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Integration of local soil knowledge for improved soil management strategies

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Abstract

The increasing attention paid to local soil knowledge in recent years is the result of a greater recognition that the knowledge of people who have been interacting with their soils for a long time can offer many insights into the sustainable management of tropical soils. A participatory approach in the form of a methodological guide has been developed and used in Latin America and the Caribbean (Honduras, Nicaragua, Colombia, Peru, Venezuela, Dominican Republic) and Africa (Uganda, Tanzania) in order to identify and classify local indicators of soil quality related to permanent and modifiable soil properties. This methodological tool aims to empower local communities to better manage their soil resource through better decision making and local monitoring of their environment. It is also designed to steer soil management towards developing practical solutions to identified soil constrains, as well as, to monitor the impact of management strategies implemented to address such constraints. The methodological approach presented here constitutes one tool to capture local demands and perceptions of soil constraints as an essential guide to relevant research and development activities. A considerable component of this approach involves the improvement of the communication between the technical officers and farmers and *vice versa* by jointly constructing an effective communication channel. The participatory process used is shown to have considerable potential in facilitating farmer consensus about which soil related constraints should be tackled first. Consensus building is presented as an important step prior to collective action by farming communities resulting in the adoption of improved soil management strategies at the landscape scale.

Keywords: Africa, collective action, landscape, local knowledge systems, Latin America, participatory methodologies

Introduction

A considerable proportion of soil degradation induced by human-related activities is a result of deforestation, overgrazing and improper agricultural practices. Eighty five percent (85%) of agricultural land is estimated to be degraded to some extent (Oldeman and van Lynden, 1997). The mounting evidence of land degradation induced by agriculture is resulting in a gradual shift from a high input agriculture paradigm, based on overcoming soil constraints to fit plant requirements by amending soils with fertilizers, lime, biocides and tillage, to a paradigm with more reliance on biological processes (Sanchez, 1994). This paradigm invokes a more ecological approach based on the adaptation of germplasm to adverse conditions, the enhancement of biological activity of the soil and the optimization of nutrient cycling to minimize external inputs and maximize the efficiency of their use. This new paradigm focuses on the need to improve agricultural production in more benign ways compared with traditional agricultural improvement that is based on high inputs with subsequent detrimental environmental impacts that result in soil degradation. Nevertheless, while this paradigm shift is a good sign its beneficial impact, in terms of improved soil management options for healthier landscapes, will be limited if there is little adoption by local land managers.

The limited adoption of new technology and new cropping systems has been often attributed to local inertia rather than the failure to take into account the local experience and needs (Warren, 1991). According to Walker et al. (1995), increased application of indigenous knowledge to rural research and development can be attributed to the need to improve the targeting of research to address client needs and thus increase adoption of technological recommendations derived from research. The complementary role that indigenous knowledge plays to scientific knowledge in agriculture has been increasingly acknowledged (Sandor and Furbee, 1996). Experimental research is an important way to improve the information upon which farmers make decisions. It is questionable, however, if relying on experimental scientific methodology alone is the most efficient way to fill gaps in current understanding about the sustainable management of agroecosystems. There has been limited success of imported concepts and scientific interpretation of tropical soils in bringing desired changes in tropical agriculture. This has led an increasing recognition that local soil knowledge can offer many insights about managing tropical soils sustainably (Hecht, 1990).

Local knowledge related to agriculture can be defined as the indigenous skills, knowledge and technology accumulated by local people derived from their direct interaction with the environment (Altieri, 1990). Transfer of information from generation to generation undergoes successive refinement leading to a system of understanding of natural resources and relevant ecological processes (Pawluk et al., 1992). Nevertheless, although benefits of local knowledge include high local relevance and potential sensitivity to complex environmental interactions, without scientific input local definitions can sometimes be inaccurate and unable to cope with environmental change. It is thus argued that research efforts should further explore a suitable balance between scientific precision and local relevance resulting in an improved knowledge base as indicated by Barrios and Trejo (2001). Furthermore, this approach would overcome the limitations of site specificity and the empirical nature of local knowledge and would allow knowledge extrapolation through space and time as suggested by Cook et al. (1998).

A participatory approach for integration of local and technical knowledge systems

A common language is required to link local and technical knowledge about soils and their management so that acceptable, cost-effective strategies for improved soil management can be developed. For this purpose a methodological guide has been developed and used in Latin America and the Caribbean (Trejo et al., 1999) and Africa (Barrios et al., 2001) in order to help stakeholders identify and classify local indicators of soil quality (ISQ) related to permanent and modifiable soil properties as this is the first step in the development of local soil quality monitoring systems (Fig.1).

Selecting a suitable set of ISQ, and developing its use as a monitoring system (Soil Quality Monitoring System, SQMS), can be captured in the following figure (modified from Beare et al., 1997):

Suitable ISQ are identified from the local and technical knowledge base and critical levels defined. This phase is followed by the definition of guidelines to establish a Soil Quality Monitoring System (SQMS) along with interpretation information as well as reaching an agreement about the suitable ISQ for the relevant conditions. User feedback is very important at this stage as it will provide the grounds for acceptance of the SQMS for soil quality diagnosis and monitoring. Once the SQMS is fully accepted by users it becomes part of the Decision Support System for Natural Resource Management

This methodological guide is mainly focused on the first phase of this process; i.e.: identifying soil quality indicators that can be used by farmers, extension officers, NGO's, technicians, researchers and educators.

