Output 4
Improved rural livelihoods through sustainable, profitable, diverse and intensive agricultural production systems

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Rationale

Intensification and diversification of smallholder agricultural production is needed to meet the food and income needs of the poor and cannot occur without investment in natural resource management, especially soil fertility. Investing in soil fertility management is necessary to help households mitigate many of the characteristics of poverty, for example, by improving the quantity and quality of food, increasing income, and resilience of soil productive capacity. Access to multiple stress-adapted and improved crop varieties and multi-purpose legume species, improved soil and water conservation practices and improved targeting to different categories of farmers, are a few examples of existing interventions.

Investment in improving soil fertility is not constrained by a lack of technical solutions *per se* but is more linked to lack of access to: information for improved decision making and analyzing trade-offs; inputs (e.g. fertilizers, credit and improved germplasm) and profitable markets.

Technical innovation to improve poor people's agricultural productivity can link the goals of improving small farm competitiveness, increasing assets, nutrition and income to the sustainable management of the natural resource base.

Key research questions

1. Which ISFM options are appropriate, where (farm//landscape), and for which farmers (typologies/social capital) to create profitable and resilient agricultural production systems?
2. What are the component and system thresholds for improving resilience of target farming systems?
3. Where and under what conditions does market orientation lead to increased investment in integrated natural resource management (INRM) and improved livelihoods?
4. What information, resources and knowledge do farmers need for improved decision making?

Output target 2008

- ***Improved production systems having multiple benefits of food security, income, human health and environmental services identified***

Published work

Zingore[1], S., Murwira [2], H.K., Delve [2], R.J., and Giller [3], K.E. (2007) Influence of nutrient management strategies on variability of soil fertility, crop yields and nutrient balances on smallholder farms in Zimbabwe. Agriculture Ecosystems and Environment, 119: 112-126

[1]CIAT-TSBF, Malawi; [2]CIAT-TSBF, Zimbabwe; [3]WUR, The netherlands

Abstract: An improved understanding of soil fertility variability and farmers' resource use strategies is required for targeting soil fertility improving technologies to different niches within farms. We measured the variability of soil fertility with distance from homesteads on smallholder farms of different socio-economic groups on two soil types, granite sand and red clay, in Murewa, northeast Zimbabwe. Soil organic matter, available P and CEC decreased with distance from homestead on most farms. Soil available P was particularly responsive to management, irrespective of soil type, as it was more concentrated on the plots closest to homesteads on wealthy farms (8–13 mg kg^{-1}), compared with plots further from homesteads and all plots on poor farms (2–6 mg kg^{-1}). There was a large gap in amounts of mineral fertilizers used by the wealthiest farmers (>100 kg N and >15 kg P per farm; 39 kg N ha^{-1} and 7 kg P ha^{-1}) and the poorest farmers (<20 kg N and <10 kg P per farm; 19 kg N ha^{-1} and 4 kg P ha^{-1}). The wealthy farmers who owned cattle also used large amounts of manure, which provided at least 90 kg N and 25 kg P per farm per year (36 kg N $ha^{-1}$and 10 kg P ha^{-1}). The poor farmers used little or no organic sources of nutrients. The wealthiest farmers distributed mineral fertilizers evenly across their farms, but preferentially targeted manure to the plots closest to the homesteads, which received about 70 kg N and 18 kg P per plot (76 kg N ha^{-1} and 21 kg P ha^{-1}) from manure compared with 23 kg N and 9 kg P per plot on the mid-fields (26 kg N ha^{-1} and 10 kg P ha^{-1}), and 10 kg N and 1 kg P per plot (and ha^{-1}) on the outfields. Crop allocation on the homefields was most diversified on the wealthiest farms where maize was allocated 41% of the area followed by grain legumes (24%) and paprika (21%). Maize was allocated at least 83% of the homefields on farms with less access to resources. All the farmers invariably applied nutrients to maize but little to groundnut. Maize grain yields were largest on the homefields on the wealthy farms (2.7–5.0 t ha^{-1}), but poor across all fields on the poor farms (0.3–1.9 t ha^{-1}). Groundnut grain yields showed little difference between farms and plots. N and P partial balances were largest on the wealthy farms, although these fluctuated from season to season (-20 to +80 kg N per farm and 15–30 kg P per farm; average 21 kg N ha^{-1} and 8 kg P ha^{-1}). The partial balances on the wealthy farms were largest on the homefield (20–30 kg N and 13 kg P per plot; >26 kg N ha^{-1} and >13 kg P ha^{-1}), but decreased to 10–20 N and 6–9 kg P per plot (<20 kg N ha^{-1} and 13 kg P ha^{-1}) in mid-fields and -7 to +10 kg N and -1 to +1 kg P per plot (<10 kg N ha^{-1} and <2 kg P ha^{-1}) in the outfields. N and P balances differed little across plots on the poor farms (-2 to +4 kg per plot; -5 to +4 kg ha^{-1}) due to limited nutrients applied and small off-take from small harvests.

This study highlights the need to consider soil fertility gradients and the crop and nutrient management patterns creating them when designing options to improve resource use efficiency on smallholder farms.

Delve[1], R. J., Huising[2], J E. and Bagenze[3], P. (2007) Target area identification using a GIS approach for the introduction of legume cover crops for soil productivity improvement: A case study in eastern Uganda. African Journal of Agricultural Research (AJAR), Vol 2, no10, pp 512-520

[1]*CIAT, Zimbabwe;* [2]*CIAT-TSBF, Kenya;* [3]*Makerere University*

Abstract: Improved fallow management using legume cover crops is largely seen as an option to intensify the production systems while maintainig the provision of environmental services. The paper addresses the target area identification and does not report on the improved performance of the production system propagated, as established through trials or otherwise. The rational for the study has been that improved targetting of the technology will contribute to enhancing the adoption potential.

Mairura[1], F.S., Mugendi[1], D.N., Mwanje[1], J.I., Ramisch[2], J.J., Mbugua[3], P.K., Chianu J.N. (2007) Integrated scientific and farmers' evaluation of soil quality indicators in Central Kenya. Geordama 139:134 -148

[1]*Kenyatta University, Kenya;* [2]*TSBF – CIAT, Kenya;* [3]*Department of Botany, Kenyatta University*

Abstract: A study was conducted to determine farmers' perceptions of soil quality and common soil management practices that influenced soil fertility within farmers' fields in Chuka and Gachoka division, Kenya. Soils were characterized by smallholders after which they were geo – referenced and sampled at surface depth (0-20cm) for subsequent physical and chemical analyses, to determine differences within farmers' soil quality categories. Indicators for distinguishing productive and non-productive fields included crop yield and performance, soil colour and soil texture. There were significant differences among soil fertility categories, using parametric techniques (ANOVA) for key soil properties ($p<0.005$), implying that there was a qualitative difference in the soils that were characterized as different by farmers. Fertile soils had significantly higher pH, total organic carbon, exchangeable cations and available-N. Factor analysis on 15 soil properties identified 4 main factors that explained 68% of the total variance in soil quality. The four Varimax-rotated factors were designated as contrasts that described soil quality status on farmers' fields. The first factor grouped calcium, magnesium and soil pH, while the second component available nitrogen, organic carbon and total nitrogen. The third factor included plant nutrients mainly extractable phosphorus and available nitrogen, while the fourth factor comprised soil physical properties (macroaggregates, microaggrates, silt, and clay). Soil fertility and crop management practices that were investigated indicated that farmers understood and consequently utilized spatial heterogeneity and temporal variability in soil quality status within their farms as a resource to maintain or enhance agricultural productivity.

Mairura[1], F.S., Mugendi[2], D.N., Mwanje[2], J.I. Ramisch[1], J.J. Mbugua[3], P.K. Chianu[1], J.N. (2007) Scientific Evaluation of Smallholder Land Use Knowledge in Central Kenya. Wiley Interscience DOI: 10, 1002/Idr.815

[1]CIAT– TSBF, Kenya; [2]Department of Environmental Resource Conservation, Kenyatta University, Kenya; [3]Department of Botany, Kenyatta University

Abstract: The following study was conducted to determine stallholders' land use management practices and agricultural indicators of soil quality within farmers' fields in Chuka and Gachoka divisions in Kenya's Central Highlands. Data on cropping practices and soil indicators were collected from farmers' through face to face interviews and field examinations. Farmers characterized their fields into high and low fertility plots, after which soils were geo – referenced and sampled at surface depth (0-20cm) for subsequent physical and chemical analyses, Farmers' indicators for distinguished productive and non-productive fields included crop yield, crop performance and weed species. Soils that were characterized as fertile had significantly higher chemical characteristics than the fields that were of poor quality. Fertile soils had significantly higher pH, total organic carbon, exchangeable cations and available nitrogen. Factor analysis identified four main factors that explained 76 percent of the total variance in soil quality. The factors were connected with farmers' soil assessment indicators and main soil processes that influenced soil quality in Central Kenya. Soil fertility and crop management practices that were investigated indicated that farmers understood and consequently utilized spatial hererogeneity and temporal variability in soil quality status within their farms to maintain and enhance agricultural productivity.

