Centro Internacional de Agricultura Tropical
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TSBF

THE COMMINUTOR

NEWSLETTER OF THE TSBF INSTITUTE OF CIAT

Partly digested bits of high quality information about the Tropical Soil Biology and Fertility (TSBF) Institute of CIAT, Volume 6 No. 1

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DIRECTOR'S MESSAGE

TSBF, CIAT and ICRAF join to combat soil fertility decline

One of the most far-reaching recommendations of the External Programme and Management review of the TSBF Programme in June 2000 was that we should consider reforming our institutional status. This sparked a lengthy and intensive process of discussion and review of possible options, not least at the last AfNet Assembly in Arusha a year ago. And as most of you must already know this resulted in the decision last June by the TSBF Board to join in a Strategic Alliance with two CGIAR Centres, CIAT and ICRAF. The purpose of the institutional changes is not only to provide greater institutional stability for TSBF but, more importantly, to enhance the capacity of all three organisations for soil fertility research

The first step in realising the alliance was the signing of an agreement with CIAT in December 2001 to create the Tropical Soil Biology and Fertility Institute of CIAT (known as TSBF-CIAT). Although the full process of amalgamation will not be complete for some months the new Institute is already operating as an integral part of CIAT under CGIAR procedures. The soils research programme of CIAT in Latin America and that of TSBF in Africa are being integrated under the new Institute, effectively creating a single agenda operating on two continents. The Institute's research programme is overseen by a Scientific Advisory Committee (SAC) of the CIAT Board of Trustees, with membership derived in part from the former Board of Management of the TSBF Programme. The SAC will visit East Africa in June for its inaugural meeting and will visit TSBF research sites in the region.

In May the second step in the process was taken when the DGs of CIAT and ICRAF agreed join in an alliance the goal of which is to improve rural livelihoods in SSA through sustainable integrated management of soil fertility. The agreement enables the location of TSBF-CIAT on the ICRAF campus. More importantly the alliance is committed to a fully integrated research programme built round five major themes: (i) Empowering farmers to scale up research and results; (ii) Managing carbon and nutrient cycles for enhanced agricultural productivity; (iii) Managing soils for enhanced ecosystem services; (iv) Managing soil genetic resources for enhanced biodiversity and pest management; and (v) Capacity building for ISFM research and development. This programme was designed at a workshop hosted by the Rockefeller Foundation at its Bellagio Study and Conference Centre in early March. This meeting is described elsewhere in the Comminutor and the report is available from the TSBF-CIAT office. The major intention of the alliance is to act as a catalyst for enhancing and facilitating soil fertility research in the region on behalf of the many partners engaged in these activities.

AfNet will be the main agency for the implementation of TSBF's contributions to the alliance programme. We live in uncertain times both because of the circumstances in which our continent exists and because of the limits to our opportunities to respond within the specific but crucial area of soil fertility management. The TSBF Board and management was convinced that institutional change, and in particular closer integration with other agencies, was essential in order to maintain and increase impact. I am convinced that the sweeping changes that have been put in place, disruptive though they may seem in the short term, bring greatly enhanced opportunity for TSBF staff and network members alike. There are exciting times ahead!

Soil Fertility Degradation in Africa: Leveraging Lasting Solutions to a Long-Term Problem: A Workshop at the Rockefeller Foundation Bellagio Conference Centre, March 4th-8th, 2002

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 centres (IARCs), CIAT, TSBF and ICRAF, have recently joined forces in an alliance targeted at tackling this challenge. The objectives of the workshop were to: 1) Present the new alliance between the three organizations 2) Review tropical soil degradation and proposed solutions 3) Identify mechanisms to sustain an integrated attack on this long-term problem.

The rural population of SSA is trapped in a vicious cycle between poverty, land degradation and the lack of resources, knowledge or opportunity to generate adequate income to break out. A large proportion of the soils in SSA exhibit a variety of constraints to agricultural production, among them, nutrient deficiency, low organic matter, moisture stress, and high erodibility. In agricultural systems nutrient balances are commonly negative due to failure to replace those removed in crop harvest and other losses. A range of economic and institutional failures has resulted in fertiliser use in SSA being by far the lowest in the world.

Soil fertility decline 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 an holistic approach

Progress and Achievement

The good news is that progress is being made. 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. 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. Such effects can be seen from a range of technologies and practices that have been implemented and adopted in many parts of the continent including: integrated nutrient management (ie. combinations of fertilisers with organic inputs of various kinds), high-efficiency 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. The increasing success with these practices is derived from the emergence of a consensus on guiding principles for Integrated Soil Fertility Management (ISFM). In essence, ISFM is the adoption of an holistic approach to soil fertility that embraces the full range of driving factors and consequences – biological, physical, chemical, social, economic and political – of soil degradation. 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 the wider concepts of Integrated Natural Resource Management (INRM), represents a very significant step beyond the earlier, narrower, nutrient replenishment approach to soil fertility enhancement.

The Way Forward

This progress has demonstrated that investing in farmer-centred soil fertility research is integral to successful rural development. Despite these successes however the impact is still small in scale and often disappointingly short-term. The major target for future research is to empower farmers to sustainably manage their soils. Moving from a nutrient replenishment to a pro-poor approach to soil fertility management allows local approaches to generate global benefits.

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. 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. Stable funding is critically needed to improve this position and to provide for the laboratory facilities that are essential for ISFM research.

Three international institutions have joined together to form a strategic alliance, the goal of which is "to improve rural livelihoods in SSA through sustainable integrated management of soil fertility". The three partners have made significant contributions to combating soil fertility degradation over the past decade and also have a long record of collaboration through joint research projects.

The former Tropical Soil Biology and Fertility Programme (TSBF), an international institution solely devoted to ISFM research, has joined with the International Centre for Tropical Agriculture to form the TSBF Institute of CIAT. This merger builds on the strong collaboration between CIAT and TSBF in soil fertility research in East Africa that has developed within the CGIAR Systemwide Programme on Soil Water and Nutrient Management (SWNM) for which CIAT is the convening centre. The third partner in the alliance is the International Centre for Agroforestry Research (ICRAF) has played a leading role in ISFM research in SSA over the last decade, including representation of the CGIAR in the World Bank Soil Fertility Initiative for Africa (SFI). TSBF and ICRAF have also collaborated closely in soils research for many years.

As already stated in the director's message, the alliance is committed to a fully integrated research programme built round five major themes: (i) Empowering farmers to scale up research and results; (ii) Managing carbon and nutrient cycles for enhanced agricultural productivity; (iii) Managing soils for enhanced ecosystem services; (iv) Managing soil genetic resources for enhanced biodiversity and pest management; and (v) Capacity building for ISFM research and development.

The alliance is itself the beginning of a process of greater institutional collaboration, effectively presenting a nucleus around which greater future collaboration can take place when addressing ISFM. By building on the existing networks, systemwide and regional programmes of both NARs and IARCs, sufficient capacity may be achieved in all phases along the research – development continuum. As described above soil fertility degradation is a long-term problem. Funding support for ISFM research is needed that recognises both the urgency for immediate actions and for longer-term investment in lasting solutions. At the heart of that support is the vital need to maintain a critical mass and diversity of soil scientists in SSA. This requires a targeted and committed investment in ISFM to enable and enhance the momentum that has already been achieved by the alliance and its partners.

A message from Prof. Ken Giller, the Chairman of TSBF-CIAT Scientific Advisory Committee on the search for a new Director for TSBF

As many already know, our current Director, Prof Mike Swift, announced last year that he would retire at the end of 2002 to further other pursuits. Of course this came as something as a shock for all of us, particularly given the very close association that Mike has had with TSBF from its inception in the 1980's. Before anyone asks - many of us have asked Mike if he would consider staying on for another year or so, but the answer has always been a polite but firm - No!

As Chairman of the Board of Management (BoM) of TSBF, I was charged with initiating the process of advertising and searching for a new Director at the annual meeting of the Board last year. In the meantime, the status of TSBF has changed, as has the status of the Board of Management which now becomes a smaller 'Scientific Advisory Committee' that will still meet annually in June for the foreseeable future. The former vice-Chair of the TSBF BoM, Professor Mary Scholes of Witwaterstrand University in South Africa and I as former Chair of the BoM were appointed to the Board of Trustees of CIAT at the meeting in Colombia in December last year.

With the new status of the TSBF Institute being part of CIAT, the responsibility for appointment of the new Director of TSBF falls firmly with the CIAT Director General, Dr Joachim Voss. However, as another of the many actions that CIAT have taken which demonstrate their faith in and commitment to TSBF, Dr Voss suggested that we continue with the process as planned, of course in close discussion with the CIAT management. We appointed a selection committee which I have chaired, with membership of Dr JoachimVoss (Director General, CIAT), Dr Doug Pachico (Research Director, CIAT), Professor Mary Scholes (TSBF Scientific Advisory Committee and CIAT Board of Trustees), Dr Mateete Bekunda (Representative of AfNet and other collaborating scientists at large),Dr André Bationo (Representative of TSBF staff in Africa), Dr Edmundo Barrios (Representative of TSBF staff in South America).