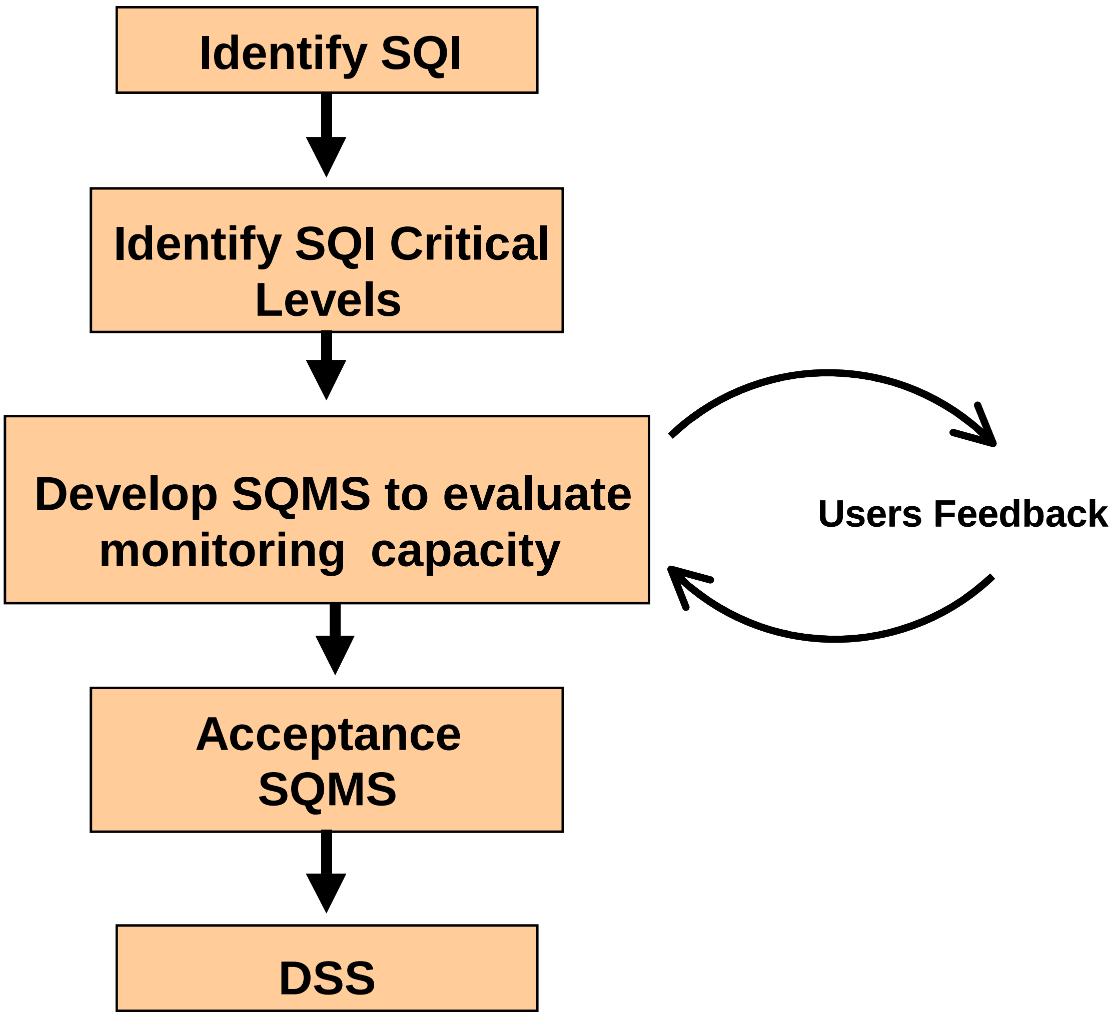

Fig. 1 Process leading to the development of Soil Quality Monitoring Systems

The ISQ will help in identifying the main soil biophysical limitations of the agricultural system under study. The most sensitive and robust ISQs selected for the soil constraints identified can then be incorporated into a Soil Quality Monitoring System (SQMS), and should include basic parameters such as bulk density, pH, effective rooting depth, water content, soil temperature, total C and electrical conductivity (Doran and Parkin, 1994). Since our objective is to develop a SQMS for the land users, local indicators of soil quality must be included in the monitoring system. The mix of native and scientific parameters varies according to the monitoring objectives; e.g.: if they are farmers, extension agents or policies makers. It is likely that integrative ISQ might be more useful to land users, than a measurement, for example, soil available P, since many indicators used by the farmers are also of the integrative type; for instance, soil color, soil structure, crop yield, presence of specific weed species. Attention should be paid to the inclusion of indicators that can be used while progressively increasing the scale at which results are applied (e.g. from plot to field and farm level, up to watershed, region and nation level). Some examples of such indicators might be crop yield and yield trends, land cover, land use intensity and nutrient balances (Pieri et al., 1995). More recently, Defoer and Budelman (2000) have proposed the use of resource and nutrient flows at farm scale to assess land use sustainability and local variation usually missed in studies at higher levels of aggregation (i.e. region, country).

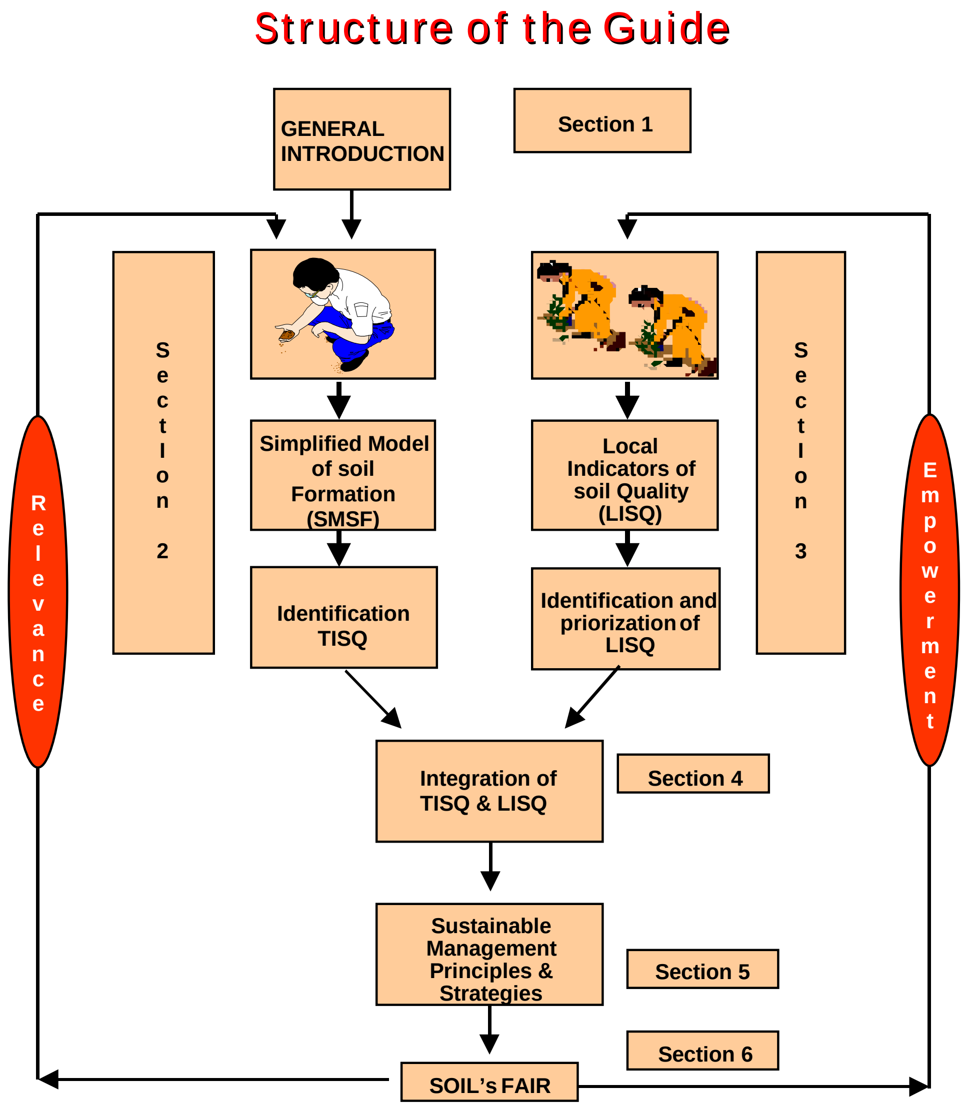

Fig. 2 Structure of the Methodological Guide

The methodological approach proposed by Trejo et al. (1999) and Barrios et al. (2001) rests on the belief that in order for sustainable management of the soil resource to take place, it has to be a result of improved capacities of the local communities to better understand agroecosystem functioning. Improved capacities by technical officers (extension agents, NGO's, researchers) to understand the importance of local knowledge is also part of the methodology. Therefore, after identifying if there is poor or a lack of adequate communication between the technical officers and the local farm community as a major constraint to capacity building, the methodology proposed deals with ways of jointly generating a common knowledge that is well understood by both interest groups. The structure of the guide is shown in Fig.2 shows the different sections of the methodological guide for Africa.

This methodological guide is made up of six sections: Section 1 provides a general introduction about the management of the soil resource in the African context and the ISQ. Section 2 presents a technical conception of the soil through a Simplified Model of Soil Formation (SMSF) based on Jenny's seminal work (Jenny, 1941; 1980) in order to bring participants to a common starting point.

Table 1. Integration of LISQ identified and ranked by farmers of Jalapa village, Yoro, Honduras with TISQ and their association with permanent or modifiable soil properties.

