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Estimation of carbon emission from agricultural and pasture field

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ABSTRACT

Agriculture is one of the significant contributors to greenhouse gas to the atmosphere, thereby play a role to intensify the greenhouse gas effect. Carbon dioxide, even being the principal component of gas emitted from the soil, there is no, or little research has been conducted on carbon dioxide emission from the soil surface under cultivated land. This study was intended to explore the carbon dioxide emission from soil-grown with various crops and management practices. The measurement was done with the Japanese closed chamber technique. The result showed that the level of emission not only differed due to management practices but also due to the type of vegetation covered. Therefore, intensive research on emission from different agricultural systems is imperative to develop climate-smart agricultural soil management technologies in Nepal.

Key Words: Nepal, Carbon emission, Climate change, Pasture and Agriculture

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I. Introduction

Carbon dioxide (CO_2) being major greenhouse gas contributes nine to twenty-six percent greenhouse gas effect (Karki 2007). Agriculture soil emissions comprise up to 20% of the carbon dioxide which makes the measurement of CO_2 essential in various agricultural planning processes (Yadav and Wang, 2017). Soil physical properties and various biological processes affect the total greenhouse emitted and consumed (Smith et al. 2003). In addition, the proper balance of input and output determines the soil characteristics of being a reservoir or emitter. Therefore, the farmers' practices like change in land use patterns and various management practices determine the dynamics of soil carbon. Then, this dynamism is directly related to the soil microbe's population and their activities (Muñoz et al. 2010) and thereby affects the emission from the soil. Agricultural management practices like irrigation and

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fertilizer management determine the level of CO_2 emission from the agricultural field (Yadav and Wang, 2017). The addition of the biochar with compost alone would decrease the carbon emission compared to the soil amendment with compost (Chen et al. 2015). Similarly, environmental factors like soil temperature and water have a significant correlation with carbon dioxide emission from the soils (Pitombo et al. 2015). As Nepalese agriculture is highly dependent on weather, altered weather parameters and climate change could have considerable impact on Nepalese agriculture (Timilsina et al. 2019) including amount of soil emissions. The increment in temperature and carbon dioxide emission have a positive correlation, and water scarcity in the soil has a negative impact on carbon dioxide emission (Tu and Li, 2017). A unit degree increase in temperature will help to reduce the carbon loss more in the colder region than the warmer areas (Kirschbaum, 1995). Further, Soil CO_2 flux is the combined result of plant root respiration, microbial respiration and microbial decomposition of soil organic materials (Hanson et al. 2000). Therefore, type of the vegetation, soil type, organic matter as well as the water content and management practices make the differences in total carbon emission from the soil.

The emission of carbon dioxide from agriculture and pastureland has not been explored explicitly in Nepal. Since this study highlights the representative emission level under different agriculture and pasture filed, it would be helpful to make an inventory in greenhouse gas emissions as well as for developing climate-friendly technologies.

II. Materials and Methods

The sampling unit of collection and measurement of soil gas emission was based on land cover and management practices. The simple random sampling method was adopted for selecting agriculture and pasture land of three locations; namely RARS, Lumle (Kaski district), ARS, Ranighat (Parsa district) and GRS, Bandipur (Tanahu district) in 2016. Three different soil parameters (soil pH, soil moisture and soil temperature) were measured for each sampling. The soil moisture and pH meters were used to measure soil moisture and pH from an eight-centimeters depth of the soil, respectively, while soil thermometer was used to measure the temperature of the soil.

The Japanese closed chamber technique was used for collecting gas from the soil. In this method, the cylindrical stainless metal gas chamber (20 cm wide and 25 cm high) was kept above the water-filled base's depression (Figure 01). The water on base depression prevents the exchange of gas to the outer atmosphere. At first, the gas sample was taken just after mounting the equipment (0 minutes) on the field as an ambient gas sample. Then, the cylindrical gas chamber was closed with the lid with a small pipe fitted on the center of the lid with cork to make airtight. A gas sample was, then, drawn from the enclosed chamber into a plastic bag (Tedlar sample bag) using a syringe after six minutes of mounting the instrument. Further, the collected gas samples were passed as quickly as possible through CO2 monitor to measure ambient and emitted soil gas carbon dioxide concentration. The soil gas sample was collected from the different standing crops and pasture fields as well as from two different tillage practices on wheat field.

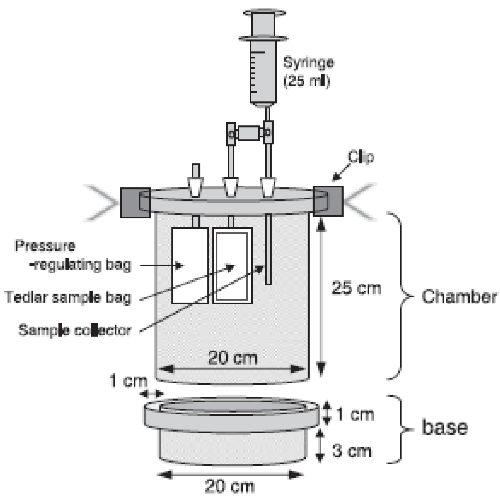

Figure 01. Gas collecting chamber (Toma and Hatano, 2007).

The carbon gas emission of each sample measured was expressed in milligram of CO2 per square meter per hour from the soil.