An advertisement was placed in a number of international journals, and widely circulated within AfNet, the wider soil science community across the globe, and through the CGIAR system. At the same time a number of people suggested as likely suitable candidates for the post of Director were approached to ask if they would consider applying for the position.

We received a large number of applications which were circulated to all members of the selection committee to comment on for a wide range of criteria. This allowed us readily to arrive at a shortlist, and after much discussion we are delighted to announce that we have invited two candidates for interview, both who are scientists of the highest international standing!

The interviews will take place on 17th and 18th June at the TSBF offices in the ICRAF complex in Nairobi where both candidates will give open seminars on the morning of Monday 17th June to which all are invited. We hope that we will be able to announce appointment of the new Director of TSBF very soon after these interviews.

Obviously Mike will be a hard act to follow! As a committee we have done our best not to think of the new Director as a substitute for Mike, but to think of the qualities that we need in a new Director to take TSBF forward over the coming years in its new form as the Tropical Soil Biology and Fertility Institute of CIAT.

TSBF-CIAT Scientists' recent publications

This section is reproducing the recent abstracts from the TSBF-CIAT scientists' recent publications. In the next issue we will synthesize the publications of our network collaborators. Please note that the list of publications by Dr. Bernard Vanlauwe and Dr. Andre Bationo is on the past work they did while working for IITA and IFDC/ICRISAT respectively.

Journal of Agronomy and Crop Science183 (1999), 35-45

Differential drought responses of faba bean (Vicia faba L.) inbred lines

Amede, T., Kittlitz, E. V. and Schubert, S.

Drought responses of 19 inbred faba bean lines of different origin were studied in the field under rain shelters with and without irrigation. Inbred lines differed significantly in response to drought ($P < 0.01$): those with a lower drought sensitivity index (SI) (more resistant) originated from the drought-prone regions characterized by smaller plant size ($r = 0.93$), and more pods and seeds per plant (r more than or equal to 0.90) regardless of seed size, while lines with higher SI (more sensitive) were those which mainly exhibited higher yield under favourable conditions accompanied by a greater biomass. In a greenhouse experiment under mild drought (-0.15 MPa soil water potential), comparisons between relatively drought-sensitive (Adriewaalse) and drought-resistant (L7) inbred lines showed that Adriewaalse used 38% more water than L7 and also produced 40% more biomass. There was a stress-induced decrease in osmotic potential (psi s) in both lines (by 0.72 and 0.50 MPa for Adriewaalse and L7, respectively) accompanied by decreased turgor in Adriewaalse and increased turgor in L7. The difference in drought-induced solute accumulation between lines was diminished when solute accumulation due to water loss and growth inhibition was considered, which indicates that solute accumulation was the result of a concentration effect. Similarly, lower SI in the field was not the result of osmotic adjustment, as the relationship between SI and drought-induced decrease in psi s was negative. The water use efficiency of both inbred lines increased markedly with increasing water deficit, though there was no difference between the lines. It was concluded that differences in drought resistance between these inbred faba bean lines were manifested through plant size-induced water demand (avoidance) but were not associated with osmotic adjustment (tolerance).

Managing Africa's Soils 23(2001), ii + 23 pp.

Reversing the degradation of arable land in the Ethiopian Highlands.

Amede, T., Belachew, T, and Geta, E.

A participatory research programme on natural resource management was conducted at Gununo, Ethiopia by the African Highlands Initiative, an integrated soil fertility management project launched in Gununo, and Ethiopian Agricultural Research Organisation to increase the capacity for independent innovation within farming communities, while working with farmers to develop appropriate technologies to combat soil degradation. Farmers spent three years testing various methods of restoring soil fertility such asintroducing legume cover crops into rotation systems, installing measures to control soil erosion, and practising minimum tillage and more efficient ways of managing crop residues. Results showed that adoption of these technologies depended on factors such as farm size, availability of labour and soil condition. Five socioeconomic strata within local communities were also identified, each with clearly different opportunities and needs. Any attempt to address agricultural problems should take account of this diversity, as blanket recommendations or technology packages are unlikely to provide effective solutions to the range of problems faced by farmers. Their interests will be best served by using a participatory approach to develop technologies that address the needs and specificities of each group, and by ensuring that farmers are fully involved in all stages of the process, from research and implementation to monitoring and evaluation.

Managing Africa's Soils No. 23, IIED, May 2001

Reversing the degradation of arable land in the Ethiopian Highlands

Amede, T., Belachew, T. and Geta, E.

Degraded soils are a major constraint to agricultural production and food security in the southern Ethiopian Highlands. As their yield and incomes decline, poor farmers have fewer resources to invest in fertilizers or soil conservation measures, while pressure from the growing population forces them to cultivate marginal lands, and discontinued fallow and the use of crop residues to maintain soil fertility. Soil fertility is declining most rapidly in the outer fields, as crop residues from these areas are used on the homestead gardens where enset and coffee crops are grown, which also receive the most manure and organic waste. Farmers need to adapt their soil fertility management strategies to the considerable spatial and temporal variations in soil degradation, focussing on restoring and maintaining the fertility of outfields and degraded land on steep slopes.

The African Highlands Initiative (AHI) and Ethiopian Agricultural Research Organisation responded to this situation by setting up a participatory research programme on natural resource management. The overall objective of the programme was to increase the capacity for independent innovation within farming communities, while working with farmers to develop appropriate technologies to combat soil degradation. Farmers spent three years testing various methods of restoring soil fertility, introducing legume cover crops into rotation systems, installing measures to control soil erosion, and practicing minimum tillage and more efficient ways of managing crop residues. The results of the research showed that adoption of these technologies depended on factors such as farm size, the availability of labour and soil conditions.

Research conducted during the programme identified five socioeconomic strata within local communities, each with clearly different opportunities and needs. Any attempt to address agricultural problems should take account of

this diversity, as blanket recommendations or technology packages are unlikely to provide effective solutions to the range of problems faced by farmers. Their interest will best be served by using a participatory approach to develop technologies that address the needs ad specificities of each group, and by ensuring that farmers are fully involved in all stages of the process, from research and implementation to monitoring and evaluation.

The AHI team found the participatory research approach to research a very positive experience, which helped them identify problems and develop technologies that were specifically tailored to local conditions. The main achievement of the programme was to increase the capacity of farmers to solve their problems through experimentation and encourage various organisations to work together and learn from each other. The next step is to move from discipline-based research towards research and development in integrated natural resource management at watershed level.

Soil Sci. Soc. Am. J. 62(1998), 1604-1609

Relating Preseason Soil Nitrogen to Maize Yield in Tree Legume-Maize Rotations

Barrios, E., Kwesiga, F., Buresh, R. J., Sprent, J. I. and Coe, R.

Legumes can be an important source of N for cereals in tropical, subsistence farming systems that use little or no fertilizers. Our objective was to identify measures of soil N availability, following growth of diverse legumes, that correlated with yield of a subsequent unfertilized maize (Zea mays L.) crop. Unfertilized maize followed nine 3-yr-old systems (six monocultures of planted trees legumes, a groundnut (*Arachis hypogea L.*)-maize-soybean (*Glycine max* (L) Merr.) rotation, an uncultivated fallow with natural regrowth of vegetation, and unfertilized maize monoculture) in two experiments on a Ustic Rhodustalf in eastern Zambia. Total soil C and N before maize planting were not related to grain yield of maize. Preseason soil inorganic N (NO_3 + NH_4), aerobic N mineralization, and light-fraction N (N in macroorganic matter, 150-2000 μm and <1.37 Mg m^{-3}) at 0- to 15cm depth correlated ($P < 0.01$) with maize grain yield. Preseason inorganic N combined with light fraction. N accounted for 59% of the variance in maize grain yield. The predictability of maize yield was slightly improved (64% of the variance) by including the population of the parasitic weed striga (Striga asiatica (L.) Kuntze) with preseason inorganic N and light-fraction N. The results suggest that yield of unfertilized rain-fed maize following different rotational systems on a N-limiting soil in an area with monomodal rainfall was strongly related lo the additive effects of preseason soil inorganic N and a soil N fraction related to N mineralization.Soil.

Journal of Agricultural Science 134 (2000), 277-284

Rotation and nitrogen fertilizer effects on pearl millet, cowpea and groundnut yield and soil chemical properties in a sandy soil in the semi-arid tropics, West Africa.

Bationo, A. and Ntare, B. R.

