In another study it was revealed that more C was mineralized form rice crop residues incubated with soil at constant temperature than surface applied [3]. Type of residue applied in soil influenced on straw C decomposition to some extent while wheat residue emitted higher $CO_2$-C rates than maize crop residues. This research revealed that P fertilizer addition enhanced $CO_2$-C emission from maize-wheat for both methods of soil residue application. In incubation study [10] reported that C decomposition kinetics and total $CO_2$ influx was increased with P fertilizer application from soil residue mixture incubated pots. In another study while incubating forest litter leaves [10] observed that P fertilizer application has less or rather negative impact on the $CO_2$-C emission entire incubation trail. It was reported that more wheat residue C was decomposed with phosphorus nutrient application than mineral nitrogen in the laboratory incubation study [11]. Whereas, many research trails revealed that P nutrient application increased [9], or decreased [10] or no effect [8] on C mineralization and soil microbial activity in soil incubated with residues. Our research findings revealed that P application enhanced $CO_2$ evolution in comparison without P applied. These results are in agreement with the findings of [9], [10] and [11].

***Table 2.*** **Cumulative $CO_2$-C (mg pot$^{-1}$) evolution from soil mixed and surface applied residue treatments.**

| **P rates** | **Soil placement of crop residues** | | | | **Average** |
|---|---|---|---|---|---|
| | **$S_IW$** | **$S_IM$** | **$S_SW$** | **$S_SM$** | |
| $P_1$ | 305.4±5.6 a | 274.3±3.8 bc | 264.4±3.2 d | 275.7±2.3c | **279.95 A** |
| $P_0$ | 278.3±4.5 abc | 303.4±2.4 ab | 231.2±3.4 e | 239.6±4.4 de | **263.12 B** |
| **Average** | **291.85 A** | **288.85 A** | **247.8 B** | **257.65 B** | |

*Significant difference among treatments are indicated at $p<0.05$: significant difference among means are indicated at $p<0.01$
***$S_IW$= wheat straw incorporated, $S_IM$= maize straw incorporated, $S_SW$= wheat straw surfced, $S_SM$= maize straw surfaced**

***Table 3.*** **Microbial biomass nitrogen (mg kg$^{-1}$) recorded as result of adding wheat maize residue.**

| **P rates** | **Soil placement of crop residues** | | | | **Average** |
|---|---|---|---|---|---|
| | **$S_IW$** | **$S_IM$** | **$S_SW$** | **$S_SM$** | |
| $P_1$ | 22.2±2.6 ab | 57.3±8.5 a | 36.1±5.3 ab | 43.4±7.3 ab | **39.80 A** |
| $P_0$ | 30.9±7.3 ab | 37.1±4.2ab | 54.3±4.2 ab | 16.5±4.2 b | **34.75 B** |
| **Average** | **26.61 A** | **47.26 A** | **45.22 A** | **30.00 A** | |

* Significant difference among treatments are indicated at $p<0.05$: significant difference among means are indicated at $p<0.01$.
***$S_IW$= wheat straw incorporated, $S_IM$= maize straw incorporated, $S_SW$= wheat straw surfced, $S_SM$= maize straw surfaced**

### *Microbial biomass nitrogen (MBN)*

Addition of crop residues brought significant increase in microbial biomass nitrogen MBN. The higher value (57.3 mg kg) MBN was observed in ($S_IMP_1$) treatment, followed by ($SsWP_0$) treatment. While minimum level of (16.5 mg kg) was recorded with ($S_SMP_0$) treatment. The $S_IMP_1$ treatment showed higher MBN values than $S_SMP_1$. With no P added $S_IWP_0$ treatment had greater microbial biomass N than $S_SMP_0$. With P and witout P applied there was no significant difference whereas soil-residue application methods had fewer variations (Table 3**).** By returning straw there was significant increase in MBN into soil but were little confined with methods of residues and P fertilizer application. This result was endorsed by the research findings of [2] where significant increase was noticed in MBN with returning residues to soil. While working on research trail of rice straw it was found that MBN was enhanced substantially in soil incubated with rice residues [15]. We observed similar results as that of [11] that P fertilizer application reduced microbial biomass in both ways of crop residues addition as soil mixed and superimposed. While returning straw to soil brought an obvious increase in soil biomass nitrogen levels.

### *Mineral nitrogen ($NH_4$-N, $NO_3$-N)*

Ammonium and nitrate nitrogen contents were not significantly affected by soil residue methods of placement. Fig. 1 clearly depicts the influence of P on soil $NO_3$-N incubated with residues of maize and wheat crop. Whereas as in $NH_4$-N no significant difference was noticed for methods of soil residue placement and fertilizer P application (Fig.1). Due to N immobilization nitrate $NO_3$-N and ammonium $NH_4$-N were comparatively lower in pots incubated with soil-residues mixture than found in controls. While $NH_4$-N level was enhanced during the initial period possibly due to organic N mineralization and $NH_4^+$N desorption [16]. $NH_4$-N was mostly absorbed by microorganisms or it may be converted to $NO_3$-N through microbial mediated process that is why very less ammonium was recovered. While working on same scientific issue same results were obtained and attributable to microbial conversion and rapid N immobilization after soil was incubated with wheat crop residues [17].

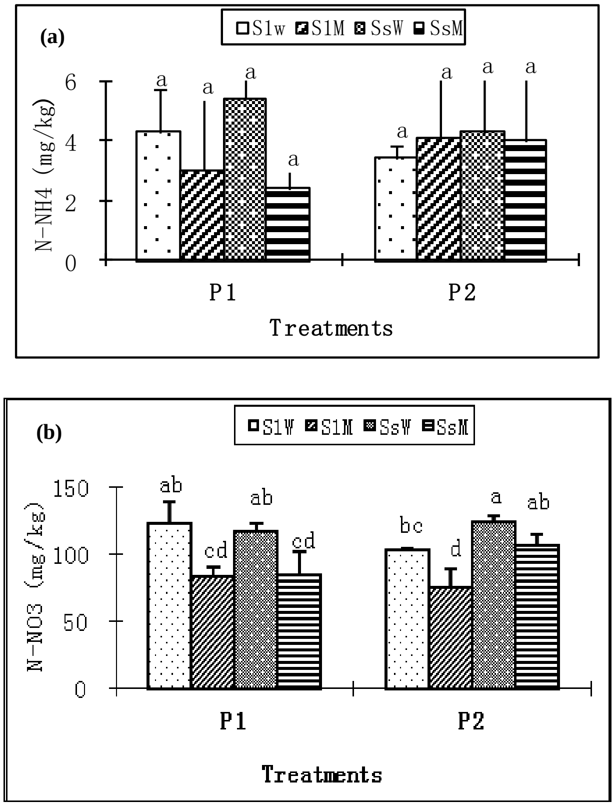

***Figure 1.*** **Ammonium (a) and nitrate (b) nitrogen, accumulations form all treatments at $25^0$C temperature**

## Conclusion

The application of organic residues and P fertilizer into soil had significant influence on $CO_2$ evolution, residue C & N decomposition at constant temperature. It was revealed that returning residue to soil brings significant increase in microbial biomass N and SOC while reduced mineral N contents. Returning residues to soil will improve carbon stocks in soil, provide waste disposal solution, nutrient recycling maintain and soil quality and environmental health.

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