Ranking[a/]	Knowledge integration		Property	
	Technical	Local	P[b/]	M[c/]
1	Effective soil depth	Thick soil layer/thin soil layer	X	
2	Soil fertility	'Opulento', no need of chemical fertilizer/ needs fertilization		X
3	Biological activity	Presence of earthworms/ lack of earthworms		X
4	Slope	Soils with gentle slopes, uniform/ soils with high slopes	X	
5	Structure	Soil macroaggregates can be broken into pieces, lose soil/ Macroaggregates can not be broken, tied soil	X	
6	Texture / water holding capacity	Soil keeps water for longer time/ soil does not keep water	X	
7	Soil burning	No burnings have occurred in the last 5 years/ Lands have been burned in the last 5 years		X
8	Color	Black / various soil colors	X	
9	Texture / infiltration	Fast water absorption/ slow water absorption	X	
10	Texture	Loamy soils, little clay/ 'Barrialosa' or "muddy", sandy	X	
11	Indicator plants	'Zaléa', 'Chichiguaste'/ 'Chichiguaste' does not grow, weeds do not develop, 'zacate de gallina'		X
12	Physical barriers	Easy tillage/ difficult tillage, 'Tronconosa'	X	
13	Productivity	Greater yields/ Lower yields, more work to produce		X
14	Stoniness	No stones present / 'Balastrosa', stony, gravely	X	
15	Drainage	Soil does not flood, no 'aguachina'/ 'aguachina', soil sweats	X	
16	Erosion	Non washed soils/ washed soils	X	

a/ Degree of importance given by farmers
b/ P: permanent property
c/ M: modifiable property

It also introduces the technical indicators of soil quality (TISQ) with the participation of professionals from National Research and Extension Organizations (NARES), NGO's, universities and International Agricultural Research Centers. Section 3 deals with participatory techniques that help gather, organize and classify local indicators of soil quality (LISQ) through consensus building and this is conducted with local farming communities. The process to elicit information about local indicators of soil quality starts with a brainstorming session guided by trainers where local farmers explain, in their own words, how they define and classify the quality of their soils. Once local indicators have been collected a ranking session is initiated where the original group of farmers is split into smaller groups of 3 or 4 in order to carry out several ranking exercises for the same information and thus obtain a more representative mean value. All results obtained from each group conducting the ranking exercise are put together in a ranking matrix where rows represent all local indicators identified during brainstorming and the columns represent the ranking assigned by different small groups of farmers.

Results to date indicate that biological indicators like native flora and soil macrofauna are important components of local indicators of soil quality. This is not surprising as biological indicators have the potential to capture subtle changes in soil quality because of their integrative nature. They simultaneously reflect changes in the physical, chemical and biological characteristics of the soil. There is considerable scope, therefore, to further explore the use of local knowledge about biological indicators of soil quality and as a tool guiding soil management decisions.

Section 4 provides a methodology to construct an effective channel of communication by finding correspondence between TISQ and LISQ which permit a better Extension/NGO officier, NGO – farmer communication. This is carried out in a plennary session exercise of integration where the most important local indicators of soil quality are analyzed in the context of technical knowledge and are classified into indicators of permanent or modifiable soil properties (Table 2). The classification of local indicators into permanent and modifiable factors provides a useful division that helps to focus on those where improved management could have the greatest impact. This strategy is particularly sound when there is considerable need to produce tangible results in a relatively short time in order to maintain farmer interest as well as to develop the credibility and trust needed for wider adoption of alternative soil management practices.

Although some local indicators can be rather general like fertility, slope, productivity and age under fallow, other local indicators are more specific. For instance, plant species growing in fallows, soil depth, color, water holding capacity and predominant soil particle sizes provide indicators that can be easily integrated with technical indicators of soil quality.

Section 5 is concerned with management principles behind potential strategies to address constraints modifiable in the short (< 2 yrs), medium (2-6 yrs) and long (> 6 yrs) term (Fig. 3).

Modifiable constraints are those that can be overcome through management. Examples include low nutrient and water availability, low and high pH, soil compaction and low soil organic matter content. The discrimination between short, medium and long term is necessary to enable ranking of management strategies, which is mainly dictated by resource endowment.

Section 6 is devoted to the Soils Fair which is designed to help farmers develop skills to characterize relevant physical, chemical and biological properties of their soils through simple methods that can then be related to their local knowledge about soil management. Here farmers and scientists communicate through a commonly developed language and simple demonstrations on how to measure soil quality *in situ* to solve local soil management and land degradation problems.

The result of this two-way exchange process is that it has a positive impact on the technical knowledge by nurturing it with local perceptions and demands. Positive impacts are also envisioned on the local knowledge base as it provides with a way for this tacit knowledge to be widely understood, assessed and utilized. Besides, local communities will be empowered by the joint ownership of the technical-local soil knowledge base constructed during this process.

The two-way improvement of communication channels will likely improve the communication of farmer's perceptions to extension agents and researchers as well as make recommendations by extension agents and NGOs better understood by the farmer community. Better communication opens opportunities for established and/or emerging local organizations to use this methodological approach for consensus building that precede collective actions resulting in the adoption of improved soil management strategies at the landscape scale.

This methodological guide aims to empower local communities to better manage their soil resource through better decision making and local monitoring of their environment. It is also designed to steer management towards solutions to the soil constrains identified as well as to monitor the impact of management strategies implemented to address such constraints.

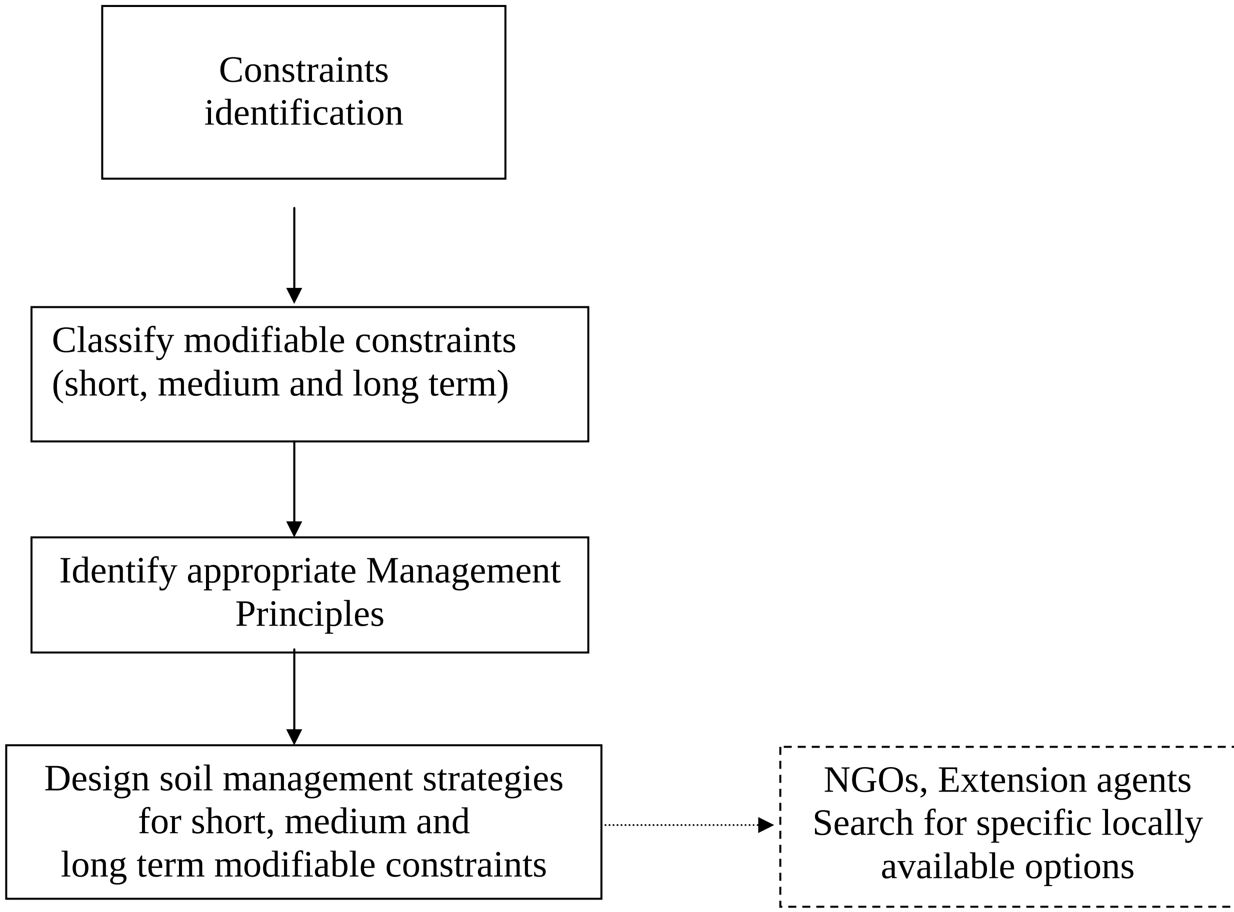

Fig. 3 Process leading to improved soil management strategies

The approach summarized in the preceeding sections provides the tools to conduct a technical-local classification of the soil, based on modifiable and permanent soil properties, which has the flexibility to work in the spatial scale continuum plot/farm/landscape (watershed) while also having the potential to take the stakeholder groups and gender issues dimensions into consideration. This guide then provides a valuable tool to evaluate the impact of the land use change across various spatial scales and social actors.