A 5-year study was conducted from 1988 to 1992 at three sites in Niger to determine the effects of crop rotation of a cereal and legumes and nitrogen fertilizer on chemical properties of the soil (0-20 cm) and yield of pearl millet (Pennisetum glaucum), cowpea (Vigna unguiculata), and groundnut (Arachis hypogaea). Four N levels (0-45 kg N/ha) and rotation treatments including continuous fallow were investigated. Soil samples taken from the top 20 cm depth at the end of the experiment from treatments without nitrogen application which included continuous fallow, fallow-millet rotation, groundnut-millet rotation, cowpea-millet rotation, and continuous millet were analysed for soil pH, organic carbon, total nitrogen and

exchangeable bases. Fertilizer N significantly increased yield of pearl millet, cowpea and groundnut. Continuous monocropping of pearl millet resulted in lower yields across N levels compared to legume-millet rotations. Legume yields were also consistently lower in monoculture than when rotated with millet. There was a decline in organic matter under continuous millet, cowpea-millet rotation and groundnut-millet rotation. The fallow-millet rotation supplied more mineral N than the legume-millet rotations. Nitrogen availability was greater in cowpea-millet rotation than continuous millet. Crop rotation was more productive than the continuous monoculture but did not differ in maintaining soil organic matter. The legume-millet rotation at 30 kg/ha N appears to be the most viable for millet production. Research should focus on understanding the effect of legume/cereal intercrops and rotations on soil productivity.

Nutrient Cycling in Agroecosystems 61(2001): 131–142

Soil organic carbon management for sustainable land use in Sudano-Sahelian West Africa

Bationo, A. and Buerkert, A.

Judged by their negative nutrient balances, low soil cover and low productivity, the predominant agro-pastoral farming systems in the Sudano-Sahelian zone of West Africa are highly unsustainable for crop production intensification. With kaolinite as the main clay type, the cation exchange capacity of the soils in this region, often less than 1 cmolc kg.1soil, depends heavily on the organic carbon (Corg) content. However, due to low carbon sequestration and to the microbe, termite and temperature-induced rapid turnover rates of organic material in the present land-use systems, Corg contents of the topsoil are very low, ranging between 1 and 8 g kg.1 in most soils. For sustainable food production, the availability of phosphorus (P) and nitrogen (N) has to be increased considerably in combination with an improvement in soil physical properties. Therefore, the adoption of innovative management options that help to stop or even reverse the decline in Corg typically observed after cultivating bush or rangeland is of utmost importance. To maintain food production for a rapidly growing population, targeted applications of mineral fertilisers and the effective recycling of organic amendments as crop residues and manure are essential. Any increase in soil cover has large effects in reducing topsoil erosion by wind and water and favours the accumulation of wind-blown dust high in bases which in turn improves P availability. In the future decision support systems, based on GIS, modelling and simulation should be used to combine (i) available fertiliser response data from on-station and on-farm research, (ii) results on soil productivity restoration with the application of mineral and organic amendments and (iii) our present understanding of the cause-effect relationships governing the prevailing soil degradation processes. This will help to predict the effectiveness of regionally differentiated soil fertility management approaches to maintain or even increase soil Corg levels.

Plant and Soil (In press)

Phosphorus use efficiency as related to sources of P fertilizers, rainfall, soil and crop management in the West African Semi-Arid Tropics

Bationo, A. and. Anand K.

The rainfall of agricultural areas of the West African Semi-Arid Tropics varies from 300 to 1200 mm. Although in absolute terms rainfall is low only in the Northen half of the desert margins, the high inter-annual variability associated with eratic distribution of rainfall in space and during the growing season constitute major limitation for agricultural production. Continuous and intensive cropping without restoration of the soil fertility has depleted the nutrient base of most of the soils. For many cropping systems in the region, nutrient balances are negative, indicating soil mining. Among soil fertility factors, phosphorus deficiency is a major constraint to crop production. Phosphorus use efficiency (PUE) is defined as yield increase per kg fertilizer P added, is related to P sources, environmental factors, soil and crop management. In addition to water soluble P fertilizers, PR sources from Niger (Parc - W PR and Tahoua PR), Mali (Tilemsi PR) and Burkina Faso (Kodjari PR) and modified partially acidulated phosphate rocks (PAPR) effect on P-use efficiency is reported. PAPR improved the PUE of PR sources. Among the four PR sources in the region, Tahoua PR (TPR) recorded highest PUE as compared to Kodjari (KPR) or Parc-W (PRW) sources. Rainfall received in September at grain filling and maturation stage was best correlated to PUE. There is large difference in PUE of different pearl millet cultivars and values varied from 25 to 77 kg grain. Kg P^{-1}.The hill placement of 4 kg $P.ha^{-1}$ at planting time improved the PUE as compared to present recommendation of 13 $kg.ha^{-1}$ broadcast and also improved the efficiency of phosphate rock. The rotation of cereals and cowpea and soil amendment with crop residue application increase drastically the PUE in the region.

Field Crop Research 72 (2001), 1-15

Efficient phosphorus application strategies for increased crop production in sub-Saharan West Africa

Buerkert, A., Bationo, A., and Piepho, H. P.

Comparable data are lacking from the range of environments found in sub-Saharan West Africa to draw more general conclusions about the relative merits of locally available rock phosphate (RockP) in alleviating phosphorus (P) constraints to crop growth. To fill this gap, a multifactorial field experiment was conducted over 4 years at eight locations in Niger, Burkina Faso and Togo, with annual rainfalls of 510-1300 mm. Crops grown were pearl millet (Pennisetum glaucum), sorghum (Sorghum bicolor) and maize (Zea mays), either continuously or in rotation with cowpea (Vigna unguiculata) and groundnut (Arachis hypogaea). Crops were subjected to six P fertilizer treatments comprising a control without P, RockP (39 kg P/ha, broadcast, applied once for 3 years (TRockP39); TRockP39 combined with hill-placement of 4 kg P/ha (P4placed); and 130 kg P/ha, broadcast, applied once for 10 years) and soluble P (13 kg P/ha, annual broadcast as single superphosphate (SSP); and P4placed, applied annually as ground SSP during 1995 and 1996 and as ground NPK fertilizer (15-15-15) during 1997, 1998 and 1999), combined with 0 and 60 kg N ha-1. For legumes, time trend analyses showed P-induced total dry matter (TDM) increases between 28 and 72% only with groundnut. Similarly, rotation-induced raises in cereal TDM compared to cereal monoculture were only observed with groundnut. For cereals, at the same rate of application, RockP was comparable to SSP only at two millet sites with topsoil pH-KCl <4.2

and annual average rainfall >600 mm. Across the eight sites, NPK placement at 0.4 g P per hill raised average cereal yields between 26 and 220%. This was confirmed in 119 on-farm trials revealing P placement as a promising strategy to overcome P deficiency as the regionally most growth limiting nutrient constraint to cereals.

Expl Agric., 38(2002),163-183

Multi-site time-trend analysis of soil fertility management effects on crop production in sub-Saharan West Africa

Buerkert, A., Piepho, K.P. and Bationo, A.

Soil fertility constraints to crop production have been recognized widely as a major obstacle to food security and agro-ecosystem sustainability in sub-Saharan West Africa. As such, they have led to a multitude of research projects and policy debates on how best they should be overcome. Conclusions, based on long-term multi-site experiments, are lacking with respect to a regional assessment of phosphorus and nitrogen fertilizer effects, surface mulched crop residues, and legume rotations on total dry matter of cereals in this region. A mixed model time-trend analysis was used to investigate the effects of four nitrogen and phosphorus rates, annually applied crop residue dry matter at 500 and 2000 kg ha71, and cereal-legume rotation versus continuous cereal cropping on the total

dry matter of cereals and legumes. The multi-factorial experiment was conducted over four years at eight locations, with annual rainfall ranging from 510 to 1300 mm, in Niger, Burkina Faso, and Togo. With the exception of phosphorus, treatment effects on legume growth were marginal. At most locations, except for typical Sudanian sites with very low base saturation and high rainfall, phosphorus effects on cereal total dry matter were much lower with rock phosphate than with soluble phosphorus, unless the rock phosphate was combined with an annual seed-placement of 4 kg ha71 phosphorus. Across all other treatments, nitrogen effects were negligible at 500 mm annual rainfall but at 900 mm, the highest nitrogen rate led to total dry matter increases of up to 77% and, at 1300 mm, to 183%. Mulch-induced increases in cereal total dry matter were larger with lower base saturation, reaching 45% on typical acid sandy Sahelian soils. Legume rotation effects tended to increase over time but were strongly species-dependent.

Soil Sci. Soc. Am. J. 66(2002), 868-877

Sequential phosphorus extraction of a ^{33}P-labeled oxisol under contrasting agricultural systems

Bühler, S., Oberson, A., Rao, I.M., Friesen, D. K., and Frossard, E.

