Understanding soil fertility management under cereal cropping systems in southern Mali

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Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment. http://africa-rising.net/

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Contents

Introduction

For decades, Malian stakeholders, including farm households and scientists, have increasingly recognized soil-nutrient depletion as one of the major constraints to sustainable agricultural development. Farming systems in the country are diverse due to variations in climate, soils, and production goals. Many complex factors influence the level of soil nutrient depletion and include nutrient management, regeneration and plant protection, livestock integration, soil and water conservation, biodiversity, agricultural policies, and marketing structures.

Farm households are confronted with declining price relations between farm inputs and outputs resulting in a net exploitation of soil nutrients. Due to prevailing poverty, farm households have limited options for investment in nutrient adding or nutrient saving technologies. Nowadays, this situation is worsening due to climate change and variability. Climate smart technologies such as using organic manure and micro dosing have been implemented by various actors to address soil nutrient depletion and the effects of climate change, but questions about the sustainability of this system remain.

In this progress report we explore farm characterization for understanding the management strategies regarding soil fertility. This activity is the first of a series of four monitoring steps for assessing nutrient flow at farm scale in the Koutiala District of southern Mali.

Objectives

The main objective is optimizing nutrient flow and determining the efficiency of fertility management options.

Sub-objectives

- Determine farming system characterization regarding resource endowment.
- Determine production (grain, biomass, manure) stock as a farm nutrient source.

Our approach

Farmer selection and partnership establishment

Farmers were selected in the three Africa RISING intervention villages (Zansoni, Sirakélé, and N'golonianasso) in the district of Koutiala. A total of 45 farmers were interviewed corresponding to 15 farms per village. Farmers were selected using the systematic random sampling method in which sample farms are selected from the total list of farmers in the village according to a random starting point and a fixed, periodic interval. This interval, called the sampling interval, was calculated by dividing the total list of farms by 15, representing the desired sample size per village.

Working in the countryside requires establishment of a partnership framework specifying the roles that should be respected by each party. Although at this stage we do not have an experimental phase, we have adopted the same rules, defining the responsibilities of each party. The objectives of the study were given in the plenary session and the selected farmers were free to accept or decline the decision.

Immediately after the engagement of each participant, individual surveys were conducted in two stages—the farming inventory survey and the farming monitoring survey.

Picture 1. Farmers selected for interview on farm characterization and composting activity (farmers concentrating on understanding the systematic random sampling method) in the village of Sirakele. Photo credit: Bouba Traore/ICRISAT.

Farming inventory survey

As the purpose of the work is to use the NUTMON toolbox for better understanding farmers' soil management strategies, the model was introduced to each participant as a virtual farmer with similar farm characteristics to theirs.

Inventory represents the first step of nutrient monitoring and consists of collecting baseline information on the demographic structure of the household representing the population and the number of men, women, and children per farm with their respective ages. For agricultural equipment, the type and number were collected as well as the type and number of crops and animals.

In the three villages, a total of 45 farmers were interviewed from July to August 2018.

The approach was based on individual interviews with the head of the family who could be accompanied by the eldest son. Questions were structured in such a way to have precise information. For example, for the number of people in the family, the respondent could be asked to present his family notebook as a supporting document especially for age determination.

Picture 2. Household survey: A farmer is explaining model functioning after a training session before starting the survey. Photo credit: Bouba Traore/ICRISAT.

Farming monitoring survey

The objective of the monitoring is to track use of biomass and grain stocks, animals, and dynamics within the population. From January to February 2019, the first monitoring survey was conducted with the 45 farmers who had been surveyed for the inventory earlier in August 2018.

A monitoring sheet was designed for collecting information on inputs such as organic matter (cattle, goat, and sheep manure, compost), mineral fertilizer (NPK), and urea or pesticide especially for cotton and maize. The number of equipment and animals was also monitored as well as biomass and grain across each farm.