Finally, participants in the training event associated with the guide are encouraged to develop "action plans". These action plans show the institutional commitment made by participants to apply the guide and gained insights in their own work plans and environments. To date more than 23 action plans have been initiated in Latin America and Africa. Follow up of these action plans in the coming years will provide a measure of the impact of this participatory approach in better natural resource management through improved soil management strategies.

Conclusions

Current estimates of degradation of the soil resource indicate that we cannot afford to adopt a grow-now and-clean-up-later approach to development. Farmers need early warning signals and monitoring tools to help them assess the status of their soils, since by the time degradation is visible because of unsuitable management, it is either too late of too expensive to revert it. The costs of preventing soil degradation are several times less than costs of remedial actions.

More often than not technical solutions to soil degradation abound but are often left on the scientist shelves because they are developed without the participation of the land user or do not build on local knowledge of soil management. Participatory approaches involving group dynamics and consensus building are likely to be key to adoption of improved soil management strategies beyond the farm-plot scale to the landscape scale through the required collective action process. Action plans developed by local actors as a result of consensus building and new insights derived from the training exercise become a vehicle by which profitable and resource conserving land management is locally promoted and widely adopted. Taking adavantage of the complementary nature of local and scientific knowledge is highlighted as an overall strategy for sustainable soil management.

The development of this methodological guide has been a good example of 'South – South' cooperation where experiences from Latin America were brought and adapted to the African context, and feedback from Africa has helped further improvement of the Latin American guide.

Acknowledgement

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References

Altieri, M.A., 1990. Why study traditional agriculture?. In C.R Carrol., J.H. Vandermeer and P. Rosset (Eds.), Agroecology. McGraw-Hill, New York, N.Y., pp. 551-564

Barrios E., Bekunda M., Delve R., Esilaba A. and Mowo J. 2001. Identifying and classifying local indicators of soil quality. Eastern Africa Version. Participatory Methods for Decision Making in Natural Resource Management. CIAT-SWNM- TSBF-AHI.

Barrios E. and Trejo M.T. 2001. Implications of local soil knowledge for integrated soil fertility management in Latin America. Geoderma (in press).

Beare M.H., Cameron K.C., Williams P.H. and Doscher C. 1997. Soil Quality Monitoring for Sustainable Agriculture. Proc. 50th New Zealand Plant Protection Conference. N.Z. Plant Protection Society. Pp. 520-528.

Cook S.E., Adams M.L., Corner R.J., 1998. On-farm experiments to determine site-specific response to variable inputs. In P.C. Robert (Ed.), Fourth International Conference on Precision Agriculture. St. Paul, Minnesota: ASA/CSSA/SSSA, ASPRS, PPI.

Defoer T., Budelman A. (Eds.), 2000. Managing Soil Fertility in the Tropics. A Resource Guide for Participatory Learning and Action Research. KIT Publishers, The Netherlands.

Doran J.W. and Parkin T.B. 1994. Defining and assessing Soil Quality. In Doran J.W., Coleman D.C., Bezdicek D.F. and Stewart B.A. (Eds.), Defining Soil Quality for a Sustainable Environment. Soil Science Society of America Special Pub. 35. Madison, Wisconsin. Pp. 3-21.

Hecht S.B. 1990. Indigenous soil management in the Latin American tropics: Neglected knowledge of native peoples. Pp. 151-157 in Altieri M.A. and Hecht S.B. (eds.) Agroecology and small farm development. CRC, PressBoca Raton, Fl, USA.

Jenny H., 1941. Factors of Soil Formation. McGraw-Hill Book Co., New York.

Jenny H., 1980. The Soil Resource: Origin and Behavior. Springer-Verlag, New York

Oldeman L.R. and Van Lyden G.W.J. 1997. Revisiting the Glasod methodology. In: Lal R., Blum W.H., Valentine C. and Stewart B.A. (Eds.), Methods for assessment of soil degradation. Advances in Soil Science. CRC Press, NY. Pp. 423-458

Pawluk R.R., Sandor J.A., Tabor J.A., 1992. The role of indigenous soil knowledge in agricultural development. Journal of Soil and Water Conservation 47(4), 298-302.

Pieri C., Dumanski J., Hamblin A. and Young A. 1995. Land Quality Indicators. World Bank Discussion Paper 315. The World Bank, Washington, DC.

Sánchez P.A. 1994. Tropical soil fertility research: Towards the second paradigm. 15th World Congress of Soil Science, Vol. 1:65-88. Acapulco, Mexico.

Sandor J.A., Furbee L., 1996. Indigenous knowledge and classification of soils in the Andes of southern Peru. Soil Science Society of America Journal 60, 1502-1512.

Trejo M.T., Barrios E., Turcios W. and Barreto H. (1999) Método Participativo para identificar y clasificar Indicadores Locales de Calidad del Suelo a nivel de Microcuenca. Instrumentos Metodológicos para la Toma de Decisiones en el Manejo de los Recursos Naturales. CIAT-CIID-BID-COSUDE.

Walker D.H., Sinclair F.L. and Thapa B. (1995) Incorporation of indigenous knowledge and perspectives in agroforestry development. Part I: Review of methods and their application. Agroforestry Systems 30: 235-248.

Warren D.M. (1991) Using indigenous knowledge in agricultural development. Discussion paper no.127. The World Bank, Washington DC.

The TSBF African Network for Soil Biology and Fertility (AfNet)

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AfNet is the single most important implementing agency of TSBF in Africa. Its main goal is to strengthen and sustain stakeholder capacity to generate, share and apply soil fertility and biology management knowledge and skills to contribute to the welfare of farming communities. It is a mechanism to facilitate and promote collaboration in research and development among scientists in Africa for the purpose of developing innovative and practical resource management interventions for sustainable food production. AfNet has membership from National Agricultural Research and Extension Services (NARES) and Universities from various disciplines mainly soil science, social science, agronomy and technology exchange.

Network collaborative trials in East and Southern Africa, 2002

Tanzania - NSS, Mlingano

- Nitrogen fertilizer equivalencies based on organic input quality; NSS, Mlingano, Tanga managed by S. Ikerra and A. Marandu
- Optimum combinations of organic and inorganic N sources managed by S. Ikerra and A. Marandu

Zimbabwe - University of Zimbabwe

- Base nutrient dynamics and productivity of sandy soils under maize-pigeon pea rotational systems managed by P. Mapfumo and F. Mtambanengwe

Zambia - Mt Makulu Research Station, Chilanga

- Nitrogen fertilizer equivalencies based on organic input quality managed by M. Mwale
- Optimum combinations of organic and inorganic N sources managed by M Mwale

Kenya

- Nitrogen fertilizer equivalencies based on organic input quality managed by P. Mutuo and J.Kimetu in Maseno, Western Kenya and Central Kenya
- Maintenance of soil P with small applications of organic and inorganic sources managed by J Kinyangi and P Mutuo in Maseno, Western Kenya and Central Kenya
- Residual effects following different rates of phosphorus application managed by P Mutuo in Maseno, Western Kenya
- Hedgerow intercropping managed by D. Mugendi at KARI, Embu
- Assessment of the adoption potential of soil fertility improvement technologies managed by D. Mugendi and R. Kangai in Chuka, Embu
- Enhancement of soil productivity using low-cost inputs managed in Central Kenya by D. Mugendi and M. Mucheru
- Nutrient management by use of agroforestry trees for improved soil productivity managed by D. Mugendi and Kinyua in Central, Kenya.

