Dry-wet cycles affect carbon mineralization of soil

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Introduction

Some tropical environments are subject to irregular rainfall events early in the crop season. This irregular rainfall and the often warm, dry climate generate rapid drying of surface soils. These dry-wet cycles are even more common in tropical areas with contrast climates. This is the case of the soils of northern Cameroon where the Sudanese tropical climate causes rapid drying of soils. Dry-wet cycles are important processes in the understanding of carbon (C) dynamics as they influence the decomposition of organic matter and aggregation.

Rewetting a dry soil causes a pulse of C mineralization « the Birch Effect » for a few days (Birch, 1958; Franzluebbers *et al.*, 2000). The increase of C mineralization with the number of dry-wet cycles can be assigned to microbial death upon rewetting of dry soil (Van Gestel et al., 1991), solubilization of organic matter (Lundquist *et al.*, 1999) and physical disruption of soil aggregates (Miller *et al.*, 2005). This unprotected organic matter could be easily mineralized by microorganisms (Denef *et al.*, 2001).

In a Mediterranean climate, (Fierer and Schimel, 2002; Miller *et al.*, 2005) reported that the dry-wet cycles cause a significant increase in carbon mineralization compared to a control soil kept moist. However, other studies have reported a reduction in carbon mineralization compared to a control soil kept moist (Degens and Sparling, 1995; Mikha et al., 2005). This resistance of C mineralization to dry-wet cycles is explained by soil organic carbon which is very stable and resistant to decomposition.

The influence of dry-wet cycles on C mineralization is controversial. To our knowledge, few studies have evaluated the influence of dry-wet cycles on C mineralization in tropical environments.

For this reason, we assessed the C mineralization in tropical environments under different dry-wet cycles. Hence the objective of this study was to evaluate the impact of dry-wet cycles on C mineralization of soil.

Materials and methods

This study was conducted in North Cameroon at Pitoa (09°23'N, 13°32'E). The region of North Cameroon is characterized by a Sudanese tropical climate with a rainy season from 5 months (mid-May to mid-October) and an average annual rainfall of 1200 mm. This study was conducted during the dry season (February-March 2014).

Design: The experimental plots were 2x2 m, according to a randomized block of Fisher, which includes three blocks and four treatments. The soil is cultivated and regularly mulched for eleven years with Bracharia (*Bracharia ruziziensis)* and subjected to different dry-wet cycles.

The four treatments were designed as follow: continually dry soil, continually moist soil (pF 2), soils subjected to five dry-wet cycles in which wetting events were separated by dry periods of ten days (5 DWC) and soils subjected to ten dry-wet cycles in which wetting events were separated by dry periods of five days (10 DWC).

The amounts of water brought cumulatively are similar for all plots and there was no rainfall during the entire measurement period. Soils are kept moist by wetting each day with 5 mm of water. This quantity of water corresponds to the evaporation of soil in northern Cameroon during the measurement period. The amount of water applied cumulatively on moist soil was put on soils subjected to five and ten dry-wet cycles; i.e. 50 mm every 10 days or 25 mm every 5 days.

Measurements: Soil respiration was measured 32 times during 50 days, on PVC collars (10 cm in diameter and 8 cm in height), using the Li 8100 soil CO_2 flux system (Licor Inc., Lincoln, Nebraska, United States). The measurement time is limited to 1mn30s to avoid major changes in the concentration of CO_2 in the chamber. Measurements were conducted according four replications per plot. In all plots, soil temperature (10 cm depth) was measured at the same time as the soil respiration using a temperature sensor connected to Licor 8100. Soil moisture in the 0-6 cm layer was measured in each plot using a moisture probe (Decagon Inc. Campbell United States).

Results

The wetting of dry soils immediately caused a significant and rapid increase of mineralization of soil organic C (13.27 $\mu mol.m^{-2}.s^{-1}$) (Fig.1). This flush lasted about ten days. In continually dry soil, C mineralization was low (1.22 $\mu mol.m^{-2}.s^{-1}$).

