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STAKEHOLDER MEETING

Agenda Item 5. Stakeholder Interaction on Key Issues

Session II: Combating Soil Fertility Degradation in Sub-Saharan Africa

Background/Process:

Soil fertility degradation is a major issue in Sub-Saharan Africa. This session draws from the outcome of a workshop (Soil fertility degradation in sub-saharan Africa: Leveraging lasting solutions to a long-term problem) held in March this year at Bellagio. It will review the continuing problem of soil fertility degradation and its multiple impacts on the livelihoods of different sectors of African society; and progress toward combating it. Also, it will help identify priorities for research, development and institutional actions that will bring returns from investments to combat soil fertility degradation.

Document: Combating Soil Fertility Degradation in Africa

Comments:

COMBATING SOIL FERTILITY DEGRADATION IN AFRICA

PREFACE

This document is an edited excerpt from the report of a workshop organised by two centres, TSBF-CIAT and ICRAF at the Rockefeller Foundation Bellagio Study and Conference Centre in March this year. The topic of the workshop was 'Soil Fertility Degradation in sub-Saharan Africa: Leveraging Lasting Solutions to a Long-Term Problem'. The document summarises the conclusions reached at the workshop by the participants from the two CGIAR Centres and representatives of nine CGIAR donors. This material should provide useful background for the discussion on Combating Soil Fertility Degradation in Africa.

INTRODUCTION

Soil fertility degradation has been described as the single most important constraint to food security in sub-Saharan Africa (SSA). Despite proposals for a diversity of solutions and the investment of time and resources by a wide range of institutions it continues to prove a substantially intransigent problem. Three international agricultural research organizations, CIAT, TSBF and ICRAF organised a workshop hosted by the Rockefeller Foundation at their Bellagio Study and Conference Centre, to discuss the development of a strategic response to the problem of soil fertility degradation in SSA. A major rationale for the meeting was the perception that the soil fertility problem remains intractable because of the failure to deal with the issue in a sufficiently holistic way. Soil fertility decline is not a simple problem. In ecological parlance it is a 'slow variable', which interacts pervasively over time with a wide range of other biological and socio-economic constraints to sustainable agroecosystem management. It is not just a problem of nutrient deficiency but also of inappropriate germplasm and cropping system design, of interactions with pests and diseases, of the linkage between poverty and land degradation, of often perverse national and global policies with respect to incentives, and of institutional failures. Tackling soil fertility issues thus requires a long-term perspective and holistic approach of the kind embodied in the concept of Integrated Natural Resource Management (INRM) that is now driving the work of the CGIAR. This challenge also necessitates fresh inter-institutional approaches.

The following statement is a summary of the conclusions reached by the participants following presentations and discussion sessions that critically analysed the problem of soil fertility degradation, its root and proximate causes, its context within the broader agricultural system and actions of biological, social and economic nature needed to combat it.

THE PROBLEM

Poverty in SSA is largely a rural phenomenon: 85% of the poor reside in rural areas. By 2050, the rural population is still expected to exceed the urban population and without relative changes in poverty rates, the majority of the poor will continue to reside in rural areas. Agriculture is the principal economic sector upon which the rural population depends for their livelihoods and one of the most alarming aspects of rural poverty is the lack of food security.

Low agricultural production results in low income, poor nutrition, low consumption, poor education, poor health, vulnerability to risks, and lack of empowerment. The rural poor cannot expand land holdings because the frontier is limited and the availability of arable land has shrunk dramatically from 0.38 to 0.25 ha per capita over the past 20 years. The population is thus trapped in a vicious poverty cycle between land degradation, and the lack of resources or knowledge to generate adequate income and opportunities to overcome the degradation.

Intensification of agricultural production is required to meet the food and income needs of the poor, and this cannot occur without investment in soil fertility. Investing in soil fertility management is necessary to help households mitigate many of the characteristics of poverty, for example by improving the quantity and quality of food, income, and resilience of soil productive capacity.

Compared to other continents, a large proportion of soils in SSA has low inherent fertility and exhibits a variety of constraints, among them: nutrient deficiency, low organic matter, moisture stress, and high erodibility. Moisture stress is believed to affect over two thirds of all soils while each of the other constraints occur on not less than 20% of the soils. Inadequate management has exacerbated these problems to an alarming extent. Nutrients are commonly not replaced to the degree that they are removed in crop harvesting and other losses, resulting in high negative nutrient balances (e.g. net loss of over 100 kg N per hectare per year in south-western Kenya). It is also estimated that over 500 million hectares of land are physically degraded, due principally to water and wind erosion. These processes have led to the continent being characterised by declining per capita food production estimated at 150 kg/person to 130 kg/person over the past 35 years.