Network collaborative trials in West Africa, 2002

Burkina Faso

Trials managed by Vincent Bado in various sites:

- Long-term cropping systems and integrated soil fertility management in Kouare and Farakoba.

- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients in the Rice-based cropping systems at Kou Valley and also in the maize cropping system in Farakoba.

Côte d'Ivoire

Trials managed by Yao Tano in Lamto site:

- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients
- Nutrient use efficiency in legume and cereal rotation systems.

Ghana

Trials managed by E. Yebaoh in Kumasi site:

- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients
- Nutrient use efficiency in legume and cereal rotation systems.

Mali

- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients managed by M. Bagoyoko at Niono site.
- Monitoring nutrient budget managed by R. Tabo and M. Bagoyoko in both Koulikoro and Fana sites.
- Biological nitrogen fixation managed by R. Tabo and M. Bagoyoko in both Koulikoro and Fana sites.
- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients managed by R. Tabo and M. Bagoyoko in both Koulikoro and Fana sites.

Niger

Trials managed by Aboudoulaye and Manamane in various sites:

- Long-term operational scale research in Sadore site
- Long-term cropping system in Sadore site
- Long-term crop residue management in Sadore site.
- On-farm evaluation of soil fertility restoration technologies in Sadore, Karabedji, Gobery and Gaya sites.
- Methods of P and manure application in Sadore and Karabedji sites.
- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients in Banizoumbou, Karabedji, Gobery and Gaya sites.
- Monitoring nutrient budget in Banizoumbou site.
- Biological nitrogen fixation in Banizoumbou site.
- Coral experiment in Sadore site.

Nigeria

- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients managed by Emmanuel Iwuafo in Zaria site.
- Nutrient use efficiency in legume cereals rotation systems managed by Emmanuel Iwuafo in Zaria site.
- Biological nitrogen fixation managed by Abdou and Abdoulaye in Mirijibur IITA Research Station.
- Monitoring nutrient budget managed by Abdou and Abdoulaye in Mirijibur IITA Research Station.

Togo

- Fertilizer equivalency and optimum combination of low quality organic and inorganic plant nutrients managed by Tossah in Davie site.
- Nutrient use efficiency in legume cereals rotation systems managed by Tossah in Davie site.

Results: Long-term soil fertility management trials

Long-term management of phosphorus, nitrogen, crop residue, soil tillage and crop rotation in the Sahel
Since 1986 a long-term soil fertility management was established by ICRISAT Sahelian Center to study the sustainability of pearl millet based cropping systems in relation to management of N, P, and crop residue, rotation of cereal with cowpea and soil tillage. The traditional farmers' practices yields 146 kg/ha of pearl millet grain whereas with application of 13 kg P/ha, 30 kg N/ha and crop residue in pearl millet following cowpea yielded 1866 kg/ha of pearl millet grain. These results clearly indicate the high potential to increase the staple pearl millet yields in the very poor Sahelian soils.

Maintenance of soil fertility under continuous cropping in maize–bean rotation
The Kabete long-term trial was started by KARI at the National Agricultural Laboratories site, on a humic Nitisol in 1976. The objective of the trial was to find appropriate methods for maintaining and improving the productivity of soil through the use of inorganic N and P fertilizers, farmyard manures and crop residues under maize-bean rotation practices that are common to small-scale farmers. In 2001, samples were collected from key treatments to study P dynamics and to examine the effects of the different treatments on P pools and P availability. The results will be given in the next progress report.

Long-term management of manure, crop residues and fertilizers in different cropping systems
Since 1993 a factorial experiment was initiated at the research station of ICRISAT Sahelian Center at Sadore, Niger. The first factor was three levels of fertilizers (0, 4.4 kg P + 15 kg N/ha, 13kg P + 45 kg N/ha), the second factor was crop residue applied at (300, 900 and 2700 kg/ha) and the third factor was manure applied at (300, 900 and 2700 kg/ha). The cropping systems are continuous pearl millet, pearl millet in rotation with cowpea and pearl millet in association with cowpea. The analysis of variance data indicate that fertilizer; crop residue and manure application resulted in a highly significant effect of both pearl millet grain and total dry matter yields. Fertilizer alone account for 34% in the total variation of the dry matter whereas manure account for 18%. Although some interactions are significant they account for les than 3% in the total variation.

For pearl millet grain, the application fertilizer, manure, crop residue and cropping systems alone account for 66% of the total variation. The farmer's practices yield 236 kg/ha; the application of 13 kg P and 45 kg N/ha yielded 800 kg/ha but when these mineral fertilizers are combined with 2.7 t/ha of manure or crop residue in rotation with cowpea, yield of 1500 kg/ha can be achieved.

The N and P fertilizer value of manure and crop residue is 27 and 13 respectively and the N and P equivalency of manure is 113% and 153% for crop residue. The high values of fertilizers equivalency of manure and crop residue over 100% suggest that the organic amendment have beneficial roles other than the addition of plant nutrient such as addition of micronutrients and better water holding capacity. In addition, the release of nutrient with mineralization over time can match more the plant demand and this will result in higher nutrient use efficiency from the organic amendments. It is also well established that the application of organic amendments can reduce the capacity of the soil to fix P and then increase P availability to plant.

Results: Optimum combination of organic and inorganic sources of nutrients

Although the combined application of organic resources and mineral inputs forms the technical backbone of the Integrated Soil Fertility Management approach, procuring a sufficient amount of organic matter of a desired quality is very often a problem farmers are facing. While high quality organic resources (high %N, low %lignin and polyphenols) are known to behave as fertilizers through fast mineralization of their tissue N, lower quality organic resources are often more abundant on farmers' fields. Examples of such lower quality resources are crop residues or farmyard manure.

Sole application of low quality organic resources may lead to N immobilization and reduced crop growth. Consequently, mineral N is required to overcome the demand for N by the microbial decomposer community and to supply N to the crop. While preliminary evidence shows that high quality resources rarely cause immobilization of mineral N, low quality organic resources may lead to immobilization of fertilizer N. Depending on whether this immobilization phase lasts or not, decreased or enhanced crop yields may be the result. In the case of long-term immobilization, residual effects may be more relevant rather than immediate N supply to the crop.

In 2002, network experiments were conducted at 7 benchmark locations across 7 countries to investigate the nitrogen and phosphorus contribution of different low quality organic materials that are available for direct use by farmers.

Soils in the Sahel are acidic and inherently low in nutrients with ECEC of less than 1 cmol/kg for all the sites except Gaya where the organic carbon is slightly higher and an ECEC of 1.3 cmol/kg. The data on phosphorus sorption isotherm clearly indicated that most of the soils have very low capacity to fix P due to their sandy nature.

As manure was used in most of the trials in combination with mineral fertilizer, a systematic chemical characterization of the manure used at the different sites was undertaken. These analysis will be used to determine the fertilizer equivalencies of different manure sources for nitrogen and phosphorus. The nitrogen and phosphorus levels in the manure were very low and varied from 0.47% to 0.71% and the P levels varied from 0.08% to 0.38%.

