Talking soil science with farmers

When agricultural researchers visit farms in order to gather information for their research programmes, farmers rarely get proper feedback. Research information on scientific concepts such as soil fertility and nutrient balances is often considered too abstract for them. Researchers in Kenya returned to farmers to discuss their results in the context of Farmer Field Schools. Through the workshops that ensued, they managed to find a common language to bridge the communication gap.

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We researchers often visit farms to extract information, take measurements and samples, and then we leave. We publish our results for the scientific community, assuming that the result of our research will benefit farmers in the long run. However, farmers usually do not get direct feedback about research findings. We also needed better understanding of how they make decisions. When conducting research on soil nutrients in the field in western Kenya, we noticed that farmers very much appreciate feedback. We therefore set out to discuss basic processes together to help them to make decisions on the adoption and use of technology, while also helping us to learn about how farmers make decisions.

Our research context

Research was conducted on sixty farms in Emuhaya, western Kenya, and concentrated on understanding soil nutrient balances better to help improve integrated soil fertility management (ISFM) strategies (see Box). Soil on smallholder farms of sub-Saharan Africa tends to vary greatly in quality depending on location. Particularly in highly populated areas such as western Kenya, soil fertility typically decreases within a farm the further you move away from the homestead. These heterogeneous patterns, known as soil fertility gradients, result partly from the variability in soil types in the landscape, but also as a consequence of farmers' decisions on applying nutrient resources (e.g. animal manure) as well as where to best use their labour. When either nutrient resources or labour is scarce,

Figure 1: A farmers' resource flow map, showing movement of all nutrient resources throughout the farm.

farmers tend to concentrate these resources in the fields and gardens around their homesteads. Over time, this pattern of resource allocation leads to the typical picture observed across different areas of sub-Saharan Africa: well growing crops around the homestead or in the village fields versus sparse stands of poorly yielding crops in the bush fields. Clearly, soil fertility gradients need to be taken into consideration when designing ISFM strategies.

Our data collection included drawing resource flow maps (see example in Figure 1) and calculating nutrient balances, combined with soil sampling from the different field types within farms for laboratory analysis. We also measured the yield of maize crops growing on different fields within the farms, and large differences were observed. We saw that farmers tended to concentrate their organic resources in the home gardens. Very often, crop residues are also collected from the fields and brought to a compost pit where they are mixed with animal manure to be applied to the home gardens in the next season. Farmers used little mineral fertilizer in general, and those who did, applied less than 20 kg/ha (strikingly low when compared with the 200 kg/ha that is common in European agriculture!).

The partial nutrient balances (inputs as mineral and organic fertilizers minus outputs in crop harvest and residues removed) were negative for most fields for all farmers. The outer fields receive few inputs, but they also yield little, so not much is harvested from them. Therefore, the most negative balances were calculated for the close and middle fields, which are where the largest crop harvests are normally obtained. Along a soil

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What is integrated soil fertility management?

ISFM is a knowledge-intensive rather than input-intensive approach that aims at raising productivity levels while maintaining the natural resource base. It aims to replenish soil nutrient pools, maximise on-farm recycling of nutrients, reduce nutrient losses to the environment and improve the efficiency of external inputs. ISFM makes use of both local, traditional and scientific knowledge and integrates them into technologies that enable sustainable natural resource management systems. The diagram shows a number of examples of such technologies.

Green manures
Mineral fertilisers
Animal manure
N_2 fixation by legumes
Micro-dosage of fertilisers
Improved germplasm
Composting
Biomass transfers
Crop rotation
Agroforestry (fertiliser trees)
Traditional soilmanagement
Improved fallows

Recycling · Sustainability · Efficiency · Knowledge · **ISFM**

fertility gradient, maize yields varied from almost 4 tonnes per hectare near the homestead to less than 0.5 tonnes per hectare in the remote fields.