Chemical sequential extraction procedures are widely used to divide soil phosphorus (P) into different inorganic and organic fractions, but the assignment of these fractions to pools of different availability, especially for low P tropical soils, is still matter of discussion. To improve this assignment, the effect of land-use systems and related P fertilizer inputs on size of P fractions and their isotopic exchangeability was investigated. Differently managed Colombian Oxisols were labeled with carrier free ^{33}P and sequentially extracted after incubation times of 4 hours, 1 and 2 weeks. Phosphorus concentrations (inorganic=P_i and organicP=P_o) and ^{33}P recovery in fractions sequentially extracted with resin (P_i), 0.5 *M* $NaHCO_3$ (Bic-P_i, Bic-P_o), 0.1 *M* NaOH (P_i, P_o), hot concentrated HCl (P_i, P_o) and residual P were measured at each time. Resin-P_i, Bic-P_i, NaOH-P_i and hot HCl-P_i were increased with fertilization, with highest increase for NaOH-P_i. The recovery of ^{33}P in the two soils with annual fertilizer inputs and large positive input-output P balances indicate that resin-P_i, Bic-P_i and NaOH-P_i contained most of the exchangeable P. In these soils the label moved with increasing incubation time from the resin to the Bic-P_i and NaOH-P_i fraction. As the ^{31}P content of these

fractions remained constant, the transfer of ^{33}P suggests P exchange among these fractions. The organic or more recalcitrant inorganic fractions contained almost no exchangeable P. In contrast, in soils with low or no P fertilization, more than 14% of added ^{33}P was recovered in NaOH-P_o and HCl-P_o fractions two weeks after labeling, showing that organic P is involved in short term P dynamics.

Developments in Plant and Soil Sciences 92 (2001), 972-973

Causes of legume-rotation effects in increasing cereal yields across the Sudanian, Sahelian and Guinean zone of West Africa.

Burkert, A., Bagayoko, M., Alvey, S. and Bationo, A.

On-farm experiments and pot trials were conducted from 1995 to 1999 on eight West African soils in Niger, Burkina Faso and Togo to explore the mechanisms governing the often reported legume rotation-induced cereal growth increases in this region. Crops comprised pearl millet (Pennisetum glaucum), sorghum (Sorghum bicolor), maize (Zea mays), cowpea (Vigna unguiculata) and groundnut (Arachis hypogaea). In groundnut trials, the observed 26 to 85% increases in total dry matter (TDM) of rotation cereals (RC) compared with continuous cereals (CC) in the 4th year appeared to be triggered bysite- and crop-specific early season differences in nematode infestation (up to 6-fold lower in RC than in CC), enhanced Nmin and a 7% increase in mycorrhizal (AM) infection. In cowpea trials, yield effects on millet and differences in nematode numbers, Nmin and AM were much smaller. Rhizosphere studies indicated effects on pH and acid phosphatase activity as secondary causes for the observed growth differences between RC and CC. In the study region, legume-rotation effects on cereals seemed to depend on the capability of the legume to suppress nematodes and to enhance early N and P availability for the subsequent cereal.

Plant Soil (in press)

Decomposition and nutrient release by green manures in a tropical hillside agroecosystem

Cobo, J. G., Barrios, E., Kass, D. C. L. and Thomas, R. J.

The decomposition and nutrient release of twelve plant materials were assessed in a 20-week litterbag field study in hillsides from Cauca, Colombia. Leaves of *Tithonia diversifolia* (TTH) and *Indigofera constricta* (IND) decomposed quickly ($k = 0.035 \pm 0.002$ d^{-1}), while those of *Cratylia argentea* (CRA) and the stems evaluated decomposed slowly ($k = 0.007 \pm 0.002$ d^{-1}). Potasium presented the highest release rates ($k > 0.085$ d^{-1}). Rates of N and P release were high for all leaf materials evaluated ($k > 0.028$ d^{-1}) with the exception of CRA (N and P), TTH and IND (P). While Mg release rates ranged from 0.013 to 0.122 d^{-1}, Ca release was generally slower ($k = 0.008$ - 0.041 d^{-1}). Initial quality parameters that best correlated with decomposition ($P < 0.001$) were neutral detergent fibre, NDF ($r = -0.96$) and *in vitro* dry matter digestibility, IVDMD ($r = 0.87$). It is argued that NDF or IVDMD could be useful lab-based tests during screening of plant materials as green manures. Significant correlations ($P < 0.05$) were also found for initial quality parameters and nutrient release, being most important the lignin/N ratio ($r = -0.71$) and (lignin+polyphenol)/N ratios ($r = -0.70$) for N release, the C/N ($r = 0.70$) and N/P ratios ($r = -0.66$) for P release, the hemicellulose content ($r = -0.75$) for K release, the Ca content ($r = 0.82$) for Ca release, and the C/P ratio ($r = 0.65$) for Mg release. After 20 weeks, the leaves of *Mucuna deerengianum* released the highest amounts of

N and P (144.5 and 11.4 kg ha^{-1}, respectively), while TTH released the highest amounts of K, Ca and Mg (129.3, 112.6 and 25.9 kg ha^{-1}, respectively). These results show the potential of some plant materials studied as sources of nutrients in tropical hillside agroecosystems.

Biol. Fert. Soils (In press)

Nitrogen mineralization and crop uptake from surface-applied leaves of green manure species on a tropical volcanic-ash soil

Cobo, J. G., Barrios, E., Kass, D. C. L. and Thomas, R. J.

Leaves of nine green manure species (GM) were surface applied to a tropical volcanic-ash soil at a rate of 100 kg N ha-1 in order to evaluate their N-fertilizer value in a glasshouse experiment. GM treatments were compared to urea at two rates, 50 kg N ha-1 (FN50) and 100 kg N ha-1 (FN100), and to a control with no fertilizer application (FN0). Two weeks after treatment application, upland rice seedlings were sown in order to conduct N uptake studies. Soil volumetric moisture content was maintained close to 50%. In general, soil showed an initial increase in inorganic N followed by a rapid decline with time. After two weeks of evaluation FN100, FN50 and leaves of Mucuna pruriens var Tlaltizapan and Indigofera constricta presented higher values of inorganic N (157-109 mg N kg-1 soil); while, FN0 and leaves of Mucuna deerengianum, Cratylia argentea and Calliandra calothyrsus presented lower values (75-89 mg N kg-1 soil). N recovery by rice, at 20 weeks after planting, was highest for FN100 (59.9%) followed by Canavalia brasiliensis (54.6%), Calliandra calothyrsus (47.4%) and M. pruriens var IITA-Benin (32.4%); while, M. pruriens var Tlaltizapan, FN50, Tithonia diversifolia and I. constricta presented lower N uptake (13-20%). Significant relationships were found between some quality parameters of GM evaluated (i.e. total N, fibers, lignin and polyphenol content), soil N availability and rice N uptake. These results suggest that GM that decomposed and released N slowly resulted in high N uptake when they were used at pre-sowing in a tropical volcanic-ash soil.

Integrated Nutrient Management Strategies in Eastern Uganda

Esilaba, A.O., Byalebeka, J.B., Nakiganda, A., Mubiru, S. and Delve, R. J.

A project of the systemwide program on Soil, Water and Nutrient Management (SWNM), concerned with improving integrated nutrient management practices on small-scale farms in Africa, has been carried out in Kenya, Tanzania and Uganda for last two years. The project aims to enable small-scale farmers to profitably reverse nutrient depletion of their soils by increasing their capacity to develop, adapt and use integrated natural resource management strategies, and to improve the participatory skills and tools of research and extension personnel to support this process.

A Participatory Learning and Action Research process (PLAR) was initiated in three villages in Eastern Uganda in September 1999. The farming systems of the area were characterised for socio-economic and biophysical conditions that include social organisations, wealth categories, gender, crop, soil, agroforestry and livestock production. Farmers identified soil fertility constraints, indicators and causes of soil fertility decline and suggested strategies to address the problem of soil fertility decline. Soil fertility management diversity among households indicated that most farmers were not carrying out any improved soil fertility management practices, despite previous research and dissemination in the area. Following the diagnosis stage and exposure visits to other farmer groups working on

integrated soil fertility projects, the farmer groups designed eleven experiments for testing in the first season. One hundred and twenty farmers then chose, for participatory technology development, sub-sets of these eleven experiments, based on the main agricultural constraints and potential solutions identified and prioritised by the farmers. Quantitative and qualitative results from the testing, farmer evaluation and adaptation, training, dissemination strategies and socio-economic assessment of these technologies are discussed.

Resource Flows and Nutrient Balances in Smallholder Farming System in Mayuge District, Eastern Uganda

Esilaba, A.O., Nyende, P., Nalukenge, G., Byalebeka, J.B., Delve, R. J. and Ssali, H.

Resource flows and soil nutrient balance studies were carried out in eastern Uganda to ascertain the movement of resources and nutrients in and out of the farm system. Resource flow mapping was carried out at three stages of a participatory learning and action research; diagnosis, planning and implementation. The resource flows were transformed into nutrient flows, using average N, P, K contents and partial nutrient balances were calculated for the crop production system and for the whole farm using the Resource Kit computer package. Results of the farmer soil fertility management classification revealed that 3% of the farmers belonged to class 1 (good soil fertility managers), 10 % to class 2 (average soil fertility managers) and 87% class 3 (poor soil fertility managers. There was a strong relationship between farmer wealth ranking and soil fertility management classification. Soil chemical and physical properties of the soils in the 3 soil fertility management classes did not differ significantly despite the differences perceived by the farmers.