Site 1: Banizoumbou, Niger

Interaction of N, P and manure.

A factorial experiment of manure (0, 2 and 4 t/ha), nitrogen (0, 30 and 60 kg N/ha) and phosphorus (0, 6.5 and 13 kg P/ha) was established in Banizoumbou to assess the fertilizer equivalency of manure for N and P. The data show a very significant effect of N, P and manure on pearl millet yield. Whereas P alone accounted for 60% of the total variation, nitrogen accounted for less than 5% in the total variation indicating that P is the most limiting factors at this site. Manure account for 8% in the total variation.

Biological nitrogen fixation.

15N dilution technique was used to quantify the biological nitrogen fixation of three cowpea varieties (local, TN5-78 and Dan illa) under different soil fertility conditions. A non-fixing (NF) cowpea variety was used as non-fixing crop. The samples have been sent to the International Atomic Energy Agency in Vienna, Austria for mass spectrophotometer analysis of 15N in order to assess the biological nitrogen fixation.

Combining organic and inorganic plant nutrients for cowpea production

The data clearly indicate the comparative advantage to combine organic and inorganic plant nutrients for the low suffering soils in the Sahel. The use of only organic P sources yield 5000 t/ha of cowpea fodder whereas the application in the organic farm gave 5718 t/ha.

Site 2: Maseno, Western Kenya.

An integrated nutrient management experiment at maseno was established in the highlands of Western Kenya on a nitisol at an elevation of 1420 m ASL and receiving an annual rainfall of about 1800mm distributed over two growing seasons. Farmyard manure (quality parameters) was used as the low quality organic resource and was integrated with 0, 30, 60 and 90 kg N ha^{-1}. Since this was a poor season, the overall grain yield and subsequent response to N was poor. However at 0-30 N levels, treatments integrated with organics consistently yielded higher than urea-N. These differences declined beyond 30N. In contrast, these manures appeared to be effective in overcoming P deficiency that is widespread on farms in Western Kenya.

Site 3: Kogoni, Mali

The experiment was conducted in collaboration with the Institut d' Economic Rurale (IER), Mali at the research station in Niono. The site was located at Kogoni in the rice-growing region. Low quality manures derived from livestock fed predominantly rice residues were used in combination with urea-N at 0, 30, 60, 90 and 120kg ha-1. The data show rice yield response to N in the presence or absence these manures. Application of 90-120 kg N gave the highest paddy yield (approx 7.5 t ha^{-1}) thereby doubling yield over the control. Integration with manure did not significantly increase the rice yields at any N levels; rather there was a slight additive effect of applying the low quality material.

Site 4: Farakou Ba, Kou Valley, Burkina Faso

In Burkina Faso, trials were conducted at the Kou valley research station in collaboration with the INERA. The low quality organic input was manure (<1.0%N). The test crop was irrigated rice. The manure applied at 1, 2, 3 and 4 tons dry matter per hectare was combined with urea-N at 0, 40, 80 and 120 Kg N ha^{-1}. The data show rice yield response to urea-N alone or in combination with organic matter at 4 levels. Applications of N alone doubled rice grain yield over the unfertilized control. There was an additive increase when organic matter was integrated with inorganic-N at all manure levels, however this increase was not significant.

Site 5: Zaria, Nigeria

The experiments at Zaria are conducted in collaboration with Ahmadou Bello University. The site is located adjacent to the Danayamaka village to the North of Zaria within the Guinean zone. Low quality manure that is typical of farmer organic resource input was used. The manure applied at 1, 2, 3 and 4 t dm ha-1 was combined with 0, 30, 60 and 90 kg N ha-1 in a split plot design arrangement where the main plots were treated with N at 4 levels and the sub-plots received manure inputs at 4 levels. The data show the yield obtained with sole applications of urea-N (response curve) or urea-N in combination with organic manure inputs. At this site, additive effects of manure and fertilizer combinations were not significant indicating that these manures contributed little to the N demand for the maize crop. In addition, the data show that these low quality manures can contribute significantly to overcome P deficiency to maize crop.

Site 6: Kumasi, Ghana

The Soils And Fertilizer Research Institute was the implementing partner for the network experiments in Ghana. The benchmark site was located within the humid forest zone north of Kumasi. The trial was arranged as a randomized block design on a uniform site that was recently cleared. Low quality maize stover and giant panicum grass were tested as possible organic resources that can be combined with mineral fertilizers for soil fertility improvements. However, the giant panicum treatments did not have sufficient replication to warrant being included in this report. In conclusion, the results for this site are not yet available.

Site 7: Davie, Togo

The site in Togo is located at Davie within the derived savannah zone. Partners from ITRA, Togo implemented the network experiments. For INM1, local organic resources used consisted of rice residues, which were obtained from an adjacent rice scheme. In order to achieve the required weight in dry matter equivalent for the materials added, not all residues could be incorporated and some of it remained as surface mulch for prolonged periods of time during the growing season. The response of maize to the application of rice residues. There was little or no response to N at this site, probably due to moisture stress resulting from drought during the first season

Site 8: Kabete, Kenya

In addition to the long-term trial that was earlier reported an adjacent experiment was established to investigate the optimum combination of organic and inorganic N sources. Three different materials of differing quality were applied at 60 kg N/ha equivalent. At this N rate, the fertilizer equivalency value of tithonia was 100% while for senna and calliandra it was 43% and 38% respectively. This indicated that tithonia was as good as urea in supplying N to maize crop.

Results: Equivalency of fertilizer value of legume-cereal cropping

Experiments were established at Maseno in Western Kenya, Zaria in Nigeria, Kumasi in Ghana and Davie in Togo

These experiments were to investigate Optimum N and P management in legume-cereal rotations. Although the combined application of organic resources and mineral inputs forms the technical backbone of the Integrated Soil Fertility Management approach, procuring a sufficient amount of organic matter of a desired quality is very often a problem farmers are facing. In-situ production of organic matter is an attractive alternative to technologies harvesting the organic resources from other sites within or outside the farm. Opting for legumes during the organic resource production phase has the potential to enrich the soil with N through biological N_2 fixation.

Herbaceous or green manure legumes usually leave substantial amounts of N in the soil although when left to grow to maturity, harvesting the seeds may substantially reduce the net N input into the soil. 'Traditional' grain legume germplasm has a large N harvest index indicating that although a significant part of the N taken up by the legume was certainly fixed from the atmosphere, more N was taken away during grain harvest resulting in a negative net N input. However, dual-purpose germplasm is now available for, e.g., cowpea and soybean, which produces substantial amounts of haulms besides grains and has a relatively low N harvest index. As such, a net N input into the soil can be expected. Besides fixing N, certain legumes are also known to access less available P pools, alter the soil pest spectrum or improve soil biological properties. These benefits are often summarized as non-N benefits. The effect of a legume on a following cereal crop is often expressed as its N equivalent. One needs to take into account that the processes mentioned above might also lead to a better utilization of legume or fertilizer N although the improved yields are not necessarily an improvement of N supply.

The current experiments aim at quantifying the contribution of herbaceous and grain legumes to N supply and, where relevant, at quantifying the impact of targeting P to certain phases of the rotation on the overall yield. No data is available for this report yet as we will be able to monitor the rotation effect only during the next cropping season.

Results: Phosphorus (P) placement and P replenishment with Phosphate rock

Single Superphosphate (SSP), Tahoua Phosphate Rock (TPR) and Kodjari Phosphate Rock (PRK) were broadcast (bc) and/or hill placed (HP). For pearl millet grain P use efficiency for broadcasting SSP at 13 kg P/ha was 18 kg/kg but hill placement of SSP at 4 kg P/ha gave a PUE of 83 kg/kg P. Whereas the PUE of TPR broadcast was 16 kg grain/kg P, the value increased to 34 kg/kg P when additional SSP was applied as hill placed at 4 kg P/ha. For cowpea fodder PUE for SSP broadcast was 96 kg/kg P but the hill placement of 4 kg P/ha gave a PUE of 461 kg/kg P. Those data clearly indicate that P placement can drastically increase P use efficiency and the placement of small quantities of water-soluble P fertilizers can also improve the effectiveness of phosphate rock .