Progress and observations

Farming equipment and population

Farmers were divided into three typologies, which had been developed according to the number of animals, particularly cattle, the number of plows, carts, and the total area of cropped land. Farm type A is considered high resource endowment, farm type B medium resource endowment, and farm type C low or limited resource endowment.
Among the 45 selected farmers in the three villages, 80% had type A farms, 47% type B, and 13% type C. This characterization shows that most farmers are well equipped to carry out agricultural activities.
Farm type A has an average of 24 people versus 16 for type B and 14 for type C (Table 1). Thirty-four percent of the total population make up the effective workforce. Farm type A has an average of five plows, two carts, and two planters, compared to three plows and one cart and planter, respectively for farm type B. In terms cropping land, farm type A had an average land size of 15 ha against 9 ha for farm type B and 5 ha for C.

Table 1. Farming characterization across difference farm typology.

	Cart	Plough	Planter	Sprayer	Cropping land	Total population	Work force
Farm type A	1.66	4.72	1.21	1.72	14.81	24.10	8.29
Farm type B	1.08	3.00	0.77	1.77	8.82	16.31	6.90
Farm type C	1.00	4.00	0.33	1.33	4.95	13.67	2.84

Workforce per farm = 0.25*(household member below 10 years old) + 0.5*(household member between 11 and 14 years old) + 1*(household member between 15 and 54 years old) + 0.5*(household member between 55 and 65 years) + 0.25*(household member between above 65 years).

Cropping system: Field distribution across the landscape

With a GPS receiver (AndroiTS GPS Test version 1.46) installed on a smartphone, the geographical coordinates of each crop field were identified. These points were used to determine the distribution of the crops and to characterize the rotation system in land management over the next three years. Figures 1, 2, and 3 illustrate the spatial distribution of crops across the three villages. Crop fields in Zansoni and Ngolonianasso are more dense and closer to the village than the distribution of the fields in Sirakele where some fields were located inside a neighboring village.

The distance from the village where organic matter is produced to the field is an indicator of a constraint for manure production and transportation and will be further investigated.

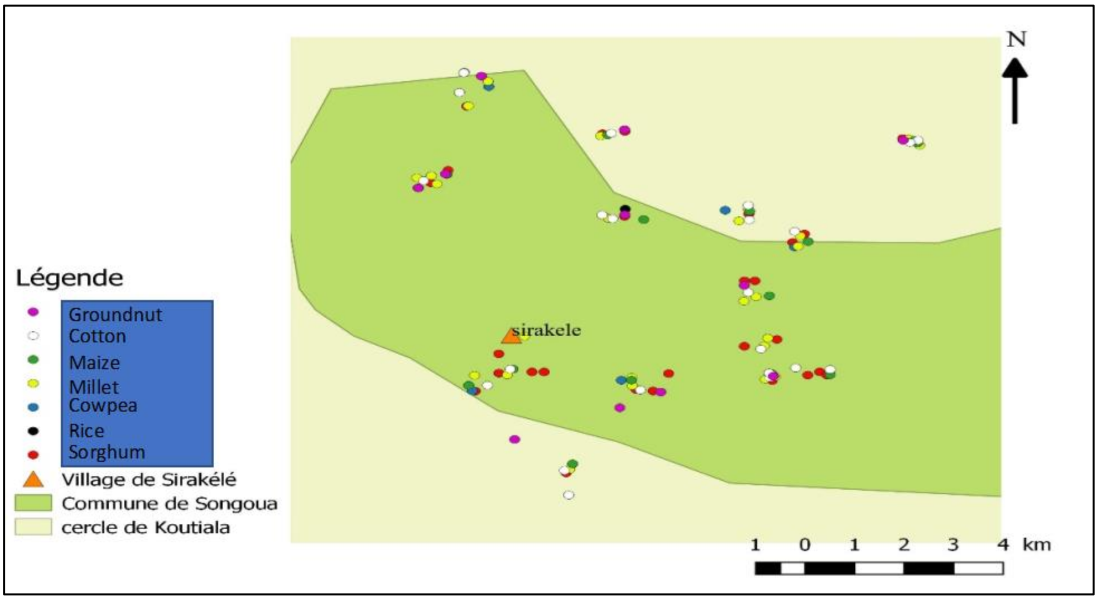

Figure 1. Crop field distribution across the landscape of Sirakele-Koutiala.