Making research feedback more accessible

The farmers were keen to obtain the results of our analysis, but handing out reports with tables full of analytical data would not have made sense to them. Therefore, we decided to first discuss with the community some basic concepts on nutrient balances, soil nutrient availability and plant nutrition. We held a workshop with 15 farmers (men and women) at the Emanyonyi Farmer Field School in Emuhaya. First we drew a farm transect on a flip chart, depicting a typical farm there. Farmers recognised the existence of soil fertility gradients and had local names for the different fields within their farms, distinguishing between home gardens, close and mid distance fields, remote fields, valley bottom lands and the grazing sites within the compound. During earlier visits to the farms, farmers had classified their fields according to their perceived fertility, by using the signs +, -, or +/- on the map to indicate fields of good, poor or medium soil fertility (see Figure 2). We next recalled all our research activities on their farms, also handing out the results of the soil analyses. And we provided reference values for the different soil indicators (soil organic carbon, total nitrogen, soil pH, etc.) corresponding to poor and fertile soils in the region.

Figure 2: An example of a typical farm transect, drawn with farmers in Emuhaya.

Useful analogies

To make the discussion on plant nutrients and soil fertility indicators more accessible to the farmers, we used a simple analogy focusing on the typical meal consumed in the area. A typical meal includes a relatively large portion of *ugali* (a warm porridge made out of white maize flour), a smaller portion of *nyama* (normally stewed or fried chopped beef) and an even smaller portion of *sukuma wikii* (boiled kale, cabbage or other local vegetables). We compared crops with the human body, which needs food to grow and function. We explained that the food of crops comprises mainly N, P, K and other nutrients in smaller proportions. We used local terms for the elements, and likened N to *ugali*, P to *nyama*, and K to *sukuma wikii*. A well growing, healthy crop needs a larger amount of *ugali* (N), a smaller amount of *nyama* (P), and some *sukuma* (K). (The latter is an assumption that works fairly well for the situation of Emuhaya, where K deficiencies are not generalised and only in few cases were crop responses to K fertilizers observed.) We

also explained that next to N, P and K, plants need other macro- and micro- nutrients, which are to the crop like the soup, the sauces, the salt and the spices that we consume together with our meal.

Looking at the reports, some of the participants asked about the roles of soil carbon and pH, following the proposed analogy. We indicated that soil C represents the 'plate' where the food is served; the amount of food can be plenty, enough for a good crop, but if the plate is too small only a small amount of food can be served (little availability). Soil pH was compared to the taste of the food, too low pH values indicating a bad taste; again, food can be available, but if it does not taste good the crop will not take it up completely.

With these analogies, we took two examples from the results of the soil analysis for illustration, using reference values for the local soils provided to farmers, together with the analytical results. One of the examples was a soil sample with a relatively high K content, and low C, N and P contents (drawn as a big plate with plenty of *sukuma* and little *nyama* and *ugali*). The other example had low C and N, K was almost adequate, and P was in excess (the plate was not big enough to contain all the *nyama*). Next to the drawing of a plate with *ugali*, *nyama* and *sukuma*, coloured bar charts were used to represent these soil indicators. After repeatedly drawing the bar charts next to the "meals" farmers got familiar with such graphic representation, so that only bar charts were necessary for illustrations later on. However, we kept the analogy going as farmers often got a good laugh out of certain images used, like the one about a person who is fed exclusively *ugali* who becomes fat but totally unproductive!

Understanding nutrient resources

Our next objective was to characterise the various nutrient resources available to farmers, on the basis of their nutrient content. When requested to recall the different nutrient resources known to them, farmers mentioned mineral fertilizers first, then farmyard manure and finally legumes and green manures. Some of the farmers pointed out that the main problem with farmyard manure was the small quantity available on the farm, which could fertilize only a small portion of their land. Where livestock is not kept in a stall, the effort needed to compost, carry and apply manure was also mentioned as a constraint to the use of manure as fertilizer. Few farmers, by the way, seemed to be aware of the fact that the quality of their manure is influenced by their animals' diet, a point that raised many questions in the group.