Results: Placement of phosphorus and manure

A complete factorial experiment was carried out with three levels of manure (0, 3, 6t/ha) three level of P (0, 6.5 and 13 kg/P ha) using two methods of application (broadcast and hill placement).

The response of millet to P and manure for the two methods of application. For pearl millet grain the hill placement of manure performed better than broadcasting and with no application of P fertilizer, broadcasting 3 t/ha of manure resulted on pearl millet grain field of 700 kg/ha whereas the point placement of the same quantity of manure gave about 1000 kg/ha. Cowpea are showing also the same effect as for pearl millet.

A complete factorial experiment of three level of P (0, 13 and 26 kg P/ha), three levels of N (0, 30 and 60 kg N/ha), and three levels of manure (0, 2, 4 t/ha) was carried out. For pearl millet grain, the optimum combination of organic and inorganic soil amendment gave yield of about 2 t/ha whereas the control yield was 450 kg/ha. The P and N fertilizer equivalency of manure range from 291 to 397%.

Results: Farmer's evaluation of soil fertility restoration technologies

Karabedji site

Past research results indicated a very attractive technology consisting of hill placement of small quantities of P fertilizers. With DAP containing 46% P2O5 and a compound NPK fertilizer (15-15-15) containing only 15% P2O5, fields trials were carried out by farmers on 56 plot per treatment to compare the economic advantage of the two sources of P for millet production. As hill placement can result in soil P mining another treatment was added consisting of application of phosphate rock at 13 kg P/ha plus hill placement of 4 kg P/ha as NPK compound fertilizers.

The data clearly shows that there was no difference between hill placement of DAP and 15-15-15 indicating that with the low cost per unit of P associated with DAP, this source of fertilizer should be recommended to farmers. The basal application of Tahoua Phosphate rock gave about additional 300 kg/ha of pearl millet grain. The combination of hill placement of water-soluble P fertilizer with phosphate rock seems a very attractive option for the resource poor farmers in this region. The data clearly show that the application of Tahoua PR with hill placement of water soluble P outperformed the other treatments in most instances.

Sadore site

Low, medium and high inputs of mineral fertilizers evaluation

Farmers' practices were compared to a low input system consistency on increasing crop planting density at recommended level, a medium input where Tahoua Phosphate rock was applied at 13 kg P/ha and SSP hill placed at 4 kg P/ha and high input as recommended by the extension services where SSP is broadcast at 13 kg P/ha with nitrogen applied at 30 kg N/ha as urea.

The data indicates that grain yield can be increased three fold with the medium input and higher economic returns can be anticipated with this treatment. The data show how the yield of the technologies evaluated fluctuated as compared to the farmers' practices with the high input systems dominating the other systems in most instances.

As for Karabedji, DAP, NPK and SSP were compared and there was any significant effect between the three sources and yield can be increased for more than two fold with this low input technology.

African Academy of Sciences (in press)

Soil Fertility Management in Africa: A Regional Perspective

Gichuru, M.P., Bationo, A., Bekunda, M.A., Goma, H.C., Kimani, S.K., Mafongoya, P.L., Mugendi, D.N., Murwira, H.M., Nandwa, S.M., Nyathi, P. and Swift, M.J. (Eds.)

Preface

In Sub-Saharan Africa (SSA) the economic growth and quality of life largely depends on the agricultural sector, which accounts for more than 25% of the Gross Domestic Product (GDP). Nonetheless, the region is characterised by declining per capita cereal production estimated at 150kg/person to 130 kg/person over the past 35 years. As a result recent estimates indicate that by year 2020, the SSA annual cereals imports will rise to more than 30 million metric tons.

Soil fertility degradation has been described as the single most important constraint to food security in SSA. A large proportion of soils in SSA have low inherent fertility but the major cause of soil fertility degradation is the imbalance caused by nutrients are not commonly replaced resulting to negative nutrient balances. 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.

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 also leads to:

- Reduced capacity to maintain vegetative cover;
- 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;
- Increases in the emission of greenhouse gases with consequent effects on climate;
- Increased prevalence of catastrophic events such as landslides and floods.

In 1988, the Tropical Soil Biology and Fertility Programme (TSBF) established the African Network for Soil Biology and Fertility (AfNet) as the single most important implementing agent of TSBF programme. The network has the overall goal of strengthening and sustaining stakeholders capacity to generate, share and apply soil fertility management knowledge to contribute and to the welfare of farm communities. AfNet is a network of resource management scientists working in Africa whose objective is to promote research collaboration to develop sustainable soil management practices through the manipulation biological processes that control soil fertility. The network is unique in that research projects are developed primarily by scientists within national academic and research institutions so that research is conducted to meet national or regional priorities as well as personal and institutional goals. The purpose of this network research is to apply the principles of soil biology with emphasis on ways to increase food production in smallholder production systems. This book is a synthesis of results from AfNet and other sources and presents the views of African scientists on the critical issue of improving the fertility and productivity of the soils of the continent. The book incorporates both thematic and agroecological reviews. In the former case the main thrust lies in an integrated approach to soil fertility management - combining biological, physical and socio-economic scientific research with farmer's needs and opportunities. In the latter, the focus is to apply the lessons from the integrated analysis to the particular problems of different agroecological zones. This book represents the first step in disseminating AfNet results, concepts and recommendations to its clients. The writing of the book as a collaborative effort of scientists from several African countries has forced a synthesis of results and a sharing and distillation of ideas among network members from many countries and institutions. The book also attempts to compile the available information from the literature and from on-going work in soil biology. The target of such a book is the first level of clients - researchers and development personnel in Africa and influential international agencies. However, the authors have also attempted to address the issues of dissemination of results to the ultimate client - the farmer.

The presentation is divided into three main sections. The first section (Chapters 1 and 2) introduces the principles of soil biology and fertility. The second section (Chapters 3 to 8) focuses on the major production systems in each of the main agroecological zones in Africa. The ecological zones and the main soil fertility constraints are defined followed by selected case studies of important production systems. Each chapter has a synthesis of strategies for integrated resource management for that agroecological zone. The final section (Chapter 9) integrates the concepts in the framework of integrated soil fertility management

We anticipate that the book will serve as a source book for university students, alongside the two previous TSBF texts (Laboratory Methods of Soil and Plant Analysis: A Working Manual, edited by JR Okalebo, K.W. Gathua and PL Woomer and The Biological Management of Tropical Soil Fertility, edited by P.L Woomer and M.J. Swift). Teachers of courses on soil biology and fertility in the region currently have only limited examples from the tropical setting. Students sometimes have difficulties relating examples from textbooks devoted almost exclusively to temperate region agriculture to production systems in tropics. The format of this book is however, aimed to serve as a source text for courses in soil biology and fertility as a reference for agricultural scientists and development workers interested in sustainable agriculture in the tropics.

We are grateful to DANIDA who provided funds to support the workshop where the initial ideas to write the book were developed as well as subsequent meetings of the Editorial Committee (Mwenja Gichuru, André Bationo, Mike Swift, Nairobi). Dr Mary Scholes, of the Department of Botany, University of the Witwatersrand, Johannesburg, Republic of South Africa, and a long time AfNet member, organised and provided the logistical support for the workshop. We are also grateful to the Technical Centre for Agricultural and Rural Cooperation (CTA) who provided the funds for the publication of this book. We also take this opportunity to thank the various donors who have funded the TSBF African Network research over the years.

AfNet 8 Proceedings (in press). African Academy of Sciences.