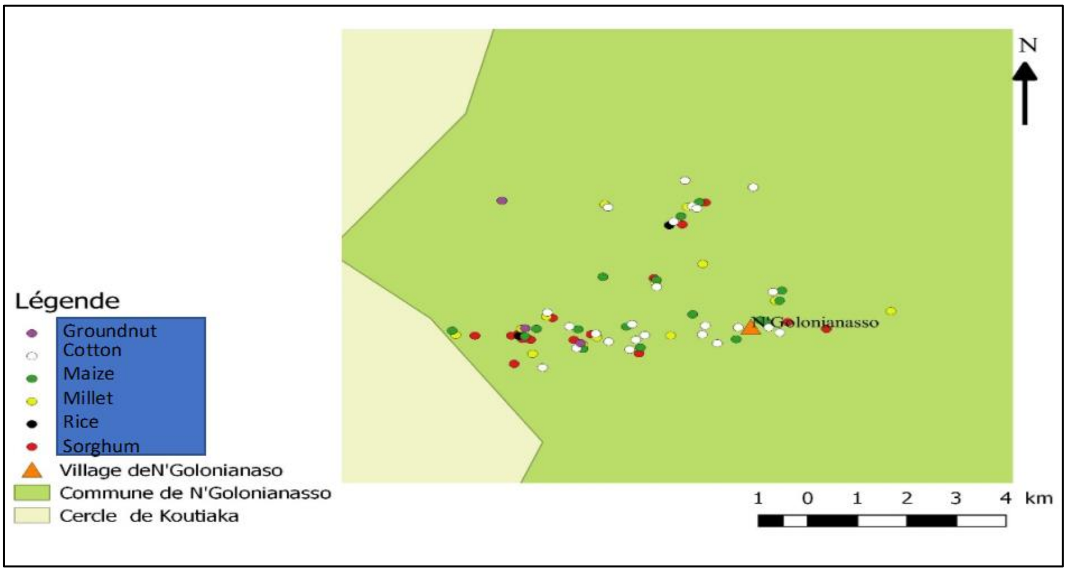

Figure 2. Crop field distribution across the landscape of Ngolonianasso-Koutiala.

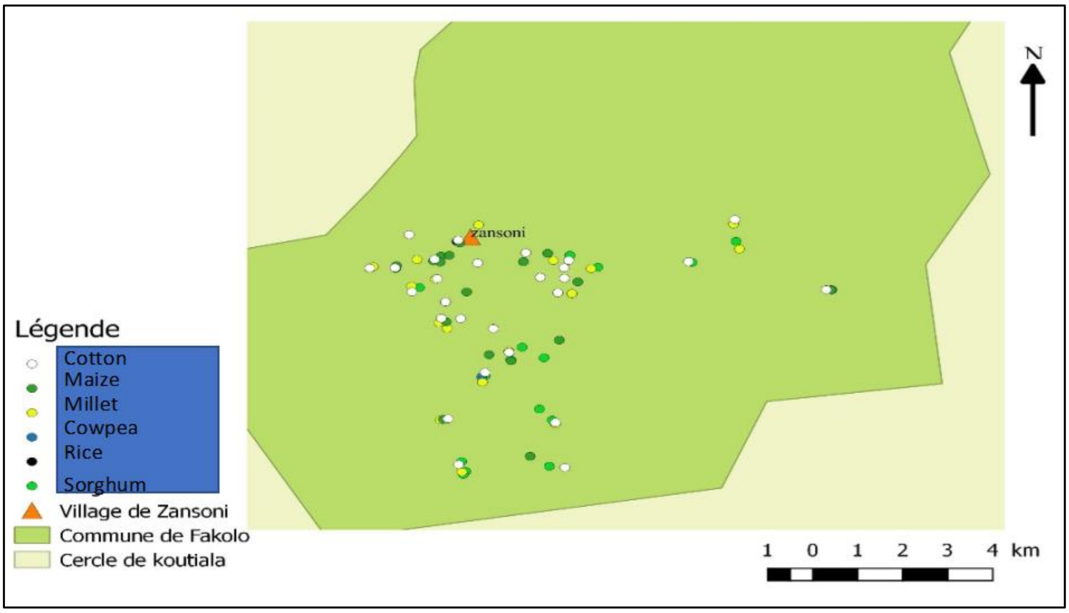

Figure 3. Crop field distribution across the landscape of Zansoni-Koutiala.

