Resilience of agroecological system to temperature variation in tropical soil of Madagascar

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Introduction

Climate change may affects soil and ecosystem functions in the short and long. Furthermore, climate change effect on agriculture is marked by low productivity through soil degradation and erosion. This makes agricultural sector as the most vulnerable areas to global warming and associated climate changes (Lal et al., 1998). Agro-ecological practices could be relevant system in adaptation and mitigation strategies and by strengthening the agro-ecosystem resiliences in terms of soil organic matter and productivity to climate change and variability (Razafimbelo et al., 2008). Few studies have been done about nutrients bioavailability (e.g. N and P) in agroecosystems face to climate variation in the tropic areas. This research aimed to study the influence of global warming on the soil nutrient bioavailability (N and P) and to assess the agroforestry system resilience under temperature variation.

Materials and methods

Mesocosm experiment was carried out in laboratory in order to monitoring the nutrient availability. Soils from agroforestry and conventional system (slash and burn) were incubated during 56 days, under two different temperatures 25 and 35°C. The studied soils were sampled in the Eastern area of Madagascar (Analanjirofo Regional Zone). A 15 g of dried soil sample (sieved at 2 mm) under two systems were placed in plastic vials and preincubated for 15 days at 25°C temperature. Soils were amended with organic manure (OM) at the rate of 0 and 0.15 g/vial (with equivalent rate of 10 tons/ha) at the end of pre- incubation periodSoil moisture was maintained at 70% of water holding capacity. Then, eight treatments (2 systems with 2 temperature levels and 2 added OM) and 4 replicates per treatment were prepared for 0^{th}, 1^{st}, 3^{rd}, 7^{th}, 10^{th}, 15^{th}, 21^{st}, 28^{th}, 42^{nd}, and 59^{th} day giving a total of 288 pots arranged in a completely randomized design. P bioavailability was assessed by anion exchange membrane extraction (resin P) and the inorganic P was determined colorimetrically according to Murphy and Riley method (1962).

Inorganic N (NO_3 and NH_4) were analyzed in KCl extracts using an analytical flow autoanalyzer.

Results and discussion

Effect of heat stress on the bioavailability of N and P

The average nutrient values were higher in 35°C compared to those in 25°C. Without OM input, increasing temperature (25 to 35°C) increased average content of NH_4^+ arround 60-80% (0.03 to 0.05 g / kg dry soil) for AGFS system, and arround 64% (from 0.007 to 0.012 g/kg) in CV system. With OM application, temperature variation increased resin P content by 24% (from 9.7 to 11.7 mg/kg) in AGFS system and by 24% (7.4 to 9.2 mg / kg) in CV system. A similar effect was found by Grierson et al. (1999) under rise of temperature of 15 to 38°C. The same authors also noted nitrification doubling under increasing temperature of 24°C to 36°C. In fact microbial processes are mostly active at temperatures from 20-35°C (Kaila and al, 1953. Avnimelech, 1971). The observed temperature variation induced a decrease of 1% of the NO_3^-/NO_2 average content under AGFS system against an increase of 45% (0.05 to 0.07 g / kg) under CV system. Temperature had a significant effect on NO_3^-/NO_2 bioavailability under conventional system that prioritizes N mineralization to immobilization in low organic matter case. Indeed, microbial inorganic nitrogen immobilization followed by microbial reorganization or denitrification process frequently accompanied N mineralization (Duguet, 2005).

Potentiality of Simple Agroforestry System to climate stress

Phosphorus fixation under AGFS system appeared lower compared to that under CV. Microorganisms have played an important role on capital P. This process seems to change depending on P availability (Harrison, 1982). AGFS system resilience over the long term resulted in ΔP resin (content P balance between 25 and 35°C) which had greater variation compared to CV. The system AGFS presented a strong resilience in terms of NH_4^+. Temperature variation increased NH_4^+ availability may be due to high microbial organic nitrogen conversion activity. In the organic system without input, the same trend of increasing the variation ΔNH_4^+ was observed. The temperature thus affects the nitrogen mineralization.

Studies have shown that gross N-mineralization is positively correlated to soil organic nitrogen content (Booth et al, 2005), carbon content (Barrett and Burke , 2000). Under AGFS system, with organic manure, ΔNH_4^+ trend presented higher growth.

Conclusion

This study was carried to quantify nutrient bioavailability, N and P, in agroecosystems subject to a temperature change in the tropics. Incubation as an artificial conditions simulated the temperature effect on soils nutrients (N and P) availability under two different agricultural systems. The temperature influenced in a comprehensive way P resin and mineral N contents of due to its stimulating effect microbial activity.

Agroforestry is shown to be a resilient system in terms of nutrient bioavailability face to temperature variation. With OM application, the temperature change effect was relatively mitigated under agroforestry system in terms of soil NH_4^+ content. However, agroforestry seems to be less resilient in terms of NO3/NO2.

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