The effects of soil fertility degradation are not confined to the impact on agricultural production. The living system of the soil also provides a range of ecosystem services that are essential to the well-being of farmers and society as a whole. Degradation of the soil resource leads to:

- reduced vegetative cover;
- increased conversion of natural habitats,
- decreased water quality;
- lowered efficiency of use of water and management;
- increased risk from pests and diseases because of lowered biological control capacity, increased risk to human health for the same reason and because of lowered water quality;
- potential increases in the emission of greenhouse gases with consequent effects on climate;
- increased prevalence of catastrophic events such as landslides and floods.

Society as a whole will therefore benefit from investment in effective soil fertility management to correct and avoid these problems as well as the more immediate welfare gains for farmers which are expected to be high because:

1) yield gaps for most crops are very high, with potential yields 2-4 times higher than average actual yields;
2) grain yields for some crops have been falling owing to poor soil management;
3) Farmers in SSA apply the lowest recorded rates of nutrients - only 10% of those in the rest of the world; and
4) improved fertility will enhance nutrient and water use efficiency, reduce pest and disease incidence, and enable greater use of higher yielding varieties.

Farmers in SSA are attempting to improve soils, but their efforts are constrained by limited access to knowledge, low resource endowments, and lack of incentives. The high level of poverty lies at the heart of soil fertility degradation problem. Wealthier households, with more options available, are more likely to manage their soils better. Poor households lack knowledge of soil management options, the capacity to invest in soils (especially in fertilizer), and have less ability to bear risk and wait for future payoffs from investment. In Western Kenya, resource-poor households, in comparison to the wealthy, were found to make only 5% of the farm investments, had over twice the erosion rates, and obtained only 28% of maize yields. Tragically, these resource-poor households constitute about 90% of the population. Compounding the problem are poor price incentives, land and labour

constraints, and the weakness or complete lack of rural institutions for supporting information and other services.

PROGRESS AND ACHIEVEMENTS

The good news is that progress is being made. Soil fertility degradation takes place over a long time and recuperation of soil quality can be equally slow so that lasting impacts of improved management require long-term investment of time and resources. But the impacts of improved management on crop yields are often dramatic even in the short term. Significant achievements from agricultural research have been demonstrated in terms of improved livelihoods based on the development of soil management principles, and of methodological approaches to address the major causes driving poverty.

The impact of recommendations for soil management practices has been enhanced by the emergence of a consensus on guiding principles for Integrated Soil Fertility Management (ISFM). In essence, ISFM is the adoption of a holistic approach to research on soil fertility that embraces the full range of driving factors and consequences – biological, physical, chemical, social, economic and political – of soil degradation as described above. There is a strong emphasis in ISFM research on understanding and seeking to manage the processes that contribute to change. The emergence of this paradigm, very closely related to, and influenced by, the wider concepts of INRM represents a very significant step beyond the earlier, narrower, nutrient replenishment approach to soil fertility enhancement.

1. Stakeholders influenced and livelihoods improved:

Principles of ISFM have influenced diverse stakeholders in SSA to alter the ways they address soils and their management, at a variety of scales:

- ISFM approaches are increasingly used by national and international research and development organizations, networks, NGO's, and extension agencies working in SSA
- Significant adoption of a range of ISFM technologies has been documented across a number of countries in SSA:
    - integrated nutrient management;
    - micro-dose use of fertilisers;
    - improved manure management practices;
    - inter-cropping systems;
    - integration of multipurpose legumes;
    - improved fallows;
    - biomass transfer of high quality organic inputs.
- A substantial number of short term, degree-related, and on-the-job training activities, across the continent, have helped spread ISFM approaches at all national levels, including university curricula.