III. Results and Discussion

Emission from agricultural lands

The soil sample taken for different cereals and horticultural crops showed almost enough level of moisture and slightly acidic pH range (6.0 to 6.3). The ambient temperature ranged from 21 to 23°C at mid-hill locations (Lumle and Kaski) and 31°C at Terai (Ranighat, Parsa). The result showed that emission from the vegetable field was higher as compared to cereal crops and Tea (Table 01). Moreover, the higher CO_2-C gas emission was observed in the field with a standing chilly crop (322 mg/m²/hr) than brinjal (283 mg/m²/hr). The emission from wheat-grown field was 100 mg/m²/hr at Ranighat, Parsa. The higher emission of CO_2-C in the vegetable field might be due to higher dose application of manures and fertilizers (basically nitrogenous fertilizers) for vegetable production as compared to cereal and tea. Nitrogenous fertilizer is one of the major sources of carbon emission as contains a higher amount carbon and nitrogen (Lal 2004). Cheng et al. (2011) stated that 76% of total CO_2-C emission was contributed by Nitrogenous fertilizer application.

Table 01. CO_2-C Emission from different standing crops

S.N.	Crops	Air Temperature (°C)	C flux (mg/m²/hr)	pH	Soil Moisture
1	Maize (*Zea mays*)	23	150.4	6.0	8.0
2	Wheat (*Triticum aestivum*)	31	100.8	6.3	7.9
3	Chilly (*Capsicum frutescens*)	22	322.0	6.2	8.0
4	Brinjal (*Solanum melongena*)	21	283.0	6.3	8.0
5	Tea (*Camellia sinensis*)	22	175.7	6.1	8.0

Emission from pasture field

The CO_2-C emission was measured in Agricultural Research Station, Bandipur on the field-grown with ten different pastures. The soil was found slightly acidic in nature ranging from 6.0 to 6.5 with enough moisture level (8). The average air temperature was 31°C and soil temperature ranged from 29.0 to 29.5 °C. The lowest emission was recorded in soil-grown with Setaria (26.2 mg/m²/hr) and highest under field covered with stylo (174.5 mg/m²/hr). Other higher levels of emission were from the fields grown with Rhodes grass, signal, molasses, etc (Table 02). The differences might be due to fertility status of the soil, nutrient uptake nature of the vegetation, root density as well as root exudes for determining the microbial activity on the soil.

Table 02. CO_2-C emission from different pasture field at Agriculture Research Station (ARS), Bandipur

No.	Pasture	Air Temperature (°C)	C flux (mg/m²/hr)	Soil Temperature (°C)	Soil pH	Soil Moisture
1	Rhodes grass (*Chloris gayana*)	31	153.4	29.5	6.5	8
2	Joint Vetch (*Aeschynomene spp.*)	31	126.6	29.0	6.0	8
3	Signal (*Brachiaria decumberns*)	31	139.2	29.0	6.0	8
4	Stylo (*Stylosanthes guianenisis*)	31	174.5	29.0	6.0	8
5	Setaria (*Setaria spp.*)	31	79.7	29.0	6.5	8
6	Molasses (*Melinis minutiflora*)	31	133.5	29.0	6.3	8
7	Summa setaria	31	26.2	29.0	6.0	8
8	Forage peanut (*Arachis spp.*)	31	105.7	29.0	6.0	8
9	Guinea grass (*Megathyrsus spp.*)	31	35.5	29.0	6.4	8
10	Paspalum (*Paspalum spp.*)	31	60.6	29.0	6.0	8

Emission from wheat field grown with mulch and no mulch

Generally, mulching practices are adopted to take multiple benefits. It helps to reduce the soil exposure to ambient air thereby reduces the water loss into the atmosphere through evaporation process. On the other hand, it acts as substrate for microbial decomposition and supplies nutrients to the plant. The

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addition of carbon to the soil helps to form soil aggregates required for proper aeration and hold soil moisture.

The ambient air temperature was 31^{0}C and the soil temperature was 15.3^{0}C and 15.6^{0}C under mulch and no mulch condition (Table 03). The average C flux was more than one-third higher under no-mulch condition compared to mulch condition. Liu et al. 2016 stated that carbon flux differs based on crop stage and has found higher C flux from soil with transparent and black plastic mulch compared to no mulching at early stage of maize while higher emission at later stage of maize with no mulch condition. The rate of loss of soil carbon as CO_2 flux is affected by practices such as tillage, crop rotation and residue management (Sartori et al. 2006).

Table 03. CO_2 emission from mulch and no mulch condition on wheat at ARS, Ranighat

No.	Treatment	Air temperature (^{0}C)	C flux (mg/m^2/hr)	Soil temperature (^{0}C)	pH	Soil moisture
1	Mulch	31	84.5	15.6	6.0	7.8
2	No-Mulch	31	117	15.3	6.6	8.0

IV. Conclusion

In the context of climate change, its negative consequences and contribution of the agriculture sector to greenhouse gases, the inventory on emission level becomes essential for various adaptive and mitigate planning perspectives. As crop management practices like mulching and land utilization with different vegetation types govern total amount of CO_2-C emitted from the soil, further research is necessary to find out best land utilization pattern and management practices to make the Nepalese agriculture environment-friendly.

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