Chianu[1], J.N. Tsujii[2], H. and Mbanasor[3], J. (2007) Determinants of decision to adopt improved maize variety by smallholder farmers in the savannas of northern Nigeria. Journal of Food, Agriculture & Environment 5:84 – 90

[1]TSBF-CIAT, Kenya; [2]Ishikwa Prefectural University, Japan; [3]Michael Okpara University of Agriculture, Umuahia, Nigeria

Abstract: Improved germplasm of various cereals (maize, sorghum, millet, etc.) have been introduced to farmers in the savannas of northern Nigeria. Farmers' adoption rate for improved maize (49%) was the highes. The technological reasons for the high adoption rate for improved maize have been documented. However, only very little is known about the socioeconomic factors. This paper investigates these using the logit model on data collected from household survey. Significant parameters with the expected signs were household size, farmers' crop diversification level, membership of farmers' associations, household income and nearness to market. This shows that household's labor availability, risk management capability, access to information, economic capability and market access are important socioeconomic factors that explain farmer adoption of improved maize. The study was concluded with the policy recommendations for promoting the adoption of improved maize among farmers, including the need for maize varieties that combine high yield with labor-efficiency, national and international research systems and other agencies involved in agricultural development in the study area and similar environments to increase research on plant health management and small farmers' crop diversification strategies in order to reduce risk that small farmers face, and improvements in farmers' access to market through improvements of market infrastructure to reduce transaction costs.

Chianu[1], J.N. Tsujii[2], H. and Manyong[3], V.M. (2007) Crop-livestock interaction in the savannas of Nigeria: Nature and determinants of farmer decision to use manure for soil fertility maintenance. Journal of Food, Agriculture & Environment 5: 295 – 301. 2

[1]CIAT-TSBF, Kenya; [2]Ishikwa Prefectural University, Japan; [3]IITA, Nigeria

Abstract: In Nigeria, increased land-use intensity has depressed the use of fallow for soil fertility restoration. Crop yields have fallen, threatening food security. High cost limits farmers' access to fertilizers. Reliance on crop-livestock interaction is plausible because animals provide manure. This paper evaluates the nature of crop-livestock interactions in the savannas of northern Nigeria, assesses its capability to maintain productivity, and uses logit model to estimate determinants of farmers' decision to adopt manure for fertility maintenance. Results show that although 86% of the farmers indicated some interaction between crops and livestock, the interaction is weak. Manure is inadequately provided, only 56% of the farmers applied manure (40–67% of requirement) to their largest upland plot. Results of the logit model indicate that farmers' characteristics and perceptions are the most crucial factors. The paper concludes with recommendations to promote crop-livestock integration and the use of manure for fertility maintenance in the savannas of Nigeria and similar ecologies.

Chianu[1], J.N. Mairura[1], F. and Ihedioha[2], D. (2007) Socioeconomic and policy factors undermining farmers' access to soil fertility enhancing farm inputs in western Kenya. Soil Science Society of East Africa

[1]CIAT-TSBF, Kenya; [2]USAID/IITA-Abuja, Nigeria

Abstract: Increasing rural poverty in sub-Saharan Africa (SSA) has been of great concern to the development community. Compared to other regions of the world, low use of farm inputs (especially fertilizers) by small farmers is one of the factors responsible for the gap between potential and actual yields. Soil fertility decline is the main biophysical factor leading to poor crop yields in SSA. This study interviewed 130 agro-input dealers in Kenya to analyze the fertilizers stocked and sold, distance to markets from where agro-dealers source fertilizers, business constraints faced by agro-dealers, and policies for improving the agro-input sub-sector. The most common fertilizers stocked were Di-ammonium phosphate (DAP) (stocked by 92% of respondents), Calcium ammonium nitrate (CAN) (84%), Urea (78%) and NPK (40%). High transport cost (53%), low demand (30%), lack of market information (21%), lack of storage facilities (13%), and limited business knowledge (12%) were the most important constraints faced by agro-dealers. Selling price of inputs increased with distance to markets. Results indicate that farm gate prices continued to rise, while trade margins remain unfavorable for small scale farm input dealers. Policies and institutional frameworks were suggested for mitigating the constraints to farm input delivery and widespread access of small farmers to farm-inputs. The study concludes with suggestions on how to enhance efficiency of agro-dealers in input delivery.

Chianu[1], J N., Adesina[2], A., Sanginga[3], P., Bationo[1], A., Sanginga[1], N. (2007) Ex-ante evaluation of the impact of a structural change in fertilizer procurement method in sub-Saharan Africa.

[1]CIAT-TSBF, Kenya; [2]The Rockefeller Foundation, Kenya; [3]CIAT-Africa, Kawanda Agricultural Research Institute, Uganda.

Abstract: In June 2006, the African Heads of State made a declaration to support increase in use of fertilizers in the farming systems of sub-Saharan Africa from the present average, about 8 kg ha^{-1}, to about 50 kg ha^{-1}. One route to attain this goal is to engender regional joint fertilizer procurement to reduce farm gate price and increase fertilizer demand and use.

A review of fertilizer use in Africa has shown that structural changes in fertilizer procurement can reduce farm gate price by 11-18%. Using an average of these figures (15%), this study compares the effect of structural changes in fertilizer market (reducing farm gate price by 15%) on total fertilizer demand, total farm income, and additional farm income with the base situation (using FAO data) under three own fertilizer price elasticity of demand scenarios (low: -0.38; medium: -1.43; and high: -2.24) for 11 sub-Saharan Africa countries. Data were analyzed using Microsoft Excel. Result shows that compared with the base level, structural change in fertilizer procurement arrangement (reducing farm gate price by 15%) led to 6% additional farm income (US$125 million) under low elasticity; 22% (US$472 million) under medium elasticity; and 34% (US$730 million) under high elasticity. Switching from one scenario to another indicates the potential to further increase farm income from 20% to 32%. The paper concludes with the support for structural interventions that reduce farm gate price of fertilizers and other inputs. Such interventions increase farmer productivity, total production, and total farm income and lead to improved livelihoods.

Ihedioha[1], D., Odoemena[2], B., Ibana[3], S. and Chianu[4], J. (2007) Effects of drying of cowpea grains on consumer acceptability of moin-moin. Journal of Agriculture and Food Sciences 4(2): 125-131

[1]IITA, Nigeria; [2]PCU, Nigeria;[3]University of Calabar, Nigeria;[4] CIAT – TSBF, Kenya

Abstract: A drying test was conducted on wet de-hulled cowpea grains to ascertain the effects of drying at 60^{o}C, 70^{o}C, 80^{o}C, and 90^{o}C on the physico-chemical properties and sensory evaluation (consumer acceptability) of moin-moin from different flours. Chemical analyses were conducted on the flour to ascertain the effect of different levels of drying on the protein, carbohydrate and water binding capacity of the flours. A fifteen member trained panelist was purposively chosen to assess the quality of the moin-moin produced. The results of the analysis revealed that temperature of drying affected the protein, carbohydrate and water binding capacity of cowpea flour. The different drying scenarios also affected the acceptability of moin-moin by consumers. The study showed that moin-moin produced from a 60^{o}C dried cowpea grains was sensorily preferred and accepted by consumers.

Ajuruchukwu[1], O., Pote[1], P. and Chianu[2], J (2007) Paper presented at an International Symposium on "Innovations as Key to the Green Revolution in Africa Market access: components, interactions and implications in smallholder agriculture in the former homeland area of South Africa

[1]Department of Agricultural Economics and Extension, University of Fort Hare, South Africa, [2]CIAT-TSBF, Kenya

Abstract: While insufficient market access is recognized as a key institutional constraint to smallholder development in Africa, the generalities that characterize much of recent research on the subject mean that the mechanisms by which market access exerts influence are not well understood. Drawing on household-level data from the former "independent homeland" of South Africa, this paper employs the logistic model to isolate key components of market access, including access to market/price information, productive inputs, infrastructure, etc. Differences in the extent to which these factors constrain smallholder crop and livestock farmers buttress the expectation of greater policy impact from research that takes a wider view of market access. The paper fits the foregoing finding against the backdrop of South Africa's troubled past that continues to negatively impact on its agricultural economy. How this history has influenced intra- and inter-sectoral relationships and coordination is discussed. The paper further presents

results that shed light on how policy and smallholder support measures can be better targeted to address the problems of limited market access in the communal/rural areas in order to increase the use of agricultural inputs such as mineral fertilizers, enhance agricultural productivity and equity as well as improve overall rural livelihoods. Results will be extrapolated to other rural areas of sub-Saharan Africa which, in many respects, are similar to the former "independent homelands" of South Africa.

