Sustanaibility of agroecological practice for soil fertility and C sequestration face to climate variability in Madagascar.

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Abstract

Natural climate variability related to environmental disorders affects significantly the agriculture production and cropping system management in smallholder farmers in Madagascar. Agroecological practice is considered as a sustainable practice in climate change mitigation and soil fertility improvement compared to the current conventional farming. In this context, the influence of land use change on nutrient availability and soil carbon stock was studied in the East region of Madagascar in order to assess the resilience of agroecological practices in climate change mitigation. Soils under agroforestry system (AF), direct seeding mulch-based cropping system, and conventional system (CV) were sampled at Ambodimanga site while soils under forest system (F) were sampled at Analalava site. Availability of soil P was assessed by anion exchange membrane extraction (resin P) while soil total N by the Kjeldahl method, and soil organic C by Walkley and Black method. The bulk density and particle size of soil was also measured. The land use effect was observed on the stock of resin P (P<0.0001), and carbon (P<0.0001). The resin P stock ranged from 1.9 to 3.1 kg P.ha^{-1} and was highest under AF system and lowest under CV system regardless of the depth of soil. Similar values of NT stock were found for all studied systems (around 2.8 kg P.ha^{-1}). The C stock was higher in AF system (with average value of 25.5 kg P.ha^{-1}) compared to that under F system (18.9 kg P.ha^{-1}). The lowest C stock in forest system is mainly due to physical property of soil classified as sandy soil marked by significant high value of bulk density (1.4 g.cm^{-3}). The decrease of nutrient and C stocks with soil depth is related to bulk

density increasing. Results indicate that AF system could be a resilient system for soil fertility face to climate variability.

Keywords: agroecological practice, land use change, P availability, C sequestration, climate variability

Introduction

Natural climate variability related to environmental disorders affects significantly the agriculture production and cropping system management in smallholder farmers in Madagascar. Deforestation and traditional agriculture practice present a global atmospheric C emission, by 3.1 ton.year (Raunet, 2005), and contribute significantly to terrestrial surface warming and to soil fertility depletion. Technique innovation including climate smart agriculture could increase the productivity of cropping land by recycling nutrients and protecting soil environment, and could also decrease the anthropic pressure on forest area by reducing the deforestation for the agriculture (Minang et al. 2014 ; Mathews et al. 2014). This study intended to assess the potentiality of current cropping system practices including the agroecological system in term of C stock and nutrient availability in the setting of food security and climate change mitigation

Materials and Methods

The effect of land use change on C stock and nutrient availability was studied in the Eastern area of Madagascar, Région d'Analanjirofo, in order to assess the potentiality of agroecological practice. Soils under Agroforestry system (AF) characterized by association of permanent tree (clove tree) with annual crops (rice or maize), direct seeding mulch-based cropping system (SCV) marked by simple pickling of cover plant and by spreading over fields as mulching, and conventional system (CV) marked by intensive logging of environment as "tavy" practice known also as "slash and burn" terms were sampled at Ambodimanga site while soils under forest system (F) were sampled at Analalava site. Four replicates of site for each studied system were sampled. For each sampled site, soils were sampled in three points as holes of 50 cm x 50 cm with triangle disposition in 0-10, 10-20, and 20-30 cm of depth where bulk density was assessed by cylinder. Availability of soil P was assessed by anion exchange membrane extraction or resin (Res P) while soil total N (TN) by the Kjeldahl method, and soil organic C (SOC) by Walkley and Black method. The bulk density and particle size of soil was also measured.

Results and discussion

The land use change was significantly affected the soil nutrient availability and organic carbon (SOC) stock. The stock of Res P, TN, and SOC decreased significantly with the depth ($P<0.0001$). The Res P stock ranged from 1.9 to 3.1 kg $P.ha^{-1}$ and was highest under AF system and lowest under CV system regardless of the depth of soil. This difference was distinctly marked in the topsoil and was absent with depth. The topsoil is the most exposed in external conditions such as temperature, precipitation, litter deposit.... In addition, the root biomass, which is more important in subsoil, favored biological activity. The C stock was higher in AF system (with average value of 25.5 kg $P.ha^{-1}$) compared to that under F system (18.9 kg $P.ha^{-1}$). The lowest SOC stock in forest system is mainly due to physical property of soil classified as sandy soil marked by significant high value of bulk density (1.4 $g.cm^{-3}$). Similar value of TN stock was found for all studied systems (around 2.8 kg $P.ha^{-1}$). Nitrification and denitrification processes, which control the N availability in soil, could be optimal under some environmental conditions and leading to loss of gaseous N (Szukics et al. 2010). Significant decrease of NO_3^- occurs in soil incubated at 25°C and could be attributed by complete denitrification and release of N_2 gaseous in the atmosphere (Davidson et Swank 1986 ; Szukics et al. 2010). The decrease of nutrient and C stocks with soil depth is related to bulk density increasing.