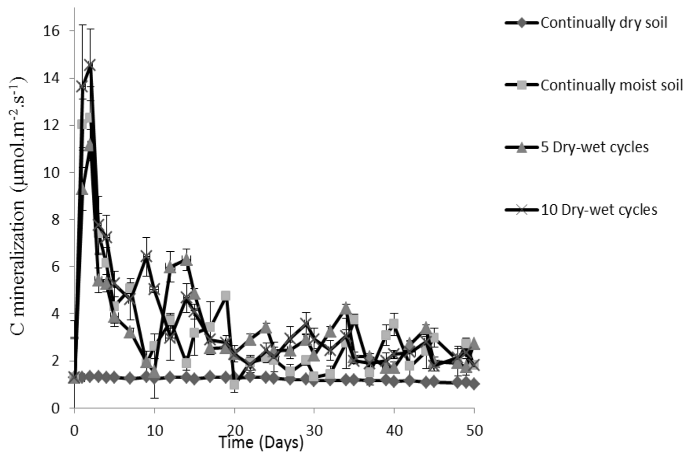

Fig.1. Flush of C mineralization for dry soil, moist soil, five and ten dry-wet cycles.

Frequency of dry-wet cycles increased moderately C mineralization compared with a continuously moist soil (Fig.2). Ten dry-wet cycles caused a cumulated C mineralization of 1.32 $tC.ha^{-1}$ on 50 days against respectively 1.17 and 1.15 $tC.ha^{-1}$ on soils with five dry-wet cycles and continually moist soils.

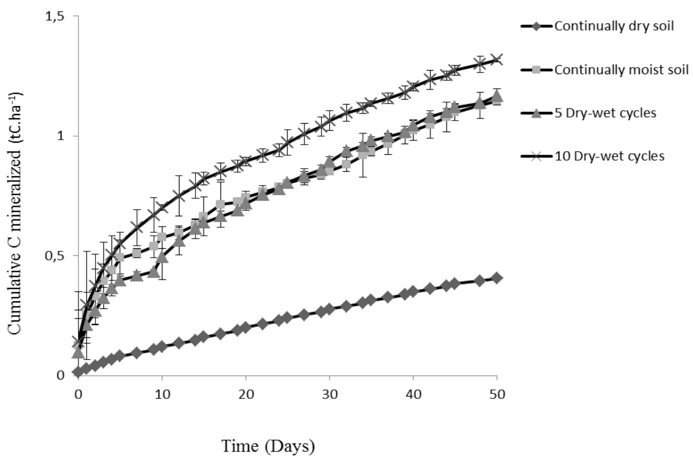

Fig.2. Cumulative C mineralized for dry soil, moist soil, five and ten dry-wet cycles.

Discussion

Dry-wet cycles increased moderately C mineralization compared with a continuously moist soil. The rates of increase of C mineralization were about one and a half times greater in the treatment with ten dry-wet cycles but not for five dry-wet cycles. It confirms the results obtained in other environments. In Mediterranean-type ecosystems, (Fierer and Schimel, 2002; Miller *et al.*, 2005) observed an increase rates of C mineralization twice greater in the treatment with several dry-wet cycles than a continuously moist soil. This increase was related to the physical disruption that could be easily mineralized by microorganisms.

We have obtained a rapid and significant increase in carbon mineralization upon rewetting a dry soil and mineralization rates showed variations. The lack of mineralization rate equivalent to the first could be explained by the reduction of the nitrogen in the soil which results in an increase in microbial activity and / or the rapid growth of the microbial biomass (Van Gestel et al., 1991). Thus microorganisms have assimilated mineral nutrients to respond to their needs (multiplication, growth).

Conclusion

Our findings indicate that in tropical agroecosystems, the frequency of dry-wet cycles moderately influenced C mineralization of soil. These cycles have an impact on the functioning of these systems by moderate loss of C and should be considered in the simulation models of the dynamics of soil C.

We call for other studies under controlled conditions to accurately determine the effect of dry-wet cycles on C mineralization.

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