2. Soil management principles

International agricultural research has significantly contributed to the development of sound soil management principles that aim at sustainable crop production without compromising the ecosystem service functions of the soil. These include:

- Application of organic resources of animal or plant origin in combination with mineral inputs to maximize input use efficiencies and return to investments.
- Integration of cover crop and multiple purpose, woody and herbaceous legumes in existing cropping systems to increase the availability of organic resources and consequently to improve crop yields and farm profits.
- Enhancement of the soil organic carbon pool as an integrator of various soil-based functions related to production and ecosystem services.
- Improved sustainability of nutrient cycles through integration of livestock with arable production.
- Soil conservation methods to control soil loss and improve water capture and use efficiency

3. Methodological innovations

Due to the complex and interactive nature of the major factors driving poverty and acting at different scales, substantial progress has been made to develop approaches that encompass:

- Pro-poor participatory approaches that increase the appreciation and use of local knowledge systems in the development of improved soil management interventions and principles.
- Tools for scaling up improved soil management practices, from GIS tools to better characterise problems and target interventions, to better understanding of information flow pathways.
- Tools and approaches to integrate processes required for monitoring and evaluating ecosystem services acting at various scales.
- Rapid spectrometry techniques to distinguish various soil constraints and properties at plot, farm and landscape scales.
- Molecular tools to study soil biodiversity and pest population dynamics.

THE WAY FORWARD

Maintaining the progress

This progress has demonstrated that investing in farmer-centred soil fertility research is integral to successful rural development. Research has allowed us to better understand the diversity of conditions where existing ISFM options can benefit the rural poor. By taking a pro-poor approach, international agricultural research has developed the means to achieve large-scale impacts, responding to the demands of small-scale farmers for improved agricultural production and ecosystem services. Many ISFM options are locally profitable, even under intensely cultivated, land-scarce conditions. The knowledge-intensity and complexity of the ISFM approach, however, makes it difficult to translate local successes from one area to another, unless the factors favouring and constraining adoption are better understood.

Facilitating widespread use and impact of ISFM to solve SSA's soil fertility problems will thus require a tighter linkage and feedback between strategic and adaptive research activities. The iterative process of learning and problem solving builds on indigenous knowledge, improves imperfect technologies, and empowers farmers and institutions. Addressing farmers' problems in a systems context generates management options better suited to their local needs. It also produces policy options that are suited to local institutional realities.

Moving from a nutrient replenishment to a pro-poor approach to soil fertility management will allow local approaches to generate global benefits. The target for future research is to create a virtuous cycle (Figure 1), to empower farmers to sustainably manage their soils. To do so, research must increase the range of options available for managing poor soils in unfavourable social and economic environments. Increasing our understanding of where ISFM options are working, why, and for whom, will address the constraints limiting their wider use. The cost of not engaging in this research is likely to be enormous, in terms of greater poverty, stagnant and declining production, degraded ecosystem services, and the loss of intellectual property rights related to the local genetic resources of the soil.

Enhancing rural livelihoods through ISFM

The imperative of soil fertility degradation and the impetus of current success demand urgent and long-term commitment to a comprehensive programme of research and development actions. It is clear from the analysis above that these actions cover many disciplines, operate across multiple scales and are highly interactive in nature. A programme of work must build on and use methods that have already proved successful and also develop and borrow others where significant gaps in understanding or application occur. The following programme identifies a number of the actions that the workshop members agreed to be most important, organised under five headings:

1. Empowering farmers to scale up research and results.
2. Managing carbon and nutrient cycles for enhanced agricultural productivity.
3. Managing soils for enhanced ecosystem services.
4. Managing soil genetic resources for enhanced biodiversity and pest management.
5. Capacity building for ISFM research and development.

1. Empowering farmers to scale up research and results

There is overwhelming demand for ways by which existing knowledge and insights about ISFM can be applied over large areas and influence the livelihoods of millions of people. Research efforts to address poverty require a pro-poor approach that moves from plot to landscape and household to community scales. Actions to achieve these research goals include:

- Synthesise and disseminate information on options already adapted for use by different clients.
- Further diversify the range of management options available to small-scale farmers.
- Create greater understanding of the factors affecting the adoption processes for ISFM.
- Empower farmers by promoting collective action and building human and social capital.
- Identify and respond to policy constraints and options of specific concern to ISFM.
- Develop methods to define and measure impacts of scaling up, including research identifying emergent properties of higher scale systems such as market, pest-disease, and watershed function impacts.