Cropping surface and observed yield

Figures 3 and 4 indicate that cropping land as well as yields vary not only within the same farm typology but also between different farms. In total, cropping land for millet, sorghum, and maize account for about 62% of the total rotation compared to 26% for cotton and 13% for cowpea and groundnut. However, this rotation varies according to the farm typology, for example the cropping land for cotton is 3 ha for farm type A against 2 ha for farm type B and 1 ha for C (Fig. 3). For millet, the average cropping area is 2.5 ha for farm type A, 2 ha for B, and 1 ha for C.

For all crops, variations in grain yield are greater at farm scale than between the different typologies (Fig. 4). For example, average maize grain yield was 2,142 t/ha for farm type A against 1,846 t/ha and 1,600 t/ha, respectively, for types B and C.

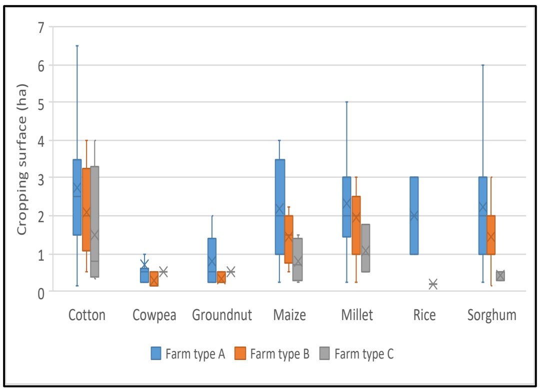

Figure 3. Cropping surface per crop and farm typlogy.

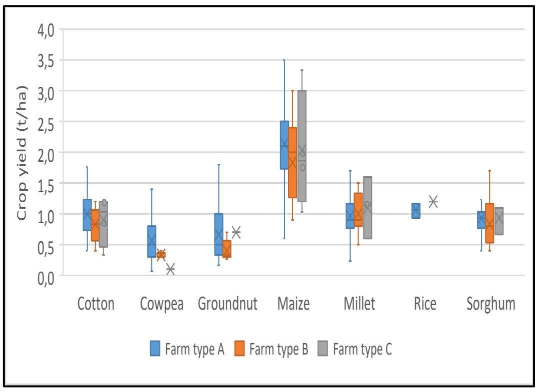

Figure 4. Observed yield (t/ha) according to farm typology.

Grain and biomass stock

Farm monitoring in January showed that biomass and grain stocks throughout (Figs. 5 and 6) were established after harvesting through crop rotations that were set up during the year 2018.

For the same crop, biomass stock varies according to farm typology. For example, while the biomass stock of millet and sorghum for farms type A and type B varies between 5 and 10 t, that of farm type C is less than 2 t. This will have a clear implication in biomass flow as well as nutrient flow across farming components that will be examined in the next phase of the monitoring process.

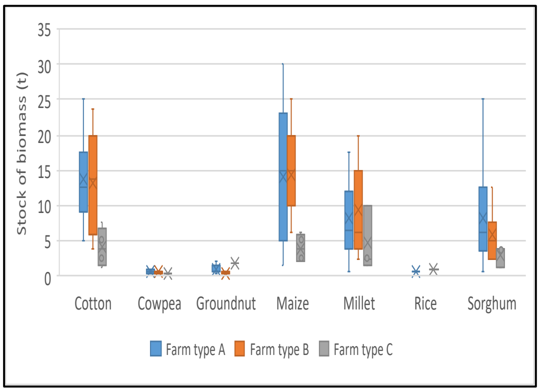

Figure 5. Stock of biomass per crop and by farm typology.

