SOIL CO_2 FLUX FROM A TROPICAL DRYLAND RICE-BARLEY-FALLOW AGROECOSYSTEM: IMPACT OF APPLICATION OF SOIL AMENDMENTS WITH VARYING RESOURCE QUALITY

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ABSTRACT:
Information on loss of carbon in form of CO_2 from the soil in response to soil amendments is wanting in tropical dryland agroecosystems. This two year study of soil CO_2 in tropical dryland agroecosystem supporting rice-barley-fallow annual sequence involved addition of equivalent amount of N through chemical fertilizer and three organic inputs (high quality resource, low quality resource, and high and low quality resource combined) besides control. A marked seasonal variation was noticed in CO_2 flux in all treatments, with higher levels obtained during rice crop (warm-wet period) and considerably decreased flux during barley crop (cool dry, period). CO_2 flux differed in various treatments. In terms of annual mean, low quality input showed 92% greater CO_2 flux relative to control (127 mg CO_2 m^{-2} hr^{-1}) whereas combined input showed 75% increase. However, the CO_2 flux expressed on the basis of per unit exogenous carbon added was ca.100 times higher in case of fertilizer relative to low quality input application (ca. 11 mg CO_2 g^{-1} C hr^{-1}) (cf. High quality input, 3 times, and combined input 1.5 times greater). These results show that CO_2 flux is more related to C input than the input of N.

Soil has been recognized as a major source and sink for atmospheric CO_2. Out of the total emission of CO_2 to the atmosphere about 20% is contributed by soil through its respiration [*Smith et al*., 1997] Emission of CO_2 from soil not only has implications in global climate change but also results in depletion of soil organic pool, soil fertility and crop productivity. However, being an important sink of CO_2, soil has great capacity to sequester atmospheric CO_2 through the net fixation of CO_2 in form of plant biomass [*Lal*, 2004]. Amongst several other factors, agricultural management strategies have an effect on both the emission of CO_2 from soil and its sequestration capacity in soil [*Rastogi et al*., 2002]. These practices are of importance not only in terms of agricultural sustainability but also in issues related to climate change. In India about 65% of total cultivable land (ca.100 mha) is under dryland farming conditions receiving moisture supply only through rainfall. These rainfed dry land agroecosystems are characterized by low crop productivity due to moisture and nutrient limitations [*Ghoshal and Singh*, 1995]. Amongst other measures, application of organic resources has been advocated in these rainfed drylands for the enhancement of crop production as these measures are tend to conserve soil moisture as well as improve soil fertility. The information available worldwide regarding the soil CO_2 flux in response to soil amendments is scanty, and sometimes conflicting, and particularly lacking in tropical dryland agroecosystems.

The objectives of the present study were to estimate in a tropical rainfed dryland agroecosystem supporting rice-barley-summer fallow crop sequence (1) the effect of application of various soil amendments on the levels of soil CO_2 flux and (2) the seasonal variation of the CO_2 flux

The experiments were conducted in Banaras Hindu University campus at Varanasi (25°18' N lat. and 83°1' E long., 76 m above the mean sea level). This region has a tropical moist sub-humid climate, characterized by strong seasonal variations with respect to temperature and precipitation. The long term average annual rainfall is about 1100 mm. The soil belongs to the order inceptisol, showing pale brown colour, sandy loam texture and a neutral reaction. The experimental design involved application of various soil amendments having equivalent amount of N (80 Kg N) but with contrasting chemical composition viz. chemical fertilizer and three organic inputs in form of high quality resource (*Sesbania aculeata* shoot, C: N 16), low quality resource (wheat straw, C: N 82), and high and low quality resource combined (*Sesbania*+wheat straw, C: N 48), besides control (cropped, no inputs). During the two year study (2002-2003 and 2003-2004), the flux of CO_2 from soil surface was determined 32 times at regular intervals under field condition using alkali absorption method [*Singh and Shekhar*, 1986].

A distinct seasonal variation in CO_2 flux was recorded across all treatments throughout the two annual cycles. CO_2 flux decreased significantly from rice crop period to barley crop period and thereafter it increased slightly during the summer fallow (Fig 1).

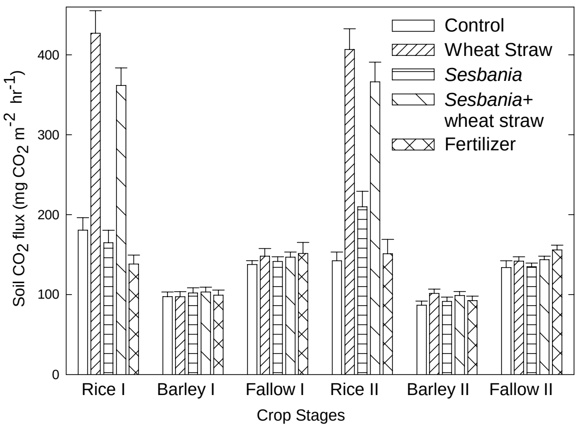

Fig. 1. Variations in soil CO_2 flux (mg CO_2 m^{-2} hr^{-1} ± SE) through two annual cycles, following various soil amendments in a tropical dryland agroecosystem; values for each crop period and summer fallow are mean of seven and two estimations, respectively.

Increased decomposition rates due to higher temperature and moisture conditions contributed to greater CO_2 evolution during rice crop. During the cool and dry winter conditions the rate of decomposition of remaining recalcitrant materials as well as the root and microbial respiration were reduced, leading to decreased CO_2 flux. The slightly increased CO_2 flux during summer fallow can be attributed to higher temperature that can lead to chemical oxidation of dead crop root and native soil organic matter as well as increased levels of microbial biomass. Soil CO_2 flux in this study was more strongly correlated with soil moisture content ($r = 0.71$, df. 22, $p < 0.001$) than soil and air temperatures ($r = 0.64$, df. 22, $p < 0.01$ and $r = 0.68$, df. 22, $p < 0.001$ respectively).

During rice crop period higher levels of CO_2 flux were recorded in single (161% increase over control) and combined application (129%) of low quality input. However, CO_2 flux in fertilizer treatment was not significantly different from that of control. Application of high quality input increased significantly the levels of CO_2 flux during second year rice crop period (2003). During barley and summer fallow periods no significant difference in CO_2 flux was recorded among treatments. On the annual basis, CO_2 flux showed the trend similar to that of rice period with significantly higher levels only in single (92% greater than control) and combined (75%) application of low quality input compared to other treatments. However, when soil CO_2 flux was expressed in terms of per unit exogenous carbon added, fertilizer treatment showed ca.100 times increase compared to low quality input (ca. 11 mg CO_2 $g^{-1}C$ hr^{-1}) whereas high quality (ca.3 times) and combined quality inputs (ca. 1.5 times) showed much lower levels. CO_2 flux was found to be strongly correlated with the amount of C added through soil amendments, ($r = 0.97$, df. 10, $p < 0.001$). These results showed that the amount of N added to the soil through soil amendments has little effect on the soil CO2 flux whereas it is the amount of C that has the pivotal role in the efflux of CO_2 from the soil. These findings may have implications not only in management of the soil fertility but also in checking carbon loss through soil in form of soil CO_2 flux.

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