2. Managing carbon and nutrient cycles for enhanced agricultural productivity

Substantial strategic information related to the appropriate management of carbon and nutrients has been obtained, as evidenced by the soil management principles summarized above. Translating this information into soil management practices relevant for and targeted at conditions experienced by farmers is a challenge that needs to be addressed to achieve large-scale implementation of ISFM practices. Actions to achieve this include:

- Optimise organic and mineral resource use at the farm level in terms of maximal returns to labour and soil amendments by taking into account existing within-farm soil fertility gradients.
- Identify niches for organic matter production within existing farming systems. The Mid-term Strategic document of the African Association for Biological Nitrogen

Fixation similarly recommends nesting legumes and associated biological N fixation within improved land management systems.

- Assess the various roles soil organic matter plays in maintaining production and ecosystem service-related soil properties and functions for various biophysical environments.
- Determine trade-offs between the use of organic resources and soil carbon for agricultural productivity and their value for carbon sequestration potential and other ecosystem properties.

3. Managing soils for enhanced ecosystem services

Soils provide a wide range of ecosystem services that are essential for the well being of agriculture, small-holder farmers, rural communities and society as a whole. These ecosystem services include regulation of nutrient and hydrological cycles, maintenance of the utilitarian functions of biodiversity (medicinals, food, fibre, etc.) and participation in C sequestration processes. Maintaining ecosystem integrity is needed for effective delivery of these services. Therefore, it is important to:

- Develop a methodological approach that integrates plot and watershed-level information related to the target ecosystem services (water quality and quantity, nutrient balance and erosion control, integrated global warming potential).
- Design and test management options to enhance soil-related ecosystem services within food secure land management systems.
- Develop monitoring systems to evaluate the impacts of ISFM options on ecosystem services beyond production.
- Valorise ecosystem services, with initial focus on C sequestration, soil conservation, and water quality, for trade-off analysis and policy recommendations.
- Define an appropriate policy and institutional environment that provides incentives to landholders that manage these services sustainably.

4. Managing the genetic resources of soil for enhanced productivity and plant health

The soil biota constitute a major fraction of global terrestrial biodiversity and are responsible for key ecosystem functions such as decomposition; nutrient acquisition, storage and cycling; soil organic matter synthesis and mineralization; soil structural modification; regulation of atmospheric composition; and the biological control of soil-borne pests and diseases . Research on the biological processes of soil lags behind those related to physical and chemical management and so these functions remain largely under-exploited by humans for services and products in agriculture.

Recent advances in the understanding of soil ecology and in molecular methods for the study of soil have however started to reverse this situation. New methods using gene micro-arrays, DNA profiling, DNA and RNA sequencing, and fatty acid analysis constitute powerful approaches to understand the relationship between soil microbial communities and biogeochemical processes, equivalent to the genomic revolution in crop improvement. A programme of strategic research is required to realise this potential but a specific area likely to yield high impact in the short to medium term is the exploitation of the interactions between pest management and soil fertility.

- Develop cultural and bio-control practices to manage the interactions of soil fertility with plant vigour, and the reduction of plant pest inoculum.
- Develop quantitative techniques for monitoring and manipulating key functional groups of soil biota and their relationship to ecosystem service functions and plant health.
- Develop and validate management practices for key groups of beneficial soil organisms for small-scale farms.

- Link local knowledge about biological indicators of soil quality with scientific knowledge to develop robust soil quality monitoring systems that combine precision and relevance.

5. Capacity Building for ISFM research and development.

The capacity for ISFM research in SSA is insufficient both in terms of the numbers of professional personnel and the essential laboratory facilities. ISFM is a knowledge intensive approach to soil management. Professional staff and students alike suffer from isolation and lack of access to up-to-date educational opportunities. Networks run by sub-Regional Organisations (SROs) and CGIAR Centres, such as the TSBF African Network for Soil Biology and Fertility (AfNet), the Rockefeller Soil FertNet and the newly formed SWMNet of ASARECA, provide a vehicle of opportunity to correct this situation. Priority actions include:

- Strengthen networking to engage a wide range of stakeholders and enhance the efficiency of ISFM research.
- In particular, strengthen links between research and extension (including NGOs) using a "learning by doing" approach, which includes local knowledge and builds on existing networks.
- Develop strategic partnerships in capacity building that identify and utilise the range of comparative expertise.
- Improve the dissemination of knowledge on ISFM through a wide range of methods including electronic sharing and training of trainers.
- Promote programmatic linkages with universities and other educational institutions to strengthen curricula with appropriate and up-to-date information and teaching materials.
- Raise awareness of ISFM issues with policy and decision makers at all levels.