Sanginga[1], Pascal C., Kaaria[1], S., Muzira[2], R., Delve[3], R., Vanlauwe[4], B., Chianu[4], J., and Sanginga[4], N., (2007) The resources to consumption system L: Framework for Linking Soil Fertility Management Innovations to Market Opportunities. Advances in integrated soil fertility management in Sub – Saharan Africa: Challenges and opportunities Pp 979-992

[1]CIAT, Uganda; [2]CIAT, Kabale, Uganda; [3]CIAT-TSBF, Zimbabwe; [4] CIAT-TSBF, Kenya

Abstract: Recent paradigms in soil fertility management research have evolved from the initial reductionist approaches of nutrient replenishment to embrace a more holistic integrated soil fertility management (ISFM) approach that goes beyond soils to address the full chain of interactions, from resources to production systems, to markets and policies. It is now recognized that the adoption of ISFM technologies critically depends on market opportunities. It is argued that without well functioning markets, the adoption of ISFM innovations will remain limited. This paper examines this "market-led hypothesis" that linking farmers to better market opportunities will provide incentives for adoption and re-investment in ISFM innovations. This hypothesis is tested with empirical data from cross-sectional household surveys and action research on linking farmers to markets in selected sites in Malawi, Uganda and Tanzania. Analysis revealed mixed results, with significant differences based on gender, wealth categories, crops and areas. On one hand, there is evidence that better access to markets and increased income led to positive investments in agricultural inputs, increased fertilizer use and soil conservation measures. On the other hand, for the majority of women and poor farmers in Uganda, re-investing in ISFM was not even among the first three priorities, compared to other livelihood needs (buying or renting more farmland, livestock, paying school fees and buying clothes). The paper outlines a novel approach for demand-driven and market-led ISFM research for development. This approach termed the Resource-to-Consumption offers a practical framework to link ISFM research to market opportunities identification in a way that empowers farmers to better manage their resources and offers them incentives to invest in soil fertility improvement. The success of this approach is highly dependent on the development of effective quality partnerships with research and extensions systems, government and non-governmental organizations, business support services, farmer communities and the private sector; and building multi-institutional and trans-disciplinary research for development teams, with complementary skills and expertise. There are four key areas that need concerted efforts by a variety of stakeholders (i) improving output and input market access; (ii) participatory technology development; (iii) strengthening farmers' institutions, and (iv) influencing policy change.

Ohiokpehai[1], O., Kimiywe[2], J., Chianu[1], J., Mbithe[2], D., and Sanginga[1], N (2007) Feeding Patterns and Practices among Households with Children Aged 6-59 Months in Mbita Division, Suba District, Kenya. Journal Food for Agriculture & Economics 5:17-23

[1]CIAT-TSBF, Kenya; [2]Kenyatta University, Kenya

Abstract: The growth patterns of children are reflective of community nutritional status and food security, which is measured in terms of food consumption patterns and practices, availability and accessibility. Vital statistics from Suba district indicate high mortality rates of 146.9/1000 and 247/1000 for infants and under fives respectively. The expected HIV cases are also estimated at 41% of the reproductive population. The purpose of this study therefore was to conduct a baseline survey on the nutrition and health situation in Mbita division, Suba district, with the aim of developing a comprehensive programme for intervention using soybean-enriched diets in the management of HIV/AIDS. To achieve this, the following objectives were formulated; to establish the food consumption and utilization practices in the households; determine food production patterns and practices; determine food accessibility and availability, and to investigate the morbidity patterns of households and children. The survey was conducted in three locations namely Gembe West, Gembe east and Rusinga West. 265 households, 162 from township, 50 from Kayanja and 53 from Kaswanga were interviewed. Food frequency and 24-hour recall were used to collect data on household and children's food consumption patterns and practices. A structured questionnaire was used to collect data on feeding and childcare practices and household morbidity patterns. To access food availability and accessibility, respondents were asked questions on methods of food acquisition and production patterns. The study findings were verified by information from key informant focus group discussions and from observational checklist. Results indicated that the diets were inadequate for the majority of the households. Most households depended on fishing and very few practiced subsistence farming, most of the foods consumed were therefore purchased. Some families resorted to food for work and donations because of insufficient incomes. There was also a high prevalence of diseases among the children and in the households in general. The common illnesses reported were malaria, upper respiratory tract infections, stomachache and diarrhea/typhoid among others**.** An in-depth study should be conducted in Suba District in order to determine the magnitude of malnutrition and rate of morbidity and its relationship to the prevalence of HIV/AIDS, and the causes and consequences of these on the socio economic status of the individuals in the community. This will facilitate in the planning of viable intervention programmes, which should involve all the relevant stakeholders

Ohiokpehai[1], O., Kimiywe[2], J., Chianu[1], J., Mbithe[1], D., and Sanginga[1], N (2007) Socioeconomic and Demographic Profiles of Households with Children Aged 6-59 Months, Mbita Division, Suba District. Journal Food for Agriculture & Economics 5:45-49

[1]CIAT-TSBF, Kenya; [2]Kenyatta University, Kenya

Abstract: Household socioeconomic and demographic characteristics have been shown to have significant influence on nutrition and health status outcome. Their role in nutrition and health status of individuals infected or in households affected by HIV cannot therefore be ignored. Several studies and scientific literature have identified socioeconomic status (SES) as powerful determinant of health status. In fact today, health disparities as a result of SES have become important issues of public health concern worldwide.

Higher morbidity and mortality among people with lower SES has been extensively reported. Moreover, household SES has been shown to have great influence on the nutritional quality of children's diet in turn affecting their nutrition status. The survey was carried out to establish the socioeconomic and demographic characteristics of households with children aged 6-59 months in Mbita Division Suba District. A Descriptive Cross-sectional survey study was conducted in three sub locations. Also a pre-tested structured questionnaire was administered in 265 households with a child aged 6-59 months inclusive. Verbal consent was sought before the questionnaire was administered. Data obtained was coded, edited and statistically analyzed using SPSS software. Over 30% of the study population was children under-five, followed by those in the 16-25 age-ranges (23%). The average household size was 4.8. Overall, the study area has young population with 92% falling between 0-36 years, an indication of low life expectancy. Females (53.9%) constituted more than half of the total household members (n=1278), while males constituted 46.1%. A large proportion of the households were male headed (87.2%) compared to 12.8% headed by females. Thirty nine percent of the households belong to the protestant religion, followed by Seventh Day Adventists (36.1%). Literacy level in the study population was relatively low, 56% has primary education, < 18% and 5% secondary and tertiary education respectively. The study also revealed high level of unemployment rate in the study area, with 17.1% involved in unpaid employment. Finally the majority of the households fall within the low SES with deepening poverty background depicted by low educational achievement, occupational status and small land holding acreage. Attention to education and poverty alleviation programs might assist in curbing the possible negative effects associated with low SES on the nutrition and health status of members of such households.

Completed work

Building adaptive capacity to cope with increasing vulnerability due to climatic change in Africa– a new approach: Paper presented at the WAFSA-WATERnet conference, September 2007.

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Abstract: The world community faces many risks from climate change, with most scenarios indicating higher temperatures and more erratic rainfall in Africa. Predictions for southern Africa suggest a general decrease in total seasonal rainfall, accompanied by more frequent in-season dry spells that will significantly impact crop and livestock production, and hence economic growth in the region. The hardest hit will be the rural poor in the drier areas, where crop failure due to drought is already common and chronic food emergencies afflict the region in most years. Lessons can be learnt on how the rural poor currently cope with the vagaries of climate and be used to help them adapt their current production systems to the future threats of further climate change. But this assumes the institutions that work towards the economic empowerment of the rural poor have the requisite skills to understand their current coping strategies and how adaptation can be facilitated.

This new initiative led by Midlands State University and the Zambian Meteorological Office proposes that improving the ability of institutions that train the 'Future Change Agents', who will subsequently support smallholder communities in adapting their agricultural practices to *current* climate variability, is the first step in building adaptive capacity to cope with *future* climate change. The capacity of African scientists, regional organizations and decision makers in dealing with the issues of climate change and adaptation will be enhanced on a continuing basis, and the impacts of their agricultural development programs improved.

Commercialising Organic Agriculture: Does it Improve Household Food Security? A Case Study from South-western Uganda: Paper presented at "Utilization of diversity in land use systems: Sustainable and organic approaches to meet human needs", Tropentag, October 9-11, 2007, Witzenhausen

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The debate about the impact of commercial organic agriculture on food security in developing countries is controversial. While some authors argue that the premium price allows farmers to purchase food, other authors are of the opinion that commercialization is at the cost of household food security. Sufficient empirical evidence that supports these propositions, however, are missing. This research addresses the lack of information in this area and was aimed at understanding how commercial organic agriculture influences food security at household level, whereas special emphasis was put on farmer's perceptions of changing food security. Based on the sustainable livelihoods approach, the study operationalized the term food security by distinguishing three essential dimensions: availability of food, access to food and utilization of food. An ex post evaluation following the conversion to organic agriculture was carried out in Rakai/Masaka district, south-western Uganda. The sample included certified and non-certified organic households which where contrasted with households carrying out traditional agriculture in neighbouring villages. Data were collected using structured household surveys in combination with PRA. Both qualitative and quantitative data were generated. The results of the study reveal that organic agriculture interventions positively address several household food security dimensions, hence supporting farmers to improve their livelihoods. Higher income through premium prices, enhanced knowledge on natural resource management and higher diversity of crop and livestock production of organic farmers were identified as the main entry points for improved household food security. However, there are gaps in the household food security equation, notably because improved access and availability of food does not always translate into proper utilization of food. The results of this study suggest that more emphasis should be placed on the knowledge dimensions through holistic training guidelines for organic farmers. These guidelines shall integrate nutritional education with other important livelihood strategies for improving dietary diversity as cross-cutting themes.

Livelihoods activities and wealth ranking among rural households in the farming systems of western Kenya. In press.

