Research Application Summary

Soil biodiversity research in Uganda: Gains, consolidation and capacity needs

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Abstract

We examined abundance and diversity of rhizobia, arbuscular mycorrhiza fungi, nematodes, collembolan, termites, earthworms, ants and beetles in forest, grassland, mixed cropping, fallow, sugar and tea plantation; encompassing Mabira forest and adjacent agro-systems. Belowground biodiversity (BGBD) sub-indicator was computed to predict the general soil quality (GISQ). Legume and earthworm inoculation for conservation and agricultural enhancement was also tested. Biota abundance and genera diversity diminished with land used change. The GISQ correlated ($p<0.0001$) with BGBD hence a feasible indicator. Inoculation either with rhizobia or earthworms gave profitable soybean and maize grain yields, respectively. Building capacity for further studies is recommended.

Key words: Biodiversity, Mabira, quality, soil

Résumé

Nous avons examiné l'abondance et la diversité des rhizobiums, des champignons mycorhizes arbusculaires, des nématodes, des collemboles, des termites, des vers de terre, des fourmis et des coléoptères en forêt, en prairies, en cultures mixtes, en jachère, dans les plantations du sucre et du thé, en englobant la forêt de Mabira et des agro-systèmes de proximité. Les sous-indicateurs de la biodiversité souterraine (BGBD) ont été calculés pour prédire la qualité générale du sol (GISQ). L'inoculation de légumineuses et de vers de terre pour la conservation et la mise en valeur agricole a également été testée. L'abondance et la diversité des genres Biota ont diminué avec le changement des terres utilisées. GISQ La corrélation ($p <0,0001$) avec BGBD, pour cette raison a donné un indicateur possible. L'inoculation, soit avec des rhizobiums ou avec des vers de terre a donné rendements rentables de graines de soja et de maïs respectivement. Le renforcement des capacités pour d'autres études est recommandé.

Mots clés: Biodiversité, Mabira, la qualité, le sol

Background

Rampant exploitation of land resources mainly for agriculture threaten biodiversity including soil biota loss. Broadly, soil biota constitute microorganisms, meso and macrofauna important for several processes e.g. organic matter decomposition, nutrient cycling and acquisition, soil structure modification, carbon sequestration, suppression of phyto-pathogens, etc. Further, belowground biodiversity (BGBD), as an integral component, are potential indicators of soil quality.

While substantial research has generated information on aboveground biodiversity and appropriate management interventions, only in the past two decades has soil biodiversity attracted modest basic and applied studies. For example, there is limited knowledge regarding changes in soil biota following agricultural land use change especially in the tropics. Thus, the Global Environment Facility(GEF) funded - "Conservation and sustainable management of belowground biodiversity (CSM-BGBD) Project", implemented in Brazil, Cote d' Ivoire, India, Indonesia, Kenya, Mexico and Uganda sought to address some of the gaps. The Project objective was to enhance awareness, knowledge, and understanding of BGBD important to profitable agricultural production in tropical landscapes by demonstration of methods for conservation and sustainable management of soil biota. Further, the project targeted increasing human and infrastructural capacity earlier identified as grossly insufficient (Rwakaikara and Nkwiine, 2007).This paper highlights the gains and gaps in knowledge and capacity needs for soil biodiversity research in Uganda.

Literature Summary

Large portions of Mabira forest have been converted to both large (plantations) and small (subsistence) agriculture. Agro-ecosystems are often subjected to regular physical and chemical disturbances (Neher, 1999) of above and below ground species. For example, the number of species and functional groups particularly in the protist taxa increased over years under no-till, attributed to accumulation of soil organic carbon compared to tillage controls (Adl *et.al.*, 2006). Earthworms and nematodes have been proposed as bio- indicators of soil quality (Doran and Safley, 1997).

Study Description

Six 1km^2 study units (windows) were demarcated in Mabira forest and surrounding farm areas, i.e., forest, grassland, mixed cropping, fallow, tea and sugarcane plantations. Using a grid system, 16 points were sampled for legume nodulating bacteria (LNB), arbscular mycorrhiza fungi(AMF), nematodes,

collembola, earthworms, beetles, ants, and termites and their abundance and diversity determined using agreed upon methods (Moreira *et al.*, 2008). The site was characterized for soils, plant aboveground biodiversity, and socioeconomics, besides reviewing pertinent existing policies and formulation of policy briefs. Legume and earthworm inoculation technologies were tested for improving nodulating bacteria population and soil structure, respectively, and simultaneously enhancing agricultural productivity. Bio-physical and socioeconomic data were subjected to ANOVA, Pearson correlations and Principal component analysis, and Shannon Diversity index H'. Sub-indicators and a general indicator of soil quality (GISQ) were calculated using SPSS version 16, ADE4, Biodiversity R, and XLSTAT software.

Findings

All selected soil biota groups were recovered from Mabira forest and surrounding farm areas and identified to genus or morphotype. Generally, BGBD declined with land use change, which reflected soil quality; forest being greater than fallow> mixed cropping>tea>grassland> sugar cane. The trend was largely attributed to decreased organic resources, disturbed habitat and use of minerals and pesticides in intensively managed systems.. The lateritic shallow soils under grassland probably explain its low ranking while poor management (abandoned and weedy) tea improved the score. Plant aboveground biodiversity improved with increasing BGBD suggesting possible direct or indirect benefits plants derive from soil biota. Soybean inoculation with nodulating bacteria (TAL 102) improved their populations over seasons and gave economic monetary gains while maize yield increased with earthworm inoculation.

Research Application

Legume and earthworm inoculation are feasible technologies for sustainable agricultural production. Soil biota likely is good indicators of soil quality.

Recommendation

Human and infrastructure capacity for soil biodiversity research should be placed high on the Uganda national research agenda. Economic evaluation for the various biota should also be done. Legume inoculation technology should be widely disseminated and local competitive strains identified and commercialised. However, earthworm technologies should be tested in wider agro-ecosystems. In addition various BGBD sub-indicators of soil quality should be validated in other geographical areas.

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