The study revealed that very low quantities of resources and nutrients enter the farm system, but substantial amounts leave the farm in crop harvests. The main source of nutrients on the farm is crop production system while the major destination is the household system. The livestock component contributed little to the flow of nutrients in the farm system. Results revealed that the net farm nutrient balances per kg per season for all the nutrients (N, P, and K) were negative for both the good (class 1) and the poor (class 3) soil fertility managers. Class 1 farm balances irrespective of the season, were however more negative than those of class 3 farm. For the long rain season (LR2000), the net farm nutrient balances for N, P and K for class 1 farms were –18.7, -3.5 and –40.3 kg/ha respectively, while for the short rain season (SR 2000), the nutrient balances for N, P and K were –17, -0.8 and –22.0 kg/ha respectively. For farm class 3, the net farm nutrient balances for N, P and K in the long rain season (LR2000) were –12.6, -1.7 and –22.8 kg/ha respectively, while for the short rain season (SR 2000), the nutrient balances for N, P and K were –9.5, -0.3 and –18.2 kg/ha respectively. The partial nutrient balances for the sub-systems in the short rain season were about half those of the long rain season. Significant nutrient loss occurred in the crop production system as almost no nutrients return to the system. Potassium export from the farm was severe especially for farmers who sell a lot of banana. Strategic interventions for these small-scale farmers should be aimed at reversing nutrient depletion with focus on profitable management of the crop production system, which is the major cause of nutrient depletion. Strategic management of nutrients that enter the household system such as through home gardening, compost making near the household would greatly alleviate the return of nutrients to the crop production system.

2002 (113-122)

Fertilizer equivalency values of organic materials of differing quality In: Integrated nutrient management in sub-Saharan Africa (Eds B.Vanlauwe, J.Diels, N.Sanginga and R.Merkx)

Murwira, H.K, Mutuo, P., Nhamo, N., Marandu, A.E., R.Rabeson, Mwale, M. and Palm, C.A.

Field trials were carried out in five countries in sub-Saharan Africa to establish fertilizer equivalency values of organic materials of differing quality and their effects on maize yield. Organic materials used were fresh leaves of tithonia, senna, calliandra, sesbania, and tephrosia,, pigeon pea litter and cattle manure.

The fertilizer equivalencies for organic materials with %N > 2.5 were positively correlated ($r = 0.86$, $P = 0.01$) to their N content, showing the dependency of the fertilizer equivalency of an organic material on its N content. The relationship was linear indicating that an increase of %N in the tissue of the plant material increased its fertilizer value. For plant materials the critical level of N for increasing crop yield relative to 0 N was 2.4%, providing materials did not have high lignin and polyphenol contents. Use of N-poor cattle manure resulted in a fertilizer equivalency of 30% or less, even depressing yields compared to the control in some instances. At two of the sites where cattle manure was used, 90 kg N and 100 kg N was required to overcome the negative effects of manures applied.

Tropical Science (In press)

Economics of heap and pit storage of cattle manure for maize production in Zimbabwe

Murwira, H.K. and Kudya, T.L.

This study evaluates the profitability of using aerobic (heap) and anaerobic (pit) composted cattle manure for maize production. Pit storage of manure gave bigger yields of maize than heap storage in the year of application, and is much more profitable. Although the yields from heaped manure increase in the second and third years after manure application, over the three-year period pit storage is more advantageous.

Plant and Soil 237(2001), 197-210

Phosphorus Transformations in an Oxisol under contrasting land-use systems: The role of the soil microbial biomass

Oberson, A., Friesen, D. K., Rao, I.M., Bühler, S. and Frossard, E.

It is generally assumed that phosphorus (P) availability for plant growth on highly weathered and P-deficient tropical soils may depend more on biologically mediated organic P (P_o) turnover processes than on the release of adsorbed inorganic P (P_i). However, experimental evidence showing the linkages between P_o, microbial activity, P cycling and P availability is scarce. To test whether land use systems with higher soil P_o are characterized by greater soil biological activity and increased P mineralization, we analyzed the partitioning of P among various organic and inorganic P fractions in soils of contrasting agricultural land-use systems and related it to biological soil properties. Isotopic labeling was used to obtain information on the turnover of P held in the microbial biomass. Soil samples were taken from grass-legume pasture (GL), continuous rice (CR) and native savanna (SAV) as control. In agreement with estimated P budgets (+277, +70 and 0 kg P ha^{-1} for CR, GL and SAV, respectively), available P tested using Bray-2 and resin extraction declined in the order CR > GL > SAV. Increases in Bray-2 and resin P_i were greater in CR than GL relative to total soil P increase. Organic P fractions were significantly less affected by P inputs than

inorganic fractions, but were a more important sink in GL than CR soils. Extractable microbial P (P_{chl}) was slightly higher in GL (6.6 mg P kg^{-1}) than SAV soils (5.4 mg P kg^{-1}) while significantly lowest in CR (2.6 mg P kg^{-1}). Two d after labeling the soil with carrier free ^{33}P, 25, 10 and 2% of the added ^{33}P were found in P_{chl} in GL, SAV and CR soils, respectively, suggesting a high and rapid microbial P turnover that was highest in GL soils. Indicators on P mineralization were higher in GL than CR soils, indicating a higher transformation potential to render organic P available. Legume-based pastures can be considered as an important land use option as they stimulate P cycling. However, it remains to be investigated whether crops planted in pasture-crop rotations could benefit from the enhanced organic P cycling in grass-legume soils, and a direct method to quantify organic P mineralization should be developed and tested in these systems.

Soil and Tillage Research 62(2001): 131-143

Disc harrowing intensity and its impact on soil properties and plant growth of agropastoral systems in the Llanos of Colombia

Phiri, S., Amézquita, E., Rao, I.M., and Singh, B.R.

Oxisols such as those of the Colombian Eastern Plains (Llanos) are susceptible to physical, chemical and biological degradation once brought into cultivation, especially under intensive use of machinery. The main objective of this study was to determine the impact of intensive disc harrowing (2, 4 or 8 disc harrow passes per year over 3 years) on soil physical and chemical properties, soil phosphorus dynamics, plant growth and nutrient acquisition of contrasting agropastoral systems on an Oxisol. The three main systems tested after 2 years of upland rice cultivation were grass alone pasture (*Brachiaria dictyoneura*), green manure (*Crotalaria juncea*), and maize (*Zea mays*). Native savanna treatment was used as a control. Intensive disc harrowing improved macroporosity values of 0-5 cm soil layer up to 59 % for grass alone pasture system compared to native savanna. Disc harrowing significantly reduced bulk densities for pasture and green manure systems compared to the native savanna in the 0-5 cm soil layer. Intensive disc harrowing significantly improved volumetric moisture content of green manure and maize systems at 5-10 cm soil depth. The distribution of biologically, moderately and sparingly available P, organic P and total P varied under green manure, maize and grass alone pasture systems. Two passes of disc harrow per year were sufficient for grass alone pasture while maize showed greater aboveground production and nutrient acquisition at 8 passes of disc harrow per year. The maize and green manure cropping systems were better than the grass alone pasture system at separating the effect of increased number of disc harrow passes on soil physical and chemical characteristics.

Plant and Soil 231(2001), 211-223

Changes in soil organic matter and phosphorus fractions under planted fallows and a crop rotation system on a Colombian volcanic-ash soil

Phiri, S., Barrios, E., Rao, I.M. and Singh, B.R.

Planted tree or shrub fallows can help increase the fertility of degraded tropical soils. We investigated the effects of planted fallows of *Indigofera* (IND), *Calliandra* (CAL), and *Tithonia* (TTH); a natural, unmanaged fallow (NAT); and a maize/bean rotation (ROT) on the dynamics and partitioning of soil organic matter (SOM) and phosphorus (P). One year after treatment, samples were collected from a fine-textured volcanic-ash soil (Oxic Dystropept) of a mid-altitude hillside in southwestern Colombia. The SOM in the sand-size fraction (150-2000 μm) was subdivided into light (LL), intermediate (LM), and heavy (LH) fractions. Total soil P was also fractionated into inorganic (P_i) and organic (P_o). Of the planted fallows, TTH most increased and NAT least increased plant-available P_i and P_o. The amounts of C, N, and P in the LL and LM fractions of SOM followed the order, TTH > CAL > NAT > ROT > IND and CAL > TTH > IND > NAT > ROT, respectively. Total amounts of N, P, K, Ca, and Mg in the soil were significantly ($P < 0.05$) highest under TTH and lowest under NAT. The fallow and ROT systems did not affect the C/N, C/P, and N/P ratios in the soil but significantly did so in the LL and LM fractions of SOM. Significant correlations indicated that the P content in the LL and LM fractions of SOM may help determine the amounts of $NaHCO_3$-extractable P_i and P_o, which may therefore serve as sensitive indicators of "readily available" and "readily mineralizable" soil P pools, respectively, in the volcanic-ash soils of the Andes.