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Abstract: The study examined the relationship between the livelihoods activities of rural households in the farming systems of Western Kenya in relation to their wealth. A stratified random sampling procedure was used to select 252 farm households from eight districts in three provinces. Focus group discussions (FGD) were used to collect community-level data which complemented household-level data. Results indicate that average household size was seven persons across survey districts. As expected, agriculture (crop and livestock) was the main activity of the farmers. Household labour was mainly allocated to crop enterprises, with household heads allocating an average of over 50 percent of their labour to crop enterprises. Maize and common beans are the most important staple food crops and traded food crops. Livestock enterprises are dominated by poultry production. For purposes of diversification for better livelihoods, some farm households engaged in small businesses (especially fish trading), employment and artisan work. The cropping system is mainly mixed cropping. Lack of cash and limited land availability were the most important factors that constrained agricultural development in Western Kenya. Although, most households preferred selling their farm produce in the markets or places where prices were better, many of them not only sold their farm produce but also purchased their farm inputs from the nearest towns due to problems and costs associated with going to where produce prices were better. Our results show a high wealth inequality among farm households in Western Kenya. This was in terms of both household wealth (with a Gini-coefficient of 0.52) and per capita wealth (with a Gini-coefficient of 0.55). The high level of inequality calls for more attention on proper targeting of development activities to ensure even distribution of resources and economic growth and development.

Key words: Livelihood activities, assets, crop and livestock enterprises gini coefficient, Lorenz curve, inequality

Ex-ante evaluation of the impact of a structural change in fertilizer procurement method in sub-Saharan Africa.

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In June 2006, the African Heads of State made a declaration to support increase in use of fertilizers in the farming systems of sub-Saharan Africa from the present average, about 8 kg ha^{-1}, to about 50 kg ha^{-1}. One route to attain this goal is to engender regional joint fertilizer procurement to reduce farm gate price and increase fertilizer demand and use. A review of fertilizer use in Africa has shown that structural changes in fertilizer procurement can reduce farm gate price by 11-18%.

Using an average of these figures (15%), this study compares the effect of structural changes in fertilizer market (reducing farm gate price by 15%) on total fertilizer demand, total farm income, and additional farm income with the base situation (using FAO data) under three own fertilizer price elasticity of demand scenarios (low: -0.38; medium: -1.43; and high: -2.24) for 11 sub-Saharan Africa countries. Data were analyzed using Microsoft Excel. Result shows that compared with the base level, structural change in fertilizer procurement arrangement (reducing farm gate price by 15%) led to 6% additional farm income (US$125 million) under low elasticity; 22% (US$472 million) under medium elasticity; and 34% (US$730 million) under high elasticity. Switching from one scenario to another indicates the potential to further increase farm income from 20% to 32%. The paper concludes with the support for structural interventions that reduce farm gate price of fertilizers and other inputs. Such interventions increase farmer productivity, total production, and total farm income and lead to improved livelihoods.

Work in progress

The Dynamics of Social Capital in Influencing Use of Soil Management Options in the Chinyanja Triangle of Southern Africa.

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Different soil fertility management options are lauded as the key to ensuring sustained production and preventing soil nutrient depletion in the Chinyanja Triangle of Zambia, Malawi and Mozambique where inorganic fertilizers are unaffordable for many rural households who are also burdened with unproductive, highly degraded small landholding sizes. Despite the short and long term tangible benefits of various low cost soil fertility management technologies, their adoption and use has been less than desirable within the Chinyanja Triangle. Hence one area of research in the Chinyanja triangle has been to access social capital, in addition to household socio-economic factors, to determine how it influences technology diffusion in the area, since it has been shown that rural communities that are characterized by strong social capital have faster rates of technology diffusion and improved environmental management outcomes (Claridge, 2007; Nyangena, 2006; Woolcock *et al*, 2007).

Logit Regression modeling, with social capital variables incorporated using Principal Factor Analysis (PFA), in combination with qualitative methods were used to analysis the data. Analysis of technology use and social capital levels shows that different types of social capital that exist within the communities, have different effects on the adoption and use of the different soil fertility management options **(Table 32).**

Bonding social capital was found to only positively influence the adoption of one technology, cover crops. Other technologies were not significantly influences by it. Many close knit communities that have strong bonding social capital have been known to be less diverse in technology adopt in as there is little outside influence and any external intervention is often viewed negatively. On the other hand, networking social capital (a combination of both bridging and linking social capital in this study) was found to have a positive relationship with incorporation of crop residues. This arises from that farmers that have been linked with external communities through formal and informal networks, have access to information and they are aware about the disadvantages of burning residues, which is a common practice in the Chinyanja Triangle.

Consequently, despite that social capital has been found to increase farmer's adoption of soil conservation measures (Cramb, 2004), the results show that it has a significant negative relationship with crop rotation, planting of agro forestry trees and use of inorganic fertilizers. Lastly Gender Social capital was found to have a positive significant relationship with agro-forestry tress, cover crops and soil erosion control. Agro-forestry trees provide different byproducts including fodder, firewood and fruit hence women are more readily willing to utilize them when available. Cover crops are an attractive source of income for women as men are less likely to control the income that is generated from their sale. The positive significant relationship between soil erosion control and gender was unexpected. It had been hypothesized that due to high labour requirement of constructing and maintaining soil erosion control structures, that the relationship between the gender variable and soil erosion structures would be negative. However, one of the most common form's of soil erosion control in Malawi is the planting of vertiver grass. Apart from being an effective mechanism for the control of erosion, the grass also provides fodder within the confines of own farms for livestock thereby reducing women's time and labour for harvesting fodder in communal areas.

Social capital variables are not isolated in influencing adoption decision but other household characteristics were also found to play an important role in influencing technology use at the household level. The study found that farmers that had negative perceptions towards inorganic fertilizers were more likely to use other forms of soil fertility management than those farmers that had positive perception of in organic fertilizer. Additionally, the study also found that farmers that perceived their land to have high fertility where less likely to use any form of soil fertility management option. Both these findings have policy implications for extension service delivery systems and the need to build capacity of farmers to effectively use both use of both inorganic and organic technologies and at all times.

Table 32: Results of Logit Model on Factors influencing use of Different Soil Management technologies in the Chinyanja Triangle

Variable	Coefficient	Std. error	p-value
Soil Erosion structures			
Constant	-1.561	0.518	0.003**
Sex of household head	0.761	0.281	0.007**
Perception of poverty	-0.114	0.232	0.625
Perception of fertilizers	-0.393	0.208	0.059*
Perception of soil fertility	-0.497	0.160	0.002**
Hire of labour	-0.078	0.222	0.722
Land area in ha	0.356	0.083	0.000***
Bonding	-0.289	0.113	0.798
Network	0.0139	0.126	0.913
Gender	0.254	0.122	0.038*
Age of household head	0.007	0.006	0.260
Household income	0.004	0.003	0.109
Use of crop rotation			
Constant	-0.037	0.488	0.939
Sex of household head	-0.049	0.244	0.984
Perception of poverty	0.058	0.225	0.794
Perception of fertilizers	-0.516	0.209	0.014*
Perception of soil fertility	-0.155	0.149	0.299
Hire of labour	0.638	0.219	0.004**
Land area in ha	0.616	0.116	0.000***
Bonding	-0.173	0.109	0.113
Network	-0.366	0.123	0.003**
Gender	-0.627	0.111	0.575
Age of household head	0.006	0.006	0.302
Household income	-0.001	0.002	0.580
Incorporation of crop residue			
Constant	-1.281	0.469	0.006**
Sex of household head	0.271	0.231	0.241
Perception of poverty	-0.011	0.218	0.960
Perception of fertilizers	-0.102	0.197	0.604
Perception of soil fertility	0.903	0.141	0.524
Hire of labour	-0.377	0.207	0.069*
Land area in ha	0.076	0.061	0.211
Bonding	0.072	0.102	0.482
Network	0.261	0.120	0.030*
Gender	0.025	0.106	0.811
Age of household head	-0.002	0.006	0.726
Household income	0.001	0.003	0.004**

Agroforestry trees			
Constant	-1.704	0.557	0.002**
Sex of household head	-0.182	0.269	0.499
Perception of poverty	-0.164	0.244	0.501
Perception of fertilizers	-0.679	0.217	0.002**
Perception of soil fertility	-0.007	0.165	0.962
Hire of labour	0.340	0.227	0.135
Land area in ha	0.091	0.659	0.169
Bonding	-0.090	0.118	0.447
Network	-0.562	0.140	0.000***
Gender	0.308	0.136	0.024*
Age of household head	0.014	0.007	0.047*
Household income	0.002	0.002	0.368
Use of cover crops			
Constant	-0.830	0.746	0.266
Sex of household head	0.554	0.437	0.205
Perception of poverty	0.602	0.315	0.849
Perception of fertilizers	-1.018	0.276	0.000***
Perception of soil fertility	-0.460	0.220	0.036*
Hire of labour	0.227	0.298	0.446
Land area in ha	0.104	0.072	0.150
Bonding	0.787	0.224	0.000***
Network	-0.168	0.171	0.324
Gender	0.680	0.209	0.001**
Age of household head	-0.006	0.009	0.539
Household income	-0.003	0.005	0.557
Use of fallows			
Constant	-2.793	0.618	0.000***
Sex of household head	0.808	0.326	0.013*
Perception of poverty	-0.660	0.281	0.019*
Perception of fertilizers	-0.999	0.233	0.000***
Perception of soil fertility	-0.173	0.182	0.339
Hire of labour	0.251	0.246	0.307
Land area in ha	0.296	0.085	0.001**
Bonding	-0.151	0.124	0.222
Network	-0.079	0.149	0.593
Gender	-0.270	0.129	0.037*
Age of household head	0.023	0.007	0.003**
Household income	0.001	0.002	0.550
Use of inorganic Fertilizer			
Constant	2.596	0.566	0.000***
Sex of household head	-0.694	0.287	0.016*
Perception of poverty	0.447	0.275	0.104

Perception of fertilizers	-0.348	0.239	0.147
Perception of soil fertility	-0.076	0.166	0.649
Hire of labour	0.938	0.267	0.000***
Land area in ha	0.191	0.114	0.094*
Bonding	0.135	0.118	0.253
Network	-0.444	0.144	0.002**
Gender	-0.112	0.126	0.374
Age of household head	-0.004	0.007	0.543
Household income	0.001	0.006	0.039*

Participation of Women in Decision Making in the Household Economy within the Chinyanja Triangle.