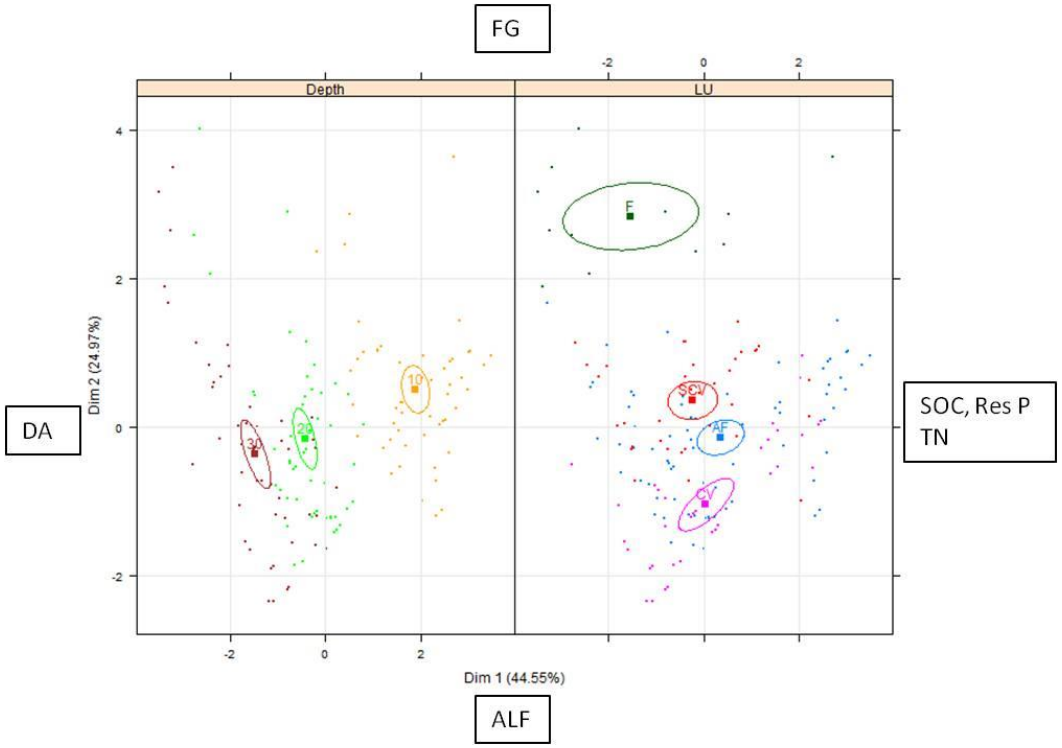

Figure 1. Projections of C, nutrient and granulometric fraction in the principal component space. FG, ALF: sand, and clay-silt composition in soil; DA: bulk density

These observations were summarized in PCA analysis (Fig. 1). PC1 explains 44.55% of the data information which is positively related with SOC, Res P, and TN, and linked negatively with bulk density. The second PC (PC2) explains 24.97% of the variance in our data and is linked positively with sand composition of soil and linked negatively with the clay and silt composition fraction. PCA analysis showed that AF has a relatively high SOC, Res P and TN. In soil under CV system, AF has higher clay and silt composition fraction. Soil under forest is distinctly different with a lower SOC and nutrient but higher soil density which is marked by higher sand composition.

In conclusion, anthropic pressure marked by land use changed affects soil fertility and environment. The traditional practice has negative impact on soil and environment as soil fertility depletion and sensitive soil on leaching. The agroecological system as AF system including the cropping association of permanent and annual plants improves the soil nutrient availability and the SOC stock. In this study, the AF system presents high potentiality in climate variability/change adaptation.

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