Reducing soil CO_2 emission and improving upland rice yield with no-tillage, straw mulch and nitrogen fertilization in northern Benin

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1. Background

✓ In Benin, rainfed upland rice ecosystems account for about 27% of the total rice area (Diagne et al., 2013). Rice is typically grown under intensive tillage in slash-and-burn systems (Saito et al., 2010). Such practices have been reported to be major contributors to soil CO_2 emission, thus depleting soil organic carbon and reducing crop yield (Baker et al., 2007).

✓ Very little is known about the effects of management practices on soil CO_2 emission and crop yield in West Africa (WA).

✓ The lack of data constraints the transition to low emission agricultural development in WA.

2. Objectives

✓ to identify the effects of tillage systems, rice straw management and nitrogen application on soil carbon emission and upland rice yield,

✓ to determine the optimum level of nitrogen fertilizers to increase rice yield under various tillage systems and rice straw management, and

✓ to suggest an optimum combination of factors for efficient management practices to reduce soil carbon emission and increase upland rice yield.

3. Methods

3.1. Study area

Lixisols (Site 1) and Gleyic Luvisols (Site 2) in the Tetonga catchment in Northern Benin, WA.

3.1. Treatments

✓2 tillage systems (no-tillage, manual tillage)

✓2 rice straw managements (no-straw mulch and 3 Mg ha^{-1} of rice straw mulch)

✓3 levels of nitrogen application (0 kg N ha^{-1} , 60 kg N ha^{-1} and 120 kg N ha^{-1}).

✓ Experimental design: Randomized complete block design

3.2. Data collection

✓Soil CO_2 emission measured using a portable infrared CO_2 sensor with closed soil respiration chambers (Fig. 1).

✓ Soil temperature measured with a hand-held soil thermometer.

✓ Soil moisture measured with a portable TDR probe.

✓Data measured at 5 cm depth in 6 to 10 days intervals from June 2014 to February 2015.

A: before land preparation
B: at sowing
C: at rice tillering stage

Fig. 1: Soil CO_2 emission measurement

4. Results

4.1 Cumulative soil carbon emission

✓ Higher cumulative soil CO_2 emission under manual tillage than no-tillage.

✓ Higher cumulative soil CO_2 emission in rice straw mulch treatments.

✓ Higher cumulative soil CO_2 emission in 60 and 120 kg N ha^{-1} compared with zero-nitrogen treatments (Fig. 2).

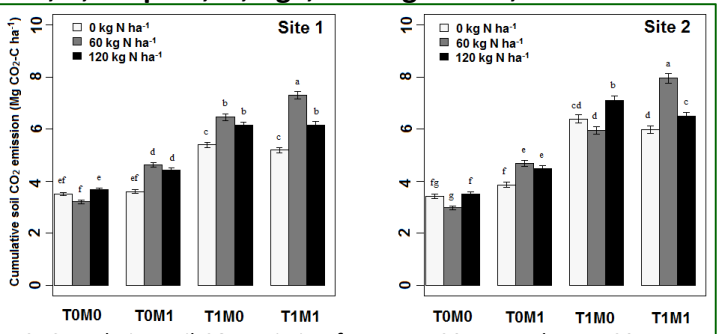

Fig. 2: Cumulative soil CO_2 emission from June 2014 to February 2015 at Site 1 and Site 2. T_0M_0: No-tillage, no straw mulch, T_0M_1: No-tillage, straw mulch, T_1M_0: manual tillage, no straw mulch, T_1M_1: manual tillage, straw mulch.

4.2 Drivers of soil CO_2 emission

✓ No relationship between daily soil CO_2 emission and soil temperature during growing and dry season (Fig. 3)

✓Soil moisture, main factor explaining seasonal variation of soil CO_2 emission (Fig. 4).

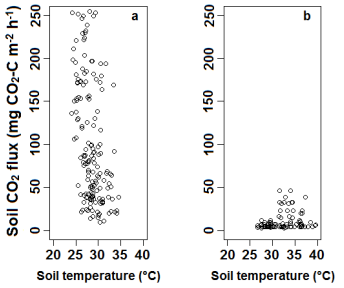

Fig. 3: Daily soil CO_2 emission and soil temperature during a) growing and b) dry season

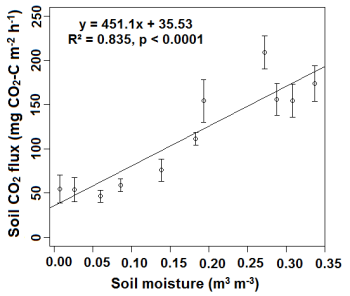

Fig. 4: Daily soil CO_2 emission and soil moisture during growing season

4.3 Agronomic efficiency of nitrogen

✓ Highest AEN under straw mulch and 60 kg N ha^{-1} (Fig. 5).

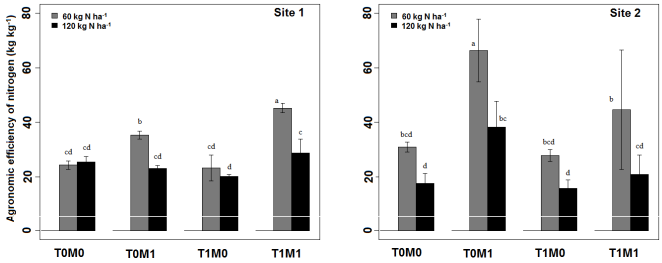

Fig. 5: Agronomic efficiency of nitrogen (AEN)

4.4 Soil carbon emission per unit grain yield

✓ Higher amount of soil CO_2 emission per unit grain yield under manual tillage and no nitrogen; but lower under no-tillage and nitrogen fertilization (Fig. 6).

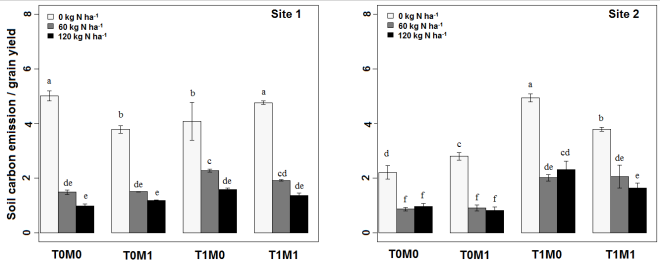

Fig. 6: Soil CO_2 emission per unit grain yield

5. Suggestions

No-tillage with straw mulch and 60 kg N ha^{-1} to reduce soil CO_2 emission and increase upland rice yield.

Literature cited

Baker, J., Ochsner, T., Venterea, R., Griffis, T., 2007. Tillage and soil carbon sequestration—What do we really know? Agric. Ecosyst. Environ 118, 1–5.

Diagne, A., Amovin-assagba, E., Futakuchi, K., Wopereis, M.C.S., 2013. Estimation of Cultivated Area , Number of Farming Households and Yield for Major Rice-growing Environments in Africa, in: Wopereis, M.C.S, Jonhson, D.E, Ahmadi, N., Tollens, E., Jalloh, A. (Eds.), Realizing Africa's Rice Promise. CAB International, pp. 35–45.

Saito, K., Azoma, K., Oikeh, S.O., 2010. Combined effects of Stylosanthes guianensis fallow and tillage management on upland rice yield, weeds and soils in southern Benin. Soil Tillage Res. 107, 57–63.

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