"Developing decision guides for managing soil fertility using organic resources available to farmers" in, *Challenges to the Farming Systems Approach: Past, Present, and Future*. 8th SEAAFSR-E (South and East African Assoc. of Farming Systems Research & Extension) Conference, 20-24 August, 2001. Nairobi, Kenya

Ramisch, J.J., Murwira, H.K. and Delve, R.J.

The FSR/E approach advocates working directly with farmers and viewing their farming practices as part of larger, holistic systems. While soil fertility decline is a major problem in sub-Saharan Africa, small holders rarely identify it as the top priority on-farm. As a result, despite their technical merits, many interventions designed to improve soil fertility have not been well adopted since they fail to adequately address on-farm resource allocation issues. TSBF has been working to design decision support tools that recognise farmers' existing knowledge of soil fertility and its management, while acknowledging on-farm constraints. The development of these decision guides is an iterative and participatory process that offers great potential for insights into farmer priority setting, decision-making, and opportunities for meaningful exchange between researchers, extensionists, and smallholders. Using the example of decision guides for using locally available organic resources (animal manure, composts, shrub or tree biomass), the methodological issues raised by the guide design process are discussed. Different scientific disciplines approached the guide development process from distinctly different starting points. Initial designs imagined far more outcomes (the so-called 'basket of options') than would be practical on-farm and largely neglected the existing knowledge of farmers. Data to support the guides was much stronger for maize than for the vegetable crops that farmers actually chose to target. Although still a work in progress, we now recognise that the guides' ultimate arbiter is the farmer, who must find the guide's steps relevant and logical, and the generated outcome(s) useful.

"Contending pathways of crop–livestock integration and the prospects of sustainable intensification in Southern Mali" in, Williams, T.O., Tarawali, S. (eds.) *Sustainable crop-livestock production for improved livelihoods and natural resource management in West Africa*, ILRI-IITA conference, November 19-22, 2001. Ibadan, Nigeria.

Ramisch, J.J.

Since the mid-1980's, the largely agricultural landscape of sub-humid southern Mali has also become the country's most important livestock-raising region. Cotton cash-crop farmers have been investing in animals for ploughing, weeding, and drawing carts. Semi-sedentary Fulani have also moved south into the region with their herds, following Sahelian droughts of the 1970's and 80's. A yearlong village-based case study investigated what forms of crop–livestock integration, competition, or co-existence were emerging in the region. Particular attention was paid to the agro-pastoral exchanges within and between the village, hamlet, and Fulani communities. The impacts of these exchanges were assessed by calculating household nutrient budgets. Although the sample-wide nutrient balance was negative, there was considerable regional and household-level variation. These differences were due to the redistribution of nutrients through exchanges, and sub-regional differences in resource endowment. The cereal-centred rotations of the Fulani used virtually no inorganic inputs, but obtained high yields and avoided soil nutrient deficits by using large applications of manure. The cotton-centred rotations favoured by the village and hamlet households were more capital intensive but typically ran substantial nutrient deficits. Nutrients were exchanged between households having a manure "surplus" they could not exploit and cart owners who would take this surplus as payment for use of their cart. Exchanges of draft power were important for increasing labour efficiency during cultivation and weeding. The exchanges also helped to maintain cordial relations between ethnic communities, and to consolidate the political power of local elites.

Despite having access to a fairly simple suite of cultivation and livestock assets, households were able to combine them in a diversity of ways by following one or more of five crop–livestock integration pathways. While the "mixed farming" model has been actively supported in the region by the CMDT, the other pathways have also led to viable livelihood strategies. These strategies need broader recognition and support, especially given the recent collapse of cotton prices and the need to increase the social and political participation of Fulani within the region.

"Crop–livestock integration policy in Africa: What is to be done?" Chapter 5 in I. Scoones and W. Wolmer (eds.), *Pathways of Change: Crops, Livestock, and Livelihoods in Africa. Lessons from Ethiopia, Mali, and Zimbabwe*. James Currey, London.

Ramisch, J.J., Keeley, J. Scoones, I. and Wolmer, W.

The aim of externally generated development interventions is not to reinforce a particular status quo, but to encourage changes that reduce poverty and improve the sustainability of livelihoods. Continuing critical interest in the role of crop–livestock integration in supporting sustainable livelihoods for Africa's poor demands, we suggest, that present policy shed its emphasis on simple evolutionary models. A review of recent agricultural and livestock policy in the three case study countries [Ethiopia, Mali, and Zimbabwe] as well as the development and research priorities of the United Kingdom (DfID) show that narrow, disciplinary approaches and linear, evolutionary models still prevail. Analysis of the case study material, however, presents the beginnings of an alternative framework for thinking about pathways of agricultural and livelihood change, by emphasising non-deterministic pathways, social differentiation, and processes of institutional mediation. Overall, the case study

material suggests the ultimate goals of technological change should include the following: a) Promoting diversity in adaptive technologies and enabling indigenous crop–livestock integration, rather than promoting particular, idealised packages like 'mixed farming'; b) Situating crop–livestock integration within a broader livelihood context of farm and non-farm commitments; c) Engaging variability directly, to formally integrate concepts of risk and vulnerability into development planning; d) Directly addressing poverty amongst vulnerable groups, such as poor households and women.

Plant and Soil 233(2001): 71–83

Effects of fertility management strategies on phosphorus bioavailability in four West African soils

Sinaj, S., Buerkert, A., El-Hajj, G., Bationo, A., Traor´e, H. and Frossard, E.

Low phosphorus (P) in acid sandy soils of the West African Sudano-Sahelian zone is a major limitation to crop growth. To compare treatment effects on total dry matter (TDM) of crops and plant available P (P-Bray and isotopically exchangeable P), field experiments were carried out for 2 years at four sites where annual rainfall ranged from 560 to 850 mm and topsoil pH varied between 4.2 and 5.6. Main treatments were: (i) crop residue (CR) mulch at 500 and 2000 kg ha.1, (ii) eight different rates and sources of P and (iii) cereal/legume rotations including millet (*Pennisetum glaucum* L.), sorghum [*Sorghum bicolor* (L.) Moench], cowpea (*Vigna unguiculata* Walp.) and groundnut (*Arachis hypogaea* L.). For the two Sahelian sites with large CR-induced differences in TDM, mulching did not modify significantly the soils' buffering capacity for phosphate ions but led to large increases in the intensity factor (CP) and quantity of directly available soil P (*E*1min). In the wetter Sudanian zone lacking effects of CR mulching on TDM

mirrored a decline of *E*1min with CR. Broadcast application of soluble single superphosphate (SSP) at 13 kg P ha.1 led to large increases in *C*P and quantity of *E*1min at all sites which translated in respective TDM increases. The high agronomic efficiency of SSP placement (4 kg P ha.1) across sites could be explained by consistent increases in the quantity factor which confirms the power of the isotopic exchange method in explaining management effects on crop growth across the region.

Soil Biology & Biochemistry 32(2000), 2063-2077

Utilization of rock phosphate by crops on a representative toposequence in the Northern Guinea savanna zone of Nigeria: Response by *Mucuna pruriens, Lablab purpureus*, and maize

Vanlauwe, B., Nwoke, O. C., Diels, J., Sanginga, N., Carsky, R. J., Deckers, J. and Merckx, R.

The availability of P from rock phosphate (RP) is often too low to demonstrate an immediate impact on cereal production. Legumes may improve the immediate availability of P from RP and eventually benefit subsequent maize crops. The ability of Mucuna pruriens (L.) var utilis (Wright) Burck and Lablab purpureus L. to use P from phosphate rock (RP) and the changes in selected plant and symbiotic properties and in the soil available P and particulate organic matter (POM) pool as affected by the addition of RP were measured for a set of soils on a representative toposequence ('plateau', 'slope', and 'valley' field) in the Northern Guinea savanna zone (NGS) of Nigeria. At 18 weeks after planting (WAP), Mucuna accumulated significantly more N and P in the total biomass in the plots treated with RP compared to the plots without RP addition on all fields. Nitrogen accumulation of Mucuna reached 175, 177, and 164 kg N ha^{-1} in the treatments with RP on the 'plateau', 'slope', and 'valley' fields, respectively. Phosphorus accumulation of Mucuna was highest at 18

WAP in all sites and reached 10, 14, and 10 kg P ha^{-1} in the treatments with RP on the 'plateau', 'slope', and 'valley' fields, respectively. Lablab accumulated significantly more N and P at 18 WAP only on the 'plateau' field, but some of the potential differences in N or P accumulation may have been masked by various pests especially affecting Lablab. A highly significant negative correlation was observed between the aboveground biomass at 16 WAP and the nematode population. The addition of RP significantly increased arbuscular mycorrhizal fungi (AMF) infection of the Mucuna (from 24% to 33%) and Lablab roots (from 15% to 28%) to a similar extent in all fields. This increased AMF infection was most likely caused by specific processes in the rhizosphere of the legumes as AMF infection of the maize roots (8%) was not affected by RP addition. Increases in nodule numbers and fresh weight were site- and species-specific and highest for the 'plateau' and 'slope' fields. The number of nodules increased on average from 8 to 19 (3 plants)$^{-1}$ and from 7 to 30 (3 plants)$^{-1}$ for Mucuna and Lablab, respectively, after RP addition. Although nearly all the aboveground legume biomass had disappeared from the soil surface at 51 WAP, both the Olsen-P status and POM N concentration were increased by the presence of legumes. Mucuna significantly enhanced the Olsen-P content of the soil after RP addition compared to the Lablab or maize treatments on the 'plateau' and 'valley' fields. Due to the relatively high initial Olsen-P content of the 'slope' field (14 mg kg^{-1}), differences between treatments were not significant. The N concentration of the POM pool was significantly higher under legumes than under maize on the 'slope' and 'valley' fields, and indicates incorporation of part of the legume biomass in the POM pool. The addition of RP to herbaceous legumes was observed to lead to site– and species–specific changes in the tripartite legume–rhizobium–mycorrhizal fungus, driven by processes taking place in the rhizosphere of the legumes, and in the soil available P pool. A cereal following these herbaceous legumes could benefit from this improvement in soil fertility status.