One farmer asked why she got greater yields in certain fields than in others, even if she had applied the same type and amount of fertilizer throughout her farm. She said she used the same maize variety in all her fields, planted and weeded the fields at the same time, and used the same planting density; however, she had not noticed differences in the visual properties of the soils within her farm, such as texture, slope or soil depth. The other farmers came up with possible causes of yield differences across the farm, such as varying pest or disease pressures on different fields, or differences in the placement of the fertilizer (e.g. by two different workers). Subsequently, we used the report of the soil analysis from her farm and drew a simple sketch to illustrate the variability she observed, using once again the analogy described above. Pointing to this sketch we suggested that she had probably applied more nutrient resources in the past to the fields around her homestead. This she confirmed. It turned out to be a very useful example as the results of the soil analysis clearly indicated higher N, P and K contents in her close fields. More
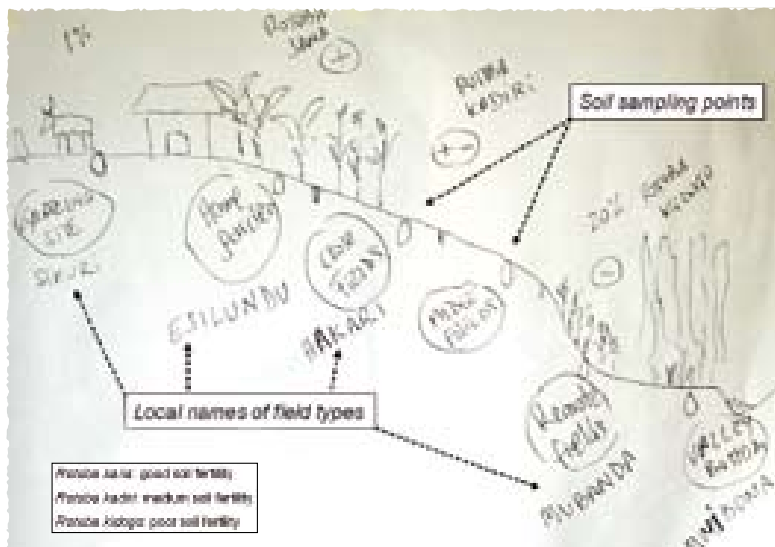
Photo: Pablo Tittonell

Reseacher and famer exchanging different perspectives and knowledge about soils.

nutrients present in the soil, together with those added by the fertilizer, led to higher yields near the homestead.

Explaining nutrient balances

Discussing the concept of nutrient balances proved to be more difficult. We started by comparing it to cash balances that are necessary to run a shop: "If we want a profit, our balances should be positive, which means that the earnings should be more than the expenditures". We explained that in the various fields of a farm, it is however practically impossible to have positive nutrient balances, but at least they should not be too negative. If nutrient balances are negative for long periods of time, the soils will be depleted. Flows of nutrients in harvested crops from the outer fields to the homestead and outflows to the market were listed. Farmers were surprised about the idea that nutrients are brought into the farm system when livestock grazing in communal land is kept on the farm at night. This discussion ended with a general feeling that the concept of nutrient balances appeared to be too abstract and puzzling to farmers: "So, the nutrient balances are *most negative* in the fields where we get the *best yields*?!!..."

Bridging farmer and scientific knowledge

Unlike technologies depending purely on inputs, the Integrated Soil Fertility Management approach is knowledge-intensive. To a large extent, ISFM strategies can be built on what farmers know and on their logic. Farmers' knowledge is largely constructed from past experience, and their adaptive capacity allows them to manage extremely complex systems (in places like western Kenya, farmers have managed to sustain their families on less than 1 hectare). Nevertheless, principles such as "nutrient stocks", "nutrient losses" or the "efficiency of

nutrient capture", which are central to ISFM, are often too abstract. The mere concept of "nutrients" is unfamiliar to many farmers. Nevertheless, our discussions with farmers revealed that they appreciate to have direct contact with scientists, to be able to access the results of their research, and to discuss issues as complex as nutrient cycling. They showed interest in learning more about the underlying processes affecting soil fertility and particularly on how their decisions contribute to soil heterogeneity.

This experience suggests that ISFM strategies will not sink down in rural communities unless parallel strategies are in place to empower farmers to make their own choices and decisions in relation to technology use and adoption. Specifically on the problem of poor soil fertility, the strategies for disseminating ISFM should go beyond comparing technologies from demonstration plots. They should place emphasis on discussing basic processes governing soil fertility together with farmers.

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