Soil fertility management in yam cropping systems in Côte d'Ivoire: exploring perceptions, solutions and knowledge transfer

Background

Yams (*Dioscorea* spp.) are tuber crops of high importance for food security and income generation for millions of people in West Africa [1]. Soil fertility management is a challenge in yam cropping systems, which traditionally are characterised by low productivity, forest loss and accelerated soil degradation due to soil organic matter (SOM) decline [2]. SOM is a key element to sustain food production, especially in low-input systems, for example by storing water and nutrients to promote crop growth [3]. Strategies to improve crop productivity and halt the decline of SOM need to be implemented to sustain yam production in this region. Such interventions will require improved agricultural practices and the engagement of farmers and other actors.

Research approach

Different aspects of soil fertility management were studied in this PhD thesis. These included: i) assessing biochar as a soil amendment with the potential to improve crop productivity and soil properties; ii) exploring farmers' perceptions about soils and soil fertility management; and iii) evaluating the use of a serious game as a tool to disseminate knowledge about innovations and soil fertility management to relevant groups. This PhD thesis builds on the knowledge, collaborations and institutional partnerships created and facilitated by the YAMSYS project, which was implemented by Swiss and West African research institutions. The thesis comprised of three studies:

Study 1: *Effects of biochar amendments on crop productivity and soil properties in two yam cropping systems in Côte d'Ivoire*

The aim of this study was to investigate the use of biochar as a soil amendment to improve crop productivity and soil properties. We installed field experiments in two sites in central Côte d'Ivoire, which presented different levels of soil fertility. Our main hypotheses were that biochar inputs would increase yam tuber yields and nitrogen fixation by legumes, and to increase carbon stocks and improve selected SOM functions, especially in the low-fertility sandy soil of one of the sites.

Key results: In this study, we found no significant biochar-induced increase in yields or nitrogen fixation. In contrast, biochar additions resulted in a slight yield decline when co-applied with manure, probably due to nutrient immobilisation. Yam tuber yields were on average 20 t ha^{-1} across sites, treatments and cropping season, which is a two-fold increase compared to average yields obtained by farmers under similar conditions. This shows the importance of optimising good agronomic practices, such as timing of planting and weeding. Although carbon stocks increased in the low-fertility soil, our findings suggest loss of native SOM across all treatments and sites. Based on our study, yam farmers are unlikely to benefit from biochar additions, at least not on the short-term, and may even experience adverse effects during the first year.

Study 2: *Farmers' perception of soil fertility management in yam cropping systems – a mental model approach*

In this study we used a mental model approach to explore farmers' perceptions, knowledge and beliefs about soils and soil fertility management in yam cropping systems. In total 30 farmers were interviewed in six villages in the two project sites. The aim was to better understand how farmers classify soils, what soil functions they were familiar with, and how they used that knowledge in their farming decisions. We also aimed to identify potential knowledge gaps in farmers' mental models and assess how these may influence their farming practices.

Key results: We found that farmers have a large degree of shared knowledge about soil management, especially regarding visual concepts and farming practices. The importance of preparing a *"clean field"*, which implies burning, was one of the most commonly shared perceptions. Farmers often used indicators such as soil colour and vegetation to distinguish between different types of soils and their level of fertility. However, we observed more inconsistency between farmers' mental models concerning the non-visible processes and functions of the system. The concept of soil organic matter was not mentioned by any farmer and is probably a missing key element of their mental models of soils. This knowledge gap should be addressed in further initiatives to improve soil fertility management.

Study 3: *A serious game as a tool for exploring land management in two yam-based systems in West Africa*

In this study, we evaluated the use of the serious game *J'igname* that was developed within the YAMSYS project as a tool to disseminate knowledge about innovations and soil fertility management. A total of 25 game sessions were carried out with farmers, extension agents and researchers, in Burkina Faso and Côte d'Ivoire. The aim of this study was to assess the validity of the game as a representation of a yam cropping system, and to understand how different actors adopt innovations and how their preferences and land management decisions translate into outcomes on their simulated farm.

Key results: Our results show that the game was an accurate representation of a yam cropping system, as it was validated by the behaviour of the players. We found that the local context had a stronger influence on players' decisions than their background as farmers, extension agents or researchers. Local cultivation practices were reflected in the players' behaviour during the game, which were associated with crop choices and fertilisation regimes. We conclude that the game *J'igname* accurately serves as a model of a yam cropping system and can be used as an educational tool to promote good agronomic practices. Such game could also bring relevant actors together to create a shared mental model of the functioning of the system and the challenges to address. Improved understanding of farmers' realities and incentive structures could eventually lead to better designed outreach activities and the development of better tailored policies.

Conclusions and relevance for development

Improved soil fertility management in yam cropping systems was at the core of this PhD thesis. The work mainly contributed to SDG 2 (Zero hunger) and SDG 15 (Life on land) by promoting sustainable agricultural practices and assessing a potential solution to soil degradation and the associated deforestation. Through study 3, we also to some extent contributed to SDG 4 (Quality education), by focusing on knowledge transfer and social learning by using a serious game.

Although biochar amendments did not generate the expected outcome in our study, the results from this project will hopefully contribute to bring nuance to the often overly positive narrative of biochar as a solution to many of the agricultural problems farmers face. Development projects and policymaking need to be based on scientific, context-relevant evidence. As shown in our study, biochar inputs may lead to a yield decline during the first year, and such technologies should therefore be introduced to farmers with caution. An integral approach, involving both the agronomic and human dimensions, is needed for the evaluation and potential scaling-up of a technology. Such evaluations need to consider the objectives and preferences of farmers and adopt a realistic time-frame for the expected benefits. This project has stressed the importance of integrating farmers' traditional knowledge in both the design and implementation of a project. Farmers are not a homogenous group, and a better understanding of their mental models of the farming system will facilitate the development and implementation of agronomically and culturally suitable solutions.

In addition to the research presented in the PhD thesis, I visited a yam growing region in northern Colombia, through a travel grant from the World Food System Center. The purpose of the study trip was to meet with yam farmers and learn about their farming systems, but also to share the work of YAMSYS and this PhD project.

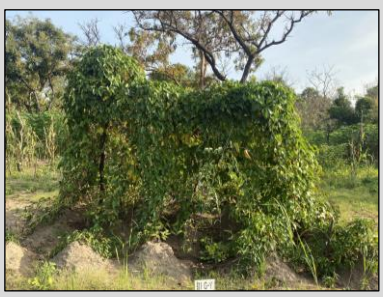

Figure 1. Yam plants in field experiment, Kouassi Kouassikro, November 2021.

Figure 2. Yam tuber harvest in Kouassi Kouassikro, November 2021.

Figure 3. Facilitation of the serious game *J'igname* in Kouassi Kouassikro, April 2022.

References

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