Soil fertility management for sustainable land use in the West African Sudano-Sahelian zone.

Bationo, A., Mokwunye, U., Vlek, P.L.G., Koala, S. and Shapiro, B.I. (Eds.)

Arrangements to publish the AfNet 8- Arusha proceedings are in progress. The publishing will be done by the Africa Academy of Sciences. All the papers have already been submitted the publishers. The selection of the best papers of AfNet members for publishing in refereed journals has not yet been done.

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Simulated partitioning coefficients for manure quality compared with measured C:N ratio effects
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Nitrogen fertilizer equivalency values for different organic materials based on maize performance at Kabete, Kenya
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Dual inoculation of woody legumes and Phosphorus uptake from Insoluble Phosphate Rock
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Economic analysis of non-conventional fertilizers in Vihiga District, Western Kenya
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Response of *Tephrosia vogelii* to Minjingu phosphate rock application on a Ferralsol of varying soil pH.
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Decomposition of organic matter in soil as influenced by texture and pore size distribution
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Soil Conservation and Fertility improvement using leguminous shrubs in central highlands of Kenya: National Agroforestry Research Project (NAFRP) case study
J. Mugwe, D.N. Mugendi, B. Okoba, P. Tuwei and M. O'Neill

The profitability of manure use on maize in the small-holder sector of Zimbabwe
K. Mutiro and H.K. Murwira

Assessment of need to inoculate common bean *(Phaseolus vulgaris l*) by quantifying nitrogen fixation using the 15N isotope dilution technique under Zambian conditions.

Synthesis of the research in West Africa has been written. A book will be written and published with financial support from ICRISAT.

The network members have already started the layout of a book entitled **"Fighting Poverty in Sub-Saharan Africa: The Multiple roles of Legumes in Integrated Soil Fertility Management"** with the following outline:

Chapter 1: Agro-ecological distribution of legumes in farming systems and identification of biophysical niches for legume growth. (S Nandwa, S. Obanyi, J Kinyangi and P Mafongoya)
- Occurrence of various classes of legumes in the different agro-ecological zones
- Current and potential niches for legumes
- Potential for highland legumes

Chapter 2: Economic evaluation of the current and potential contribution of legumes to smallholder livelihoods. (M Odendo, V Manyong J. Ramisch, K. Acheampong and S Kimani)
- Current direct and indirect role of legumes in income generation for different agroecozones
- Nutritional value

Chapter 3: Inter and intra specific variation of legumes to access stable soil P and rock phosphate and adaptation to adverse soil conditions. (H Nwoko, B K Tossah, Susan Ikerra, N Sanginga, I.M. Rao, A. Bationo, and U. Mokwunye)
- Screening species and varieties for ability to access low soil P and RP
- Screening for adverse soil conditions (water logging, low soil pH, drought…)

Chapter 4: Legumes, soil biodiversity and soil-borne pest and disease dynamics. (M Bekunda, A Emechebe, K Ampofo, R Buruchara, S Schulz and M Swift)
- Role of legumes in altering soil biodiversity (positive and negative) for various classes of legumes
- Striga dynamics in rotations
- Pest and disease spectra dynamics in legume rotations for various classes of legumes

Chapter 5: Strategies to adapt, disseminate, and scale out legume based technologies. (D Mugendi, N Karanja, P Sanginga, P Soniia, E Mulugetta, Q Noordin and R Jones)
- Identification of socio-economic niches for growth of various classes of legumes
- Farmer participatory adaptation and evaluation of various classes of legumes

Chapter 6: Comparative analysis of the current and potential role of legumes in Integrated Soil Fertility Management in West and Central Africa
(A Bationo, V.Bado, B Vanlauwe, M Bagayoko, A Buerket and S Koala)
- Impact of various classes of legumes on soil fertility, emphasizing N contributions, soil physical properties, and soil C build-up in West/Central Africa

Chapter 7: Comparative analysis of the current and potential role of legumes in Integrated Soil Fertility Management in East Africa. (J Ojiem, C K K Gachene, J Mureithi, C Palm, R Delve, J Mureithi, B Jama, S Slim and G Odhiambo)
- Idem in East Africa

Chapter 8: Comparative analysis of the current and potential role of legumes in Integrated Soil Fertility Management in southern Africa. (P Mapfumo, W Sakala, S Slim, S Mpepereki, S Waddington, H Murwira, F. Mafongoya and K Giller)
- Idem in southern Africa

List of Acronyms

ACIAR	Ausralian Centre for International Agricultural Research, Australia
AUN	Agricultural University of Norway, Norway.
AHI	African Highlands Initiative
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (para América Central), Costa Rica.
CENICAFE	Centro Nacional de Investigaciones en Café, Chinchiná, Colombia
CENIPALMA	Centro de Investigación en Palma de Aceite, Colombia
CIAT	Centro Internacional de Agricultura Tropical, Colombia
CIDIAT	Centro Internacional de Desarrollo Integral de Aguas y Tierras, Venezuela.
CIELAT	Centro de Investigaciones Ecológicas de los Andes Tropicales, Venezuela.
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
CIPASLA	Consorcio Interinstitucional para la Agricultura Sostenible en Laderas, Colombia.
CIRAD	Centre de Coopération Internationale en Recherche Agronomique poour le Depeloppement, France
CNPAB	Centro Nacional de Pesquisa de Agrobiologia, Brazil
COLCIENCIAS	Instituto Colombiano para el Desarrollo de la Ciencia y la Tecnología “Francisco José de Caldas”, Colombia
CORPOICA	Corporación Colombiana de Investigación Agropecuaria, Colombia.
CPAC	Centro de Pesquisa Agropecuaria dos Cerrados (of EMBRAPA)
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
CVC	Corporación del Valle del Cauca, Cali, Colombia
DFID	Department for International Development
DRSS	Department of Research and Specialist Services, Zimbabwe
EC	European Comisión, Belgium
ENA	Escuela Nacional de Agricultura
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brazil
ETH	Institut for Plant Science, Zurich
FAO	Food and Agriculture Organization of the United Nations, Italy
FASID	Foundation for Advanced Studies in International Development, Japan
FEDEARROZ	Federación Nacional de Arroceros, Colombia
GTZ	Technical Cooperation, Germany
IAEA	International Atomic Energy Agency, Vienna, Austria
IBSRAM	International Board for Soil Research and Managment
ICRAF	International Centre for Research in Agroforestry, Nairobi, Kenya
ICRISAT	International Crops Research Insttitute for the Semi-Arid Tropics, India
IDRC	International Development Research Centre, Canada
IFDC	International Fertilizer Development, USA
IIAP	Instituto de Investigaciones Ambientales del Pacífico, Quibó (Chocó), Colombia
IITA	International Institute of Tropical Agriculture, Nigeria
IGAC	Instituto Geográfico “Agustín Codazzi”, Bogotá, Colombia
ILRI	International Livestock Research Centre, Kenya
IPF	Instituto de Fósforo y Potasio, Ecuador
IRD	Institut Français de Recherche sicentifique pour le Developpement et Coopération, France.
IRRI	International Research Institute
KARI	Kenya Agricultural Research Institute

KWAP	Kenya Woodfuel and Agroforestry Project
LAC	Latin American and the Caribbean
MAS	Management of Acid Soils (of SWNM of the CGIAR), CIAT Colombia.
MIS	Integrated Soil Management (of SWNM of the CGIAR), CIAT Honduras
NARS	National Agricultural Research Systems
NAU	Norway Agricultural University
NGO	Non-Governmental Organization
PRONATTA	Programa Nacional de Transferencia de Tecnología, Colombia
SLU	Swedish Agricultural University
SOL	Supermercado de Opciones para Laderas
SWNM	Soil, Water and Nutrient Management (systemwide program of the CGIAR), CIAT Colombia.
UNA	Universidad Nacional Agraria, Nicaragua