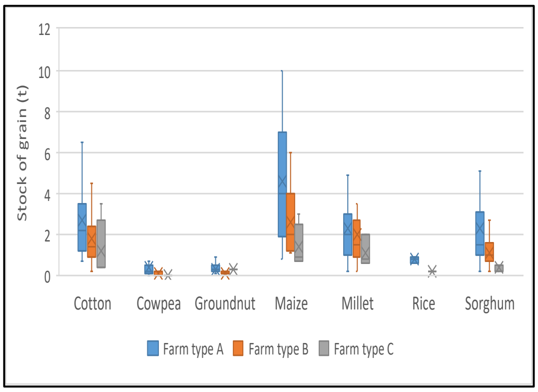

Figure 6. Stock of grain per crop and by farm typology.

Organic matter

For the organic matter, four sources were identified (not shown) across 45 farmers and include livestock park manure, household yard manure, homemade compost, and small ruminant manure. In July, representing the starting point of the monitoring process and the cropping period, there was only little organic matter in the farm due to the fact it had been used already in the field. Monitoring is ongoing for the stock distribution across different components of local farming system.

Composting activity

Composting activity supports agricultural productivity and income and is highly affected by soil nutrient depletion of farmers' fields. Although most farmers use mineral fertilizers, organic manure is applied only on 30% of the cultivated land. Organic and mineral fertilizer inputs are currently insufficient leading to general deficiency of nitrogen, potassium, and phosphorus, the main nutrients needed for major crops.

In this system, cropping rotation is dominated by millet (22%), sorghum (20%), maize (19%), and cotton (26%). Farmers using manure usually own a herd of livestock and represent only 5% of the population, while the majority mostly rely on composting with sorghum and millet stem. On the other hand, most of the cotton stem (representing 15 t for farm types A and B, and 5 t for farm type C) are burned to get rid of them, or the ordinary process for composting lasts more than a year.

Thus, to help these farmers facilitate and diversify access to organic matter, the Africa RISING project has undertaken a series of experiments and tests on producing compost

based on cotton stems. This activity aims to strengthen farmers' knowledge for sustainable soil management through improving soil organic matter content.
For the implementation of the composting activity, we first held a meeting in each of the three villages (Zansoni, Sirakele, Ngolonianasso) to explain our approach to farmers. As a result of this discussion, 15 volunteer farmers from each village were selected to take part in the composting test. Afterward they were invited to the technological park of Mpessoba for training.

Upon return to the village, each of them is implementing at least one type of composting. A total of 400 volunteer farmers from the three villages participated in the two-day practical training on heap composting of cotton stems. This training consisted of showing the need to cut the stems in pieces of 10 to 20 cm to facilitate handling (Pictures 3 and 4).

Participants learned how to properly mix the different inputs such as cattle manure, ash, glume, and residue. The participants were trained on watering techniques, water supply frequency as well as flipping heap composts.

Picture 3. Farmers cutting cotton stems into pieces of 10 to 20 cm.

Picture 4. Training farmers on composting cotton stem in the technology park of Mpessoba.

For the participants, it was their first experience of such a practical training session on heap composting with cotton stems as the basic input. Participants were enthusiastic and expressed their satisfaction and commitment to such learning. According to farm leaders, this was an opportunity to have enough organic matter for their field, especially for those who do not have animals. This activity is still ongoing and is being monitoring for sustainable intensification evaluation. Furthermore, compost is planned to be used for field experiments during the next agricultural season.

Constraints

Delay in timely availability of funds at the beginning of the rainy season has led to a delay in implementation of activities.

Conclusion and future action

Nutrient flow analysis is an activity that lasts for one to two years. The results presented here do not explicitly address the overall objective of the activity but rather help to define the baseline and establish future activities that will take place. For each farm, stocks of biomass, grain, and organic manure constituted will be monitored as and when they are being used.

The maintenance and monitoring of compost heaps that have been set up in the Mpessoba technology park as well as in farmers' fields will be continued until their maturity and will be used in the fields during the coming rainy season depending on availability of funds.