Plant and Soil, 231(2001) 187-199

Alley cropping with *Senna siamea* in South-western Nigeria: I. Recovery of N-15 labeled urea by the alley cropping system

Vanlauwe, B., Sanginga, N. and Merckx, R.

Improved cropping systems with *in-situ* production of organic matter require the input of additional inorganic N to maintain crop production in a sustainable way. For proper management of this fertilizer-N, its is necessary to quantify how the applied fertilizer N is used by the various components of the system and by the system as a whole. The fate of a single application of ^{15}N labeled urea-N through the different components (crop, hedgerow, surface litter, soil profile up to 150 cm) of a *Senna siamea* alley cropping system, intercropped with maize in the first and cowpea in the second season, was followed for a period of 1.5 years (1994-1995), equivalent to 2 maize and 1 cowpea crop. Special attention was given to the role of the particulate organic matter (POM) in the cycling of urea-N through the soil organic matter (SOM). The maize crop recovered 26.5 and 1.7% of the applied urea-N at harvest in 1994 and 1995, respectively. The cowpea pods recovered only 0.7% of the applied urea-N at harvest. The highest proportion of applied urea-N recovered by the hedgerow occurred at 38 days after 1994 maize planting (DAP) (3.8%), while at later dates, recoveries of applied urea-N were always below 1%. This indicates that the *Senna* hedge is not a strong competitor for the applied urea-N during crop growth, i.e., while the *Senna* canopy is pruned at regular intervals. At 21 DAP, 12.7% of the applied urea-N was recovered in the surface litter and this value dropped significantly to 1.6% at 107 DAP and remained below 1% up to 480 DAP. The top 10 cm of soil contained 21% of the applied urea-N at 21 DAP and this value dropped to 9% at 480 DAP. Significantly more urea-N was recovered in the top 10 cm

of soil than in the deeper soil layers at all sampling times. At 21 DAP, 11% of the applied urea-N was recovered in the 120-150 cm layer. This fast movement of urea-derived N to deep soil layers must have happened by preferential flow in macropores as the rainfall between urea application and the first sampling (74.2 mm) was not high enough to explain downward movement of N with the mobile water. Significant linear relationships between the proportion of urea-N in the different soil layers (excluding 0-10 cm) and the anion exchange capacity (AEC) and silt+clay content of the respective layers were found at 67, 107, 347, and 480 DAP. The total N content of the POM fraction increased significantly between 0 and 101 DAP from 127 to 171 mg N kg^{-1} and decreased to 92 mg N kg^{-1} at 480 DAP. The highest recovery of applied urea-N in the POM pool was measured at 101 DAP (3.6%) and this value decreased to 1.8% at 480 DAP. The total recovery of applied urea-N was 81% at 21 DAP, and decreased to values varying between 53 and 60% up from 38 to 347 DAP. At 480 DAP, the recovery decreased further to 47%. The fast movement of a substantial amount of urea-N may be responsible for this incomplete recovery, already at 21 DAP. Although the soil N status in the fertilized alley cropping system appears to be favourable for plant growth, this may be short-lived in absence of further urea additions, as the soil-derived maize uptake in 1995 was already significantly lower than in 1994 and as the labile POM pool decreased significantly between the maize harvest in 1994 and 1995.

Agronomy Journal, 93(2001), 1191-1199

Maize yield as affected by organic inputs and urea in the West-African moist savanna.

Vanlauwe, B., Aihou, K., Aman, S., Iwuafor, E. N.O., Tossah, B. K., Diels, J., Sanginga, N., Merckx, R. and Deckers, S.

Nutrient depletion is a major constraint for moist savanna soils, and inputs of nutrients are required to overcome this constraint. The impact of sole and combined applications of organic inputs (fresh tree prunings, *Pueraria phaseolides* (Roxb.) Benth. residues, and manure) and urea on maize (*Zea mays* L.) performance was investigated at four sites in West Africa. Interactions between organic inputs and urea resulting in added benefits from their mixed rather than sole application were quantified and likely causes were evaluated. Maize in the 'mixed' treatments, receiving 45 kg urea-N ha^{-1} and 45 kg N ha^{-1} as organic inputs, produced 1.6 Mg grain ha^{-1} in Sékou and 3.7 Mg ha^{-1} in Glidji. Based on the yields from sole application of either organic inputs or urea, added benefits from the mixture were 0.49 Mg grain ha^{-1} ($P < 0.001$) in Sékou and 0.58 Mg ha^{-1} ($P < 0.15$) in Glidji. These benefits were generated during grain filling, which was characterized by drought, and they were likely caused by improved soil water conditions with mixed compared with sole applications. Nitrogen recovery from urea was higher in the combined treatments (44% in Sékou and 32% in Glidji) relative to the sole urea treatments (22% in Sékou and 15% in Glidji). Positive interactions between organic inputs and urea occurred at two of four sites and were likely caused by improved soil water conditions after applying organic inputs. Organic inputs can alleviate other constraints to crop growth than N and as such improve the use efficiency of N fertilizer.

SSSA Special Publication Number 58, Madison, USA, pp 247-280, 2001
Combined application of organic matter and fertilizer. In: Sustaining Soil Fertility in West-Africa (Eds G Tian, F Ishida and J D H Keatinge),

Vanlauwe, B., Wendt, J. and Diels, J.

In the first section of this review, several points related to the sole use of fertilizer are addressed. Crops do respond to fertilizer, agronomically and socio-economically. Environmental considerations and the often high cost and low availability of fertilizer made the agricultural research and extension community turn away from fertilizers towards the 'green' organic matter strategy. In the second section, the application of organic matter (OM) as a strategy to boost crop production is evaluated. Although on poor soils, maize yield in the Moist Savanna Zone (MSZ) can be increased up to 140% relative to treatments without OM application, the absolute yield increases were at most 1000 kg grain ha^{-1}. These relatively low responses to the application of OM are related to the low N recovery by a following crop. Although long-term application of OM was observed to boost the soil fertility status, major problems associated with the sole use of OM include the limited response to OM application and difficulties to incorporate an OM production phase in existing cropping systems. In recent years most soil fertility research has been shifted towards the combined application of OM and fertilizer and possible positive interactions or added benefits generated through this combined application. In the third section, the impact of combined applications of OM and fertilizer is evaluated. Agronomically, the combined application of OM and fertilizer can easily lead to 200-400% increases in maize grain yield relative to an unamended control and give absolute yield increases easily exceeding 2000 kg grain ha^{-1}. However, the scope for obtaining positive interactions between both inputs is limited, highest for cropping systems using external sources of OM, and lowest for alley cropping systems because of tree-crop competition. A *Direct* and *Indirect Hypothesis* was formulated addressing improvements in the supply and demand side of added external inputs, respectively, and as such improving the overall nutrient use efficiency. In more detailed studies specifically addressing this issue, evidence was presented that such interactions do take place, both following the *Direct* and *Indirect Hypothesis*. To test the *Direct Hypothesis*, studies using ^{15}N labeled fertilizer were initiated. Results showed a delay in movement of fertilizer N to deeper soil layers when mixed with incorporated low quality maize stover residues and a consequent improved fertilizer-N recovery by a subsequent maize crop. Higher quality *Mucuna* residues did not significantly alter the movement of fertilizer-N. Two examples supporting the *Indirect Hypothesis* are presented. In a first example obtained from 2 sites in the MSZ in which a dry spell occurred during the grain filling period, added benefits (AB) amounted to about 500 kg grain ha^{-1}. These were believed to be related to a reduction in soil moisture stress in the treatments with both inputs relative to the treatment with sole application of urea and a consequent better use of the applied urea. In a second example, valorization of rock phosphate with low reactivity through interaction with herbaceous legumes was shown to lead to AB of about 1000 kg grain ha^{-1}. The exact mechanisms leading to these interactions and the impact of the biophysical environment on these mechanisms need to be understood more clearly before the combination strategy can be sold to the extension and farmer community as a technology yielding extra produce at no additional cost.