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Social and human capital outcomes as well as technology use and adoption are characterized by gender variations. The research challenge within the Chinyanja Triangle has been to assess the various factors that influence women's participation in critical decision making within the household economy in the three countries. The inclusion of women in decision making for critical household issues is one of the first steps in combating gender inequality in agricultural systems in SSA, hence care needs to be taken to ensure that women's mere participation in household activities (production ad otherwise) is not mistaken for participation in decision making. In view of this an index of household decision making was developed using key decisions that determine household welfare in both the short and long term. As can be seen in **(Table 33)**, decisions were grouped into production decisions, marketing decisions, and resource control decisions.

Table 33: Key Decisions Used to Compute Decision Making Index

Production Decisions
Decisions over what crops to grow
Decision on what area to plant maize
Decision on what inputs to apply for the maize crop
Decision over whether to use fertilizer or not, which types and on which crops
Marketing Decisions
Decision on whether to sell maize
Decision on whether to sell other crops
Decision on whether to sell livestock
Control of Resources
Decision on who should keep money

Preliminary analysis shows that different variables determine women's participation in decision making within the household.

The characteristics that significant positive influence on women's decision making include age of the household head, occupation of the household head, level of gender social capital within the community and number of farming plots owned. As the household head gets older, there is more tendency to allow the spouse to participate in decision making. This maybe attributed to that older men have more experience and trust with their spouse. Alternatively, it may also be attributed to that younger spouses, are less likely to allow their equally young spouses to contribute to household decisions making as the majority of people within the Chinyanja Triangle are patrilineal and hence believe the men are responsible for household decision making. And this has been evidenced by the negative significant relationship between decision making and age of the spouse. In this same vain, the results show that sex of the household head had a negative relationship with women's decisions making. This implies that in many male headed household's women are unlikely to participate in decision making.

The study further found that in household's where the head had an alternative occupation other than farming, there is greater chance of the woman being involved in decision making. This can be attributed to that men consider the alternative occupation as the main source of income and hence the women are allowed to make decisions pertaining to agriculture production as it is secondary source of income. Additionally, the study also found that in household's with a larger number of plots for cultivation allowed for women's participation in decision making. In reality such household's often divide and share the management of the plots between them and hence women make decisions pertaining to the plots to which they are responsible for managing. Despite this, it was surprising that the land holding size was not found to not be significant in influencing decision making.

Table 34: Factors affecting Women's participation in Decision Making at the Household Level for all Countries with Social Capital Incorporated

Variable	Coefficient Estimates	t-values	Þ- Values
Constant	7.75	10.14	.000***
Household characteristics			
Sex of HH head	-.438	-11.37	.000***
Age of HH Head	.067	1.73	.084*
Age of Spouse	-.154	-3.59	.000***
Residential status of HH	-.044	-1.34	.181
Occupation	.115	3.45	.001**
Total Income	-.048	-1.41	.159
Marital Status	-..030	-.877	.381
Social and Human Capital Characteristics			
Type of Village	.048	1.36	.174
Gender Relations	.063	1.89	.059*
Networking	-.106	-2.95	.003**
Farming Characteristics			
Land size	-.024	-.691	.490
Purpose	.020	.598	.550
Plots_owned	.064	1.91	.057*
Farmer Perceptions			
Fertility_Percp	.045	1.35	.178
Poverty_Percp	-.066	-1.91	.056*
Sample size	630		
R^2	.294		

** Variable is significant at the 5% level and * variable is significant at 10% level

Additionally the study also found that the higher the level of women empowerment within the community, the greater their involvement in household decision making. This entails that as communities make efforts to integrate gender in community processes and activities, individual are positively influenced and make changes at the household level as well. Other forms of social capital, namely networking social capital, was surprisingly found to have a negative impact on women's participation in decision making at the household level. This is surprising because the assumption would have been that as individuals interact with other communities and gain access to networks and new information, they would be more willing to allow women to share power within the household. Lastly the results further show that in household that perceive themselves as poor, there is lesser participation of women in decision making. This is not surprising because such household feel that they have limited resources hence the men take control of all that is available. Also in m any poor households, literacy levels are much lower hence women may not be empowered to contribute even when given the chance as they are less empowered.

Exploring smallholder farmers' knowledge towards soil erosion and the status of conservation farming across the Central Kenya Highlands.

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Introduction

Human induced soil erosion across the Central Kenya highlands poses a major threat to sustainable agricultural productivity. This is against the backdrop of disappointing uptake of recommended conservation farming measures by smallholder farmers' in-spite of the intense efforts towards promotion of appropriate conservation farming techniques. This study investigated the knowledge of the farmers on the occurrence and effects of soil erosion and, the status of conservation farming at household-farm level in relation to the household's resource endowment and agro-ecological conditions.

Materials and methods:

The study areas were Meru south and Mbeere Districts of the Central Kenya highlands within the Africa NUANCES project sites. Data from the initial rapid characterization exercises involving 150 smallholder farms in the 'benchmark villages' within the Africa NUANCES project sites had already been screened by Multi-dimensional scaling (MDS) and agglomerative cluster analysis (CA) screening techniques to generate three resource based farm typologies (rich, medium and poor). From each of the generated farm typologies, eight farms were randomly selected for the exploration of soil erosion and conservation farming activities.

Preliminary results

About 88% of the farmers were aware that erosion occurred in their farms and identified rainfall as the major cause followed by slope, soil type and conservation practices **(Figure 32)**. However, the farmers hardly associated soil and cropping practices (e.g tillage system) with the occurrence of soil erosion. Measures with multiple benefits addressing other concerns besides soil conservation like water conservation (fanya juu) and fodder supply (grass strips) were preferred by the farmers. Agricultural potential had an effect on the intensity of the conservation efforts, with the farmers in the higher potential area (Meru south) having farms with higher conservation status compared to those in Mbeere **(Figure 32)**. Insufficient farm labour was the main constraint to on-farm conservation activities identified by the farmers followed by insufficient capital and lack of tools **(Figure 33)**. The poor category of farmers was the most constrained amongst the three categories due to out-sourcing of labour and lack of capital to invest in on-farm conservation.

Preliminary conclusions

Farmers acknowledged occurrence of in their farms and were willing to control erosion but were keen to address other on-farm concerns as well. The focus of future conservation efforts should be on the measures that have multiple benefits. As well, the conservation promotion efforts should address labor and capital constraints, especially for the poor farmers.

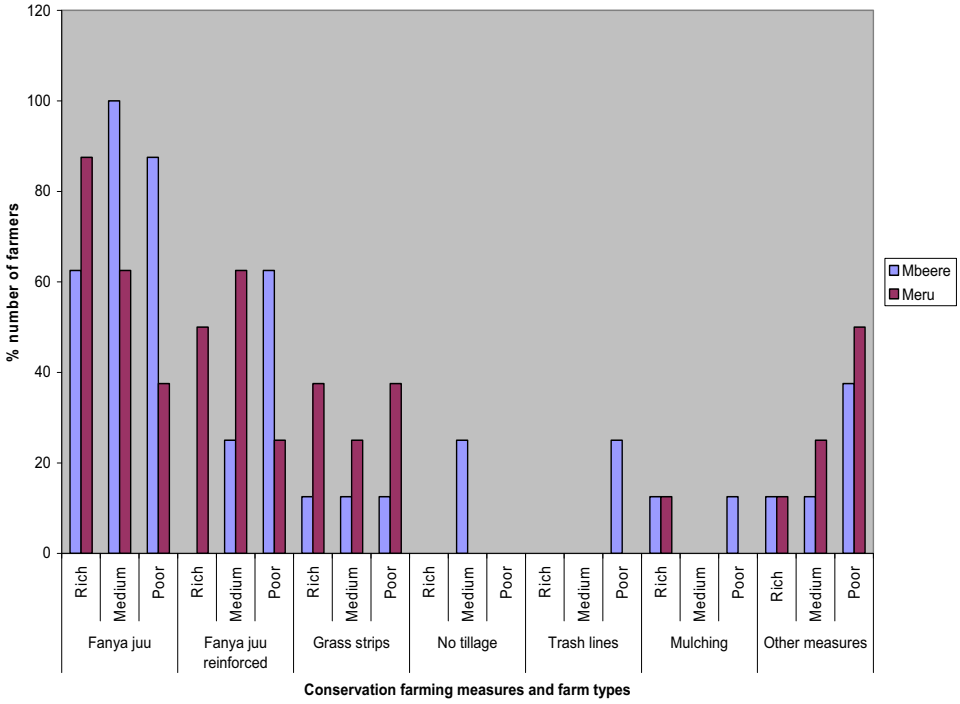

Figure 32: The occurrence of conservation measures across farm types for the two study areas