Agroforestry Systems, 54(2002), 1-12

Root distribution of *Senna siamea* grown on a series of soils representative for the moist savanna zone of Togo, West Africa.

Vanlauwe, B., Akinnifesi, F. K., Tossah, B. K., Lyasse, O., Sanginga, N. and Merckx, R.

Although crucial for assessing the functioning of alley cropping systems, quantitative information related to the hedgerow tree root distribution remains scarce. Soil mapping and destructive soil sampling was used to assess the impact of soil profile features on selected root characteristics of *Senna siamea* hedgerows, growing in alley cropping systems in three sites (Glidji, Amoutchou, and Sarakawa) representative for the derived savanna of Togo, West Africa. While the soil profiles in Glidji and Sarakawa contained a clay accumulation horizon, the Amoutchou profile was sandy up to 1 m. The number of small roots (diameter < 2 mm), quantified on a soil profile wall, decreased with depth in all sites. For most soil depths, the abundance of small roots tended to be higher near the tree base, e.g., ranging from 5.3 dm^{-2} in Amoutchou to 21.4 dm^{-2} in Glidji for the 0-20 cm layer, than in the middle of the alley, e.g., ranging from 3.1 dm^{-2} in Amoutchou to 13.8 dm^{-2} in Glidji for the 0-20 cm layer. Root length density (RLD) of the 0-10 cm and 10-20 cm layers was significantly higher in Glidji than in Amoutchou ($P < 0.05$) and in Sarakawa ($P = 0.08$). Differences in RLD between sites were not significant for layers below 30 cm. For each layer, root weight densities (RWD) were similar in all sites, e.g., ranging from 0.44 mg cm^{-3} in Amoutchou to 0.64 mg cm^{-3} in Glidji in the 0-10 cm layer, indicating that the roots in the Glidji topsoil had a smaller overall diameter than in Amoutchou. In Amoutchou, the relative RLD was lower than in Glidji or Sarakawa for the top 40 cm of soil, while the inverse was observed for the layers between 50 and 100 cm deep and this was related to the sandy soil profile in Amoutchou. Another consequence of the sandy profile was the larger tap root diameter below 50 cm in Amoutchou compared to Sarakawa. For all sites, significant ($P < 0.001$) linear regressions were observed between RLD's, RWD's, and the abundance of small roots, although the variation explained by the regression equations was highest for the relationship between RLD and RWD. The potential of the hedgerows to recover nutrients leached beyond the reach of food crops or the safety-net efficiency was evaluated for the tree sites.

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Integrated Plant Nutrient Management in sub-Saharan Africa: From Concept to Practice

Vanlauwe, B., Diels, J., Sanginga, N. and Merckx, R.

Integrated nutrient management is currently a major area of interest of the international agricultural research community in Africa. As the search for options to arrest soil fertility degradation in sub-Saharan Africa (SSA) gathers speed, strategies need to be developed to increase agricultural production, while safeguarding the environment for future generations. An in-depth diagnosis and re-definition of the problems associated with the ever-increasing nutrient depletion in SSA formed the basis of the Balanced Nutrient Management Systems (BNMS) project, a collaborative effort between the International Institute of Tropical Agriculture (IITA) and the Katholieke Universiteit Leuven (KU Leuven). Previous collaboration between IITA and KU Leuven had focussed on soil organic matter as a key parameter in soil fertility in tropical regions. Without challenging this, evidence shows that only a combination of organic and inorganic fertilisers will lead to acceptable and sustainable solutions in the long run. The ongoing collaboration therefore aims at developing and testing management practices that maintain or improve soil nutrient balances by promoting the use of locally available sources of plant nutrients, maximising their nutrient use efficiency and optimising their combination with inorganic fertilisers. This

book is a compilation of peer-reviewed papers presented during the"International Symposium on Balanced Nutrient Management Systems" which was held between 09 and 12 October 2001 in Cotonou, Republic of Benin. The symposium was attended by nearly 130 participants from many countries from all over the world and marks the end of the first phase of the BNMS project. This project has interacted with various national and international partners over the years to achieve its goals, while targeting its efforts to the development of BNMS technologies for specific agro-ecological zones. In this attempt to obtain solid research results and to ensure that they have the potential to be adapted and adopted in a sustainable and ecologically sound manner, the BNMS project has shared research responsibilities from planning to implementation with the national research systems, extension services, NGOs and farmers in various countries in West Africa. This approach has proven to be increasingly beneficial to our research effectiveness as well as contributing in a significant manner towards the enhancement of the research capacity of the collaborating national programs. As the need for answers is urgent in this complex area of international agricultural development, targeted recommendations have been formulated at the end of this book, which will hopefully catalyse implementation and further development of integrated nutrient management technologies in other countries of sub-Saharan Africa.

Plant Physiology 125(2001), 1473-1484

The high level of aluminum resistance in signal grass is not associated with known mechanisms of external aluminum detoxification in root apices

Wenzl, P., Patiño, G.M., Chaves, A.L., Mayer, J.E. and Rao, I.M.

Aluminum (Al) resistance of signalgrass (*Brachiaria decumbens* Stapf cv. Basilisk), a widely sown tropical forage grass, is outstanding, compared with the closely related ruzigrass (*B. ruziziensis* Germain and Evrard cv. Common) and Al-resistant genotypes of graminaceous crops such as wheat, triticale and maize. Secretion of organic acids and phosphate by root apices and alkalinization of the apical rhizosphere are commonly believed to be important mechanisms of Al resistance. However, root apices of *B. decumbens* secreted only moderately larger quantities of organic acids than did those of *B. ruziziensis*, and efflux from *B. decumbens* apices was 3 to 30 times smaller than from those of Al-resistant genotypes of buckwheat, maize and wheat (all much more sensitive to Al than *B. decumbens*). In the presence, but not absence, of Al, root apices of *B. decumbens* alkalinized the rhizosphere more than did those of *B. ruziziensis*. The latter was associated with a shortening of the alkalinizing zone in Al-intoxicated apices of *B. ruziziensis*, indicating that differences in alkalinizing power were a consequence, not a cause, of differential Al resistance. These data indicate that the main mechanism of Al resistance in signalgrass does not involve external detoxification of Al. Therefore, highly effective resistance mechanisms based on different physiological strategies appear to operate in this species.

Relocation of the TSBF HQ at ICRAF

That the ICRAF Campus is the ideal home for TSBF-CIAT HQ has not been debated. The restraint from seeking relocation has been, on one hand, the scarcity of office space at ICRAF with the emergence of ICRAF campus as a global science park for CGIAR, and on the other, complacency created by the support enjoyed from UNESCO at the equally ultra-modern UN office complex. Little wonder then that since some office and laboratory space became available at ICRAF about three years ago, we have not found it difficult operating with one foot at each of the two complexes.

However the merger of TSBF and CIAT and a tripartite partnership with ICRAF made it necessary to fully relocate to ICRAF and that move was accomplished on 31 May, 2002. It

has entailed changes in contact addresses and new details are as follows:

Mail address:
c/o ICRAF, P O Box 30677,
NAIROBI, Kenya (we shall also continue to receive mail at the old address)

Telephone:
TSBF General lines: +254 2 524755 / 66
Director / Social Science Officer
+254 2 524766
AfNet Coordinator / ISFM Officer
+254 2 524755
Finance &Administration:
+254 2 524767 / 8
ICRAF Pilot line:
+254 2 524000

Fax: +254 2 524763 / 4

E-mail addresses:
General line: TSBFINFO@cgiar.org Direct lines: "Initial""dot""Last name"@cgiar.org
i.e. Charles Ngutu = C.Ngutu@cgiar.org

UNESCO has assured TSBF that it does not only pride in nurturing TSBF from inception to maturity as a soil science research Programme with a global agenda but is committed to continuing its support to enable the Programme enhance its contribution to sustainable food production and poverty eradication.

Charles Ngutu, TSBF Finance and Administration Officer

Announcements

Forthcoming events

- The 10th Congress of all African Association for Biological Nitrogen Fixation, 26 - 30 August 2002. University of Ghana, Legon, Accra, Ghana.
- The 17th World Congress of Soil Science, 14 – 21 August 2002. Queen Sirikit National Convention Center, Thailand.
- The 20th Annual Conference of the Soil Science Society of East Africa (SSSEA), 2nd-6th December 2002, Tororo, Uganda.

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Books

Announcing the publishing of:

Barrett, C.B., Place, F., Aboud, A.A. (Eds) 2002. Natural Resource Management in African Agriculture: Understanding and Improving Current Practices. CAB International, Wallingford. 368 pages. ISBN: 0 85199 584 5. Price £ 60 (US$ 95) Hardback.

Vanlauwe, B., Diels, J., Sanginga, N., Merckx, R. (Eds) 2002. Integrated Plant Nutrient Management in Sub-Saharan Africa: From Concept to Practice. CAB International, Wallingford. 384 pages. ISBN: 0 85199 576 4. Price £ 55 (US$ 100) Hardback.