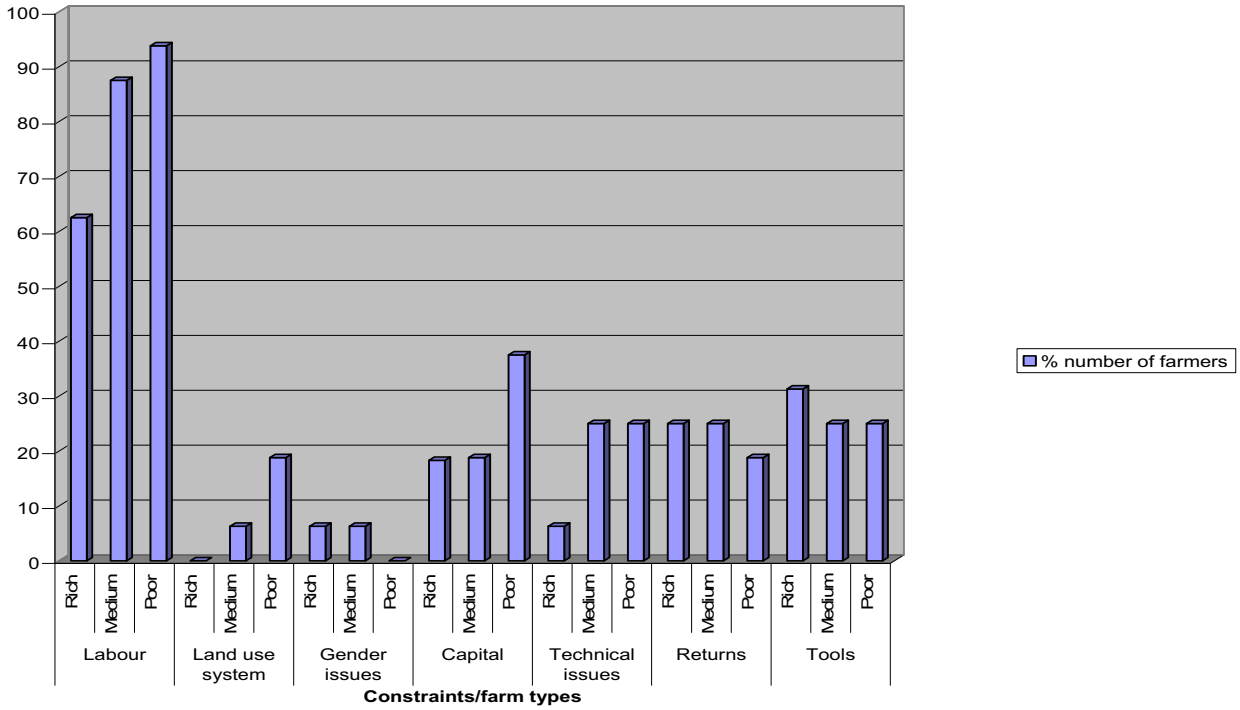

Figure 33: Farm-level constraints to conservation activities

Serum Zinc Levels of Vulnerable School Children Fed a Corn Soy Blend in Suba District, Kenya.

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Introduction

Suba District bore the brunt of HIV with approximately 32,916 (41%) of the population infected with the virus in 2005. The prevalence has since dropped to 31% by 2007 (MOH/NASCOP, 2006). Studies show that HIV can reduce household food security rendering children more vulnerable to malnutrition and infections (UNAIDS/UNICEF/USAID 2004).

A situational analysis on the nutritional status of children under five years and school going children in Suba District CIAT-TSBF showed that the effects of HIV infections were heavily felt by school children with associated malnutrition (stunting, wasting and underweight (Ohiokpehai et al, 2006). This was worsened by the irregular presence of food at the household and/or supplementary feeding considering that the district has high poverty levels (GoK, 2005).
Studies have shown that there exists a relationship between Protein-Energy Malnutrition (PEM) which is usually linked to lack of food for one reason or another and specific micronutrient deficiencies especially those of Vitamin A, Zinc, Iron and Iodine. These deficiencies are associated with consumption of foods poor in micronutrients and/or are not fortified. The presence of Protein-Energy Malnutrition (PEM) as reflected by stunting, wasting and underweight levels can sometimes be taken as an indicator of micronutrient deficiencies (WFP/UNICEF, 2006; WHO, 2002). Micronutrient deficiencies are less visible yet a devastating form of malnutrition whose consequences can be crippling or fatal hence the name 'hidden hunger'. These deficiencies are prevalent among population groups who are already experiencing insufficient quantity and quality of food in resource poor setting and in areas overburdened by diseases. Human populations with limited access to a varied diet especially diet deficient of proteins, fruits and vegetables are also likely to suffer from micronutrient deficiencies.

World Health Organization (WHO) prevalence data for micronutrient deficiencies suggest that 4 million women and young children are Vitamin A deficient, almost 7 million school children are iodine deficient and 7 million women of child bearing are anemic. According to WHO, deficiencies of one or more micronutrients usually mean there are also deficiencies of the other micronutrients such as zinc (WHO, 2002; WFP/CDC, 2005). This is because the origin of these deficiencies, a deficient diet, means that other micronutrients are also present in insufficient amounts (WFP/CDC, 2005). Zinc deficiency has of late been gathering more attention from researchers and development partners. It is estimated that some form of zinc deficiency affects about one-third of the world's population, with estimates ranging from 4% to 73% across sub regions (WFP/CDC, 2005). The worst regions are the developing countries with the most affected human population being those with other forms of malnutrition due to inadequate food, those who lack a diversified diet and those with recurrent infections like people living with HIV and AIDS (IZiNCG, 2004). Worldwide, it is estimated that zinc deficiency is responsible for approximately 16% of infections of the lower respiratory tract, 18% of malaria and 10% of diarrheal diseases. In 2002, about 1.4% of deaths world wide were attributed to zinc deficiency (WFP/CDC, 2005). Although severe zinc deficiency is rare, mild-to moderate zinc deficiency is quite common throughout the world (WHO, 2002). Serum and plasma zinc concentrations are the most widely used biochemical markers of zinc status.

Biochemical markers of zinc deficiency used in this study included serum zinc with the target population being school children. This was necessitated by the levels of macronutrient deficiency (Ohiokpehai et al, 2006), the burden of HIV and AIDS in the study area (MoH, 2005), lack of a diversified diet and the soy corn blend feeding trial and of course cost implications. The objective of the study was to assess effect of corn soybean supplementation on serum zinc levels of children aged 6-9 years the forgotten age group.

Materials and Methods

A pre-test post-test control research design was employed in this study with an experimental and control group made up of school children aged 6-9 years old. Blood samples at baseline were drawn from 156 school children aged 6 to 9 years old from three schools (Mbita, Sindo and Ong'ayo primary schools) while blood samples at follow up were collected from about 138 children. Blood samples were collected from 55, 52 and 49 children at baseline and 49, 46 and 43 children at follow up from Mbita, Ong'ayo and Sindo primary schools respectively. From these figures it is evident that the sample size at baseline was higher than that at follow up. This could be explained by the fact that there were drop outs in the course of the study and others who consented at baseline to give blood samples were not willing to do so at follow up. This could be due to previous experiences of needle pricks and the sight of blood. During transportation to the point of analysis at the Kenya Medical Research Institute (KEMRI) results tallied indicate that some samples were spoiled. The sampling procedure of school selection was reported elsewhere (Ohiokpehai et al 2006; 2007).

About 5 millimetres of blood was drawn from the arm of each child in the study in alluminium foil covered tubes by qualified laboratory technicians. The universal precautions as recommended by WHO in drawing blood samples for the safety of the technicians drawing the blood and the safety of the subject were followed (WFP/CDC, 2005). The samples were wrapped in foil paper to protect retinol from destruction by light. They were then centrifuged at 3,000 revolutions for ten minutes and clear serum samples separated into sterile cryovials. The samples were then flushed with white spot nitrogen gas and stored in liquid nitrogen at temperatures of -70º C and transported to KEMRI laboratories in Nairobi, Kenya for analysis. To determine the zinc values, zinc stock solutions were prepared. The blank was made by adding 10 mls of the sodium stock solution into a volumetric flask through a pipette to make up 100 mls. The sample was then prepared by adding 2.25 mls of de-ionised water into polythene test tubes. The serum sample was vortexed for at least 1 minute. Using a micro pipette, 250 µl of the serum was pipette into 2.25 mls of the de-ionised water and vortexed for 1 minute. The blank was aspirated followed by the standards and upon satisfaction with the standard curve, the standards were read as samples. The samples were then aspirated and read directly from the screen. The results in microgram/100 mls were multiplied by 10 since the sample was diluted in the ratio 1:9. Low plasma zinc level was considered to be < 10.7 µm/l. (MoH, 2003).

Nutri-survey and SPSS computer packages were used to analyze data using descriptive and inferential statistics. T-tests were used to compare mean differences in control and experimental subjects before and after the corn soy blend feeding trial. Chi-square tests were used to test for relationships and significances between variables. Ethical clearance for the study was sought from the Ministry of Health, Suba District and signed informed consent obtained from the parents/guardians and their children (pupils) before commencement of the feeding trial and blood harvesting at baseline and at three months.

Preliminary results

Assessment of Zinc Status and Zinc deficiency.

Documented studies on assessment of zinc show that low serum zinc levels are usually used as an indicator of poor zinc status. Low plasma zinc level were considered to be < 10.7µm/l indicating that normal serum zinc levels are those above 10.7 µm/l. (MoH, Kenya, 2003; IZiNCG, 2004). Other studies indicated higher levels of serum zinc with levels of 12-18µm/l to be the normal range (King, 1990; Thompson, 1991 and Wood, 2000). This current study adopted lower levels of serum zinc of <10.7 µm/l for low serum zinc and above 10.7 µm/l to be normal levels.

Before the intervention, nearly all the children in all schools (95.7%) had low serum zinc of less than 10.7µm/l **(Table 35)** with a mean of 8.41µm/l **(Table 36)**. There was a significant improvement ($P<0.05$) after the intervention in all schools with the percentage of those with low serum zinc reducing from 95.7% at baseline to 70.2% after the intervention. Similarly the mean serum zinc improved from 8.41 at baseline to 10.2 at follow-up, slightly lower than the normal levels of 10.7. The difference between the means was however not significant. **(Table 35)** shows the prevalence of zinc deficiency among children in the study area while **(Table 36)** shows the difference in means before and after the intervention.

Table 35: Prevalence of Zinc Deficiency among school children in the three study schools before and after feeding trial

School	*Reference Data (Cut-off Points)		Prevalence (%)		Chi-square test P<0.05
	Serum Zinc µm/l	definition of Deficiency[1,2]	Before %	After %	
Mbita	<10.7	Low	96.3	73.6	0.0491
N=54(before)	>10.7	None	3.7	26.4	0.0121
N= 53 (after)					
Ong'ayo	<10.7	Low	94.3	61.4	0.0432
N=53 (before)	>10.7	None	5.7	38.6	0.0111
N= 44 (after)					
Sindo	<10.7	Low	95.7	75.7	0.0499
N=47 (before)	>10.7	None	4.3	24.3	0.0251
N=37 (after					
Total	<10.7	Low	95.4	70.2	0.0421
N=154(before)	>10.7	None	4.6	29.8	0.0193
N=134(after)					

*Definition of Deficiency[1,2 =] MoH, Kenya, 2003 and IZiNCG, 2004

Table 36: Mean and median distribution of serum Zinc among the study schools

School	*Cut-off Points	Mean (95%CI)		**T-test	Median	
	Normal Serum Zinc µm/l	Before	After		Before	After
Mbita	Above 10.7	7.25±0.7		Not sig.	7.46	9.18
N=54(before)		9.743±1.2				
N= 43 (after)		2.49 points difference				
Ong'ayo	Above 10.7	10.3±1.1		Not sig.	7.80	10.15
N=53		10.94±1.3				
(before)		0.6 points difference				
N= 44 (after)						
Sindo	Above 10.7	7.67±1.5	9.95±0.9	Not sig.	7.94	9.33
N=47		2.29 points difference				
(before)						
N=37 (after						
Total	Above 10.7	8.41±0.9	10.2±1.1	Not sig.	7.73	9.56
N=154(before)		1. 19 points difference				
N=134(after)						

*Definition of Deficiency[1,2 =] MoH, Kenya, 2003 and IZiNCG, 2004
**Paired Sample T-test –significance at P<0.05

The results presented in **(Table 35)** show that the difference between the three schools at baseline were not significant (P>0.05) with a difference of less than two percent points. This was expected at baseline because no intervention had taken place. At follow-up however, all the schools improved significantly including Ong'ayo primary school which was a control school. While this is not expected for the control school, it can not be assumed that the intervention did not have an impact on serum zinc since the mean serum zinc for Ong'ayo primary school (control school) did not improve significantly **(Table 36)**. The mean serum zinc was also not significantly different (P>0.05) at baseline for all schools. Sindo primary school reported the highest mean serum retinol (10.3) which was close to the normal levels of 10.7µm/l. From these means therefore, it can be argued that the situation from Sindo primary school was mild. The improvement in mean serum zinc among pupils from Ong'ayo primary school which was a control school was not significant (P>0.05) as compared to the other two experimental schools. This difference between means in experimental and control school shows that the feeding trial improved serum zinc levels.
** Further tests are envisaged to explain the data.

Comparison of biochemical results by school (experimental and control) and by sex
An Independent-Sample T Test procedure which is suitable for comparing means between experimental and control schools was used to establish whether significant differences existed before and after the feeding trial. **(Table 37)** also shows mean difference across sexes for all the three schools.

Table 37: Mean Comparison of serum zinc status and by sex at baseline (before the feeding trial)

Serum Zinc (µm/l)	**Levels at baseline (before feeding trial)**			
	Experimental schools		**Control**	
	Mbita Primary N=54	**Sindo Primary N= 47**	**Ong'ayo Primary N=53**	***T-tests**
Total	7.27±0.5	7.62±1.5	**10.4±1.4	
Boys	6.901±0.9	7.260±1.9	7.227±0.4	Not significant
Girls	7.381±0.8	7.629±1.3	11.102±03	

*Independent T-tests - Significance at P<0.05 ** Difference between girls and boys significant

There were no differences in means between boys and girls in all the schools and within schools except for Ong'ayo primary school. In this school girls had a significantly higher mean (11.102±03µm/l) than their boy counterparts. Considering that the levels for low serum zinc were taken at <10.7µm/l it can be argued that the boys from Ong'ayo primary school were at a higher risk of having low serum zinc (zinc micronutrient deficiency) than girls. **(Table 38)** shows comparison of mean serum zinc among children from all the three schools after the feeding trial of three months.

Table 38: Distribution of mean serum zinc by school and sex among school children after the feeding trial

Serum Zinc (µm/l)	Levels after the feeding trial)			
	Experimental schools		Control	
	Mbita Primary N= 43	Sindo Primary N= 37	Ong'ayo Primary N=44	*T-tests
Total	9.741±1.3	9.97±0.7	10.93±1.5	
Boys	9.611±2.1	10.389±2.0	11.585±1.9	Not significant
Girls	9.721±1.9	9.692±1.8	9.773±1.2	

*Independent T-tests - Significance at P<0.05

The results presented in **(Table 38)** show no significant differences between schools, within schools and between sexes. Boys from Ong'ayo primary, who at baseline reported significantly lower serum zinc than girls now report a higher mean than girls. This however can not be attributed to the intervention since Ong'ayo was a control school.

Serum zinc levels, macronutrient deficiency and dietary intake

The results from the baseline report indicated that the subjects (school children) suffered from macronutrient deficiencies. More than 20% of children from both experimental schools (28.5%) control school (25.5%) were stunted with a Z-score of -2SD. Results improved slightly after intervention. Data from dietary patterns 24-hour recall and food frequency show low consumption of fruits and vegetables and grains which are rich sources of micronutrients. Results also indicated that there was a high consumption of cereals which have phytates that can negatively influence micronutrient absorption. Consumption of micronutrient rich foods like the soybean was also low. This could contribute to the low levels at serum zinc at baseline. A detailed report of the baseline study was reported in my last annual report and JFAE (Ohiokpehai et al, 2006; 2007)

Preliminary Discussion

The results from serum zinc presented here confirm the argument that individuals with macronutrient deficiencies are also likely to have micronutrient deficiency (hidden hunger). Majority of the children reported low serum zinc levels which slightly improved after the feeding trial. This could be explained by the fact that the children were receiving the feeding (porridge) once a day while most of the other meals of the day were taken at home. This portion (1 cup) may not yield significant results within a short time. Factors like food choice at home, reliance on cereals and the time at which the blood sample was collected (after a meal or a fasting period) could affect serum zinc levels. Results also indicated that a longer feeding period could have yielded significant results on the effect of corn soy blend supplementation.

Serum zinc levels resulting from adequate intake or zinc supplementation have shown significant positive correlations with macronutrient deficiency.

Studies done on children from different subgroups to compare zinc status and stunting levels showed a positive linear growth line with children with higher levels of serum zinc reporting Z scores of less than -2SD (Brown et al, 1998). Evidence from research shows that mean plasma concentrations of a group of people can be an indicator of the population's zinc status. Dietary assessment of zinc levels in any human population offers challenges in the sense that it requires quantitative estimation of the likely absorption of zinc from mixed diets and the fact that anti-nutrients such as phytates in cereals and legumes inhibit absorption of zinc and utilization (Brown, 1998). This indicated that households in resource poor setting or those whose staples are cereals and legumes could suffer zinc deficiency. This could explain the low zinc levels among the study children in this current study since the study was conducted in Suba District, which is resource poor (GoK, 2005). This is because high levels of dietary zinc are concentrated in grains, vegetables, fruits and animal products. Poor households may lack the resources to diversify diets.

Preliminary Conclusion and Recommendation

Preliminary results from this study indicate that supplementation and the soy corn blend can yield significant results in improving the nutritional status of a population if larger portions or main meals are given. Results also indicate that a longer feeding period is necessary to measure the effect of the corn soy blend on serum zinc levels. It is highly recommended that a similar study giving larger portions of the corn soy blend be conducted for a longer period and results compared to those of this study.

Farm input market system in Western Kenya: constraints, opportunities and policy implications.

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[1]*CIAT-TSBF, Kenya*

Widespread and increasing rural poverty in sub-Saharan Africa (SSA) has been of great concern to development community. Compared to other developing regions of the world, low use of inputs by small farmers is one of the factors responsible for the gap between potential and actual yields. Market constraints reduce profitability in use of inputs, increasing production risks. This study interviewed 130 agro-input dealers in Kenya to analyze trends, inputs stocked, distance to markets, services to farmers, and constraints and suggests how to improve input delivery to farmers. Results indicate that although the number of agro-dealers is still small relative to farmer population, there has been a steady annual increase (2–22%, with mean of 16% across inputs) in their number from 2003 to 2005. DAP fertilizer (stocked by 92% of respondents) was most commonly stocked. Others are CAN fertilizer (84%), Urea (78%), and NPK (40%). Other services provided by agro-dealers are input information (75% of respondents), credit (13%), bulk breaking (8%), and spraying (4%). Selling price of inputs increased with distance to markets. High transport cost (53%), low demand (30%), lack of market information (21%), lack of storage facilities (13%), and limited business knowledge (12%) were the most important constraints faced by agro-dealers. Policies and institutional frameworks suggested by dealers to streamline agro-input trade were associated and government was the main institution proposed. The study concludes with suggestions on how to enhance efficiency of agro-dealers in input delivery – timely since SSA governments are presently creating structures to enhance input use.

Intercropping Soybean and Grain Amaranth for Sustainable Agriculture in Western Kenya.

M.N. Ng'ang'a[1], O. Ohiokpehai[2], R.M. Muasya[1] and E. Omami[1]

[1]Moi University, Kenya; [2]CIAT-TSBF, Kenya

Intercropping is a common practice in developing countries because it may produce higher total yields than monoculture. This study was carried out to determine the effect of different intercropping systems on grain yield, land use efficiency and economic returns in soybean (*Glycine max*) and grain amaranth (*Amaranthus* spp.) intercrops for two seasons in Teso district. The experiment was carried out on-farm, at two sites (A & B) using split-plot design in three replicates. Results indicated that intercropping using single and double rows significantly ($P<0.5$) increased amaranth grain yield by 28-29% and 32-35% while intercropping using double rows increased soybean grain yield by 30-31% in sites A and B respectively. However, intercropping using single rows significantly reduced soybean grain yield by 29-34%. Both single and double row intercrops had higher land use ratios (LER = 2.1- 2.9) and (LER =2.1-3.0) than sole crops in site A and B respectively. Maximum benefit-cost ratio (BCR) values of 9.5 and 9.2 were obtained in double row intercrops in site A and B respectively. Based on the present results, soybean can be advocated as a promising intercrop in amaranth-based production systems for efficient use of land, increased food security and high economic returns.

Farming innovation for food security among the HIV/AIDS affected rural households in Western Kenya.

M.N. Ng'ang'a[1], O. Ohiokpehai[2], R.M. Muasya[1] and E. Omami[1]

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Teso District in western Kenya is the home of close to 100,000 people and currently one of the most densely populated regions. Population densities range between 500 and 1200 people per km^2 with a population growth rate of over 3.4% per annum. The district is also characterized by low crop productivity, shortened or non-existent fallow period, low fertilizer inputs, lack of pesticide use and improved seeds. The high human population density coupled with high incidences of HIV/AIDS (16-30%) within the region, implies that traditional systems of agricultural production including shifting cultivation can no longer sustain their food and socio-economic needs. However, crop diversification is an important instrument for successful agricultural innovation towards achieving high agricultural yields. The performance of soybean (*G. max*) when intercropped with grain amaranth (*A. dubious*) was investigated on-farm in two sites in Teso district. The experiment was laid out in a Randomized Complete Block Design (RCBD) in plots measuring 3mx3m and replicated three times. Results indicated that grain yield of *G. max* and *A. dubious* were significantly higher in the intercrops than in monocrops ($P<0.05$). Similarly, there was a significant difference between *G. max, A. dubious* yield from site A and site B. The Land Equivalent Ratios (LERs) of the intercrops were greater than one (1.6 & 1.4) and benefit-cost ratio (BCR) higher in intercrops compared to sole crops in both sites. It was therefore concluded that intercropping is one of the many innovations that can easily be adopted for increased biodiversity towards achieving the aims and objectives of the African Green Revolution.

Effect of Soybean (Glycine Max.) Supplementation on Nutritional Status of School Children Aged 6-9 Years from HIV affected Households in Suba District, Kenya.

J. Kamau[1], O. Ohiokpehai[2], D. Mbithe[1], J. Kimiywe[1], L. Oteba[3], G. Were[3], B. King'olla[2]
[1]Kenyatta University, Kenya; [2]CIAT-TSBF, Kenya; [3]Moi University, Kenya

Objective: To investigate the effect of soybean supplementation on the nutritional status of school children from HIV affected households. Design: A pre test post test control research design was used. Setting: Suba District, a district that is food insecure and has a high prevalence of HIV and AIDS. Subjects**:** School children aged 6-9 years and from households affected by HIV. About 54 school children received corn soy blend porridge for three months in school as a mid morning snack with a control group of 56. The groups and study children were randomly selected. A structured questionnaire and anthropometry were used to collect data. All the children in the study received an insecticide treated mosquito net, vitamin A supplementation and were dewormed. Descriptive and inferential statistics were performed. Results: Malnutrition levels among the experimental group reduced from 10.2%, 28.9% and 5.6% for underweight, stunting and wasting respectively to 6.2%, 16.7% and 3.4% respectively. The control group registered 11.4%, 28.5% and 8.7% underweight, stunting and wasting respectively before the feeding trial. Underweight and wasting rose to 14.3% and 9.5% but stunting dropped to 21.5%, all changes not significant (P>0.05). The staple foods with highest weekly consumption were maize, millet and fermented porridges with 76.4%, 46.1% and 36.2% respectively. Fish was the most consumed protein (49.2%). There was negligible consumption of soybean before the feeding trial. Conclusion: Significant improvement of nutritional status could have been realized if the trial was longer. Soy bean should be promoted in HIV and AIDS affected areas to alleviate malnutrition.

Enhancement of Agricultural Production Through Nutrition And Health Intervention Demonstrations The Case Study of Suba, Kenya.

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Agricultural productivity is widely recognized as a critical determinant to both human wellbeing and economic growth in Sub Saharan Africa (SSA), also accounting for over 70% of HIV cases globally. Several studies have shown that HIVS and nutrition operate in tandem. Moreover, it has been shown that the two greatly affect agricultural production due to reduced energy to work, inability to purchase agricultural inputs, low workforce and eventual death of the infected person especially the head of household among others. The link between agricultural productivity, malnutrition and HIV therefore cannot be overlooked. People who are inadequately nourished are more susceptible to diseases and poor health in general. In an attempt to achieve optimal nutrition and health status especially among vulnerable groups, various intervention programmes have used food supplementation using mainly plant based food products such as corn blend. These programmes have proved to be effective in restoring the nutrition and health status of the people concerned.

However, much more value would be achieved if such programmes are complemented with basic health services such as deworming, micronutrient fortification/fertilization, nutrition education as well as water, sanitation and hygiene as an additional component. This paper will explore the usefulness of adding value to agricultural production as an incentive for farmers to grow quality crops which could be used to address HIVS, hunger and malnutrition with major focus on preservation, processing, nutrition intervention and research. The benefits of research and nutrition education in order to improve nutria-health and economic well being are highlighted.

Nutrition and utilization for health and income generation: an incentive for the promotion of legumes in Kenya.

O. Ohiokpehai[1] and B. King'olla[1]

[1]CIAT-TSBF, Kenya

Soybeans contains 40% protein and 20% oil and .Soybean is both food and nutria health which can support human wellbeing. This project addresses the utilization of soybeans through sustainable and participatory capacity building in soybean processing, nutrition and mentoring in its production and marketing to act as an incentive to boost production of soybeans at the grass-root levels. Adequate and appropriate nutrition which can be achieved through the consumption of a balanced healthy diet (consisting of locally available foods and fortified food and/or micronutrient supplementation when needed) is vital for the health and wellbeing of all individuals regardless of HIV status. Nutritional support helps to maintain the immune system and to sustain healthy levels of physical activity. Our methodology included visiting farmer associations, living positive groups and giving short talks on the goodness of soybeans and allowing question and answer sessions to ensure that our clients had a voice. Also training of trainers (ToT) for five days (ToT–5 days) and training of farmers (ToF) for two days (ToF–2 days) in processing and utilization of soybeans, hygiene, sanitation, basic business management, and nutrition education were involved.

Soybean is incorporated into several locally eaten foods with taste tests carried out and analyzed to determine the degree of quality improvement. We incorporate or replaced soybeans in locally eaten dishes such as mandazi, ugali, porridges, chapatti and "omushenye" or potato dish to increase their protein content without changing the tastes.

A market-led participatory research strategy for sustainable intensification and diversification of crop production in smallholder irrigation schemes in southern Malawi.

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Large investments have been made in rehabilitation of irrigation infrastructure to alleviate the effects of poor rainfall on livelihoods of smallholder farmers in the Shire Valley in Malawi. The irrigation schemes provide farmers with opportunities to intensify crop production by reducing the risk of crop due to poor rain and allow farmers to crop several crops in a single year. The sustainability of the smallholder irrigation schemes depends to a large extent on profitable intensification and diversification of crop production.

The Enabling Rural Innovation (ERI) approach, which uses improved market access and increased income for farmers as an entry point to enhanced soil fertility management, is being used in to improve the capacity of farmers to experiment, innovate and identify new technologies and information sources for addressing food security and market opportunities. Two irrigation schemes were selected as pilot learning sites in Chikwawa District (Nkathe – surface irrigation and Mkondezi – treadle pump irrigation). A participatory diagnosis was conducted to enable communities and development partners to identify opportunities and constraints to intensify crop production and to plan together appropriate interventions for increasing crop productivity and profitability. The participatory diagnosis was linked to participatory market research targeting the main cash crop, rice, to improve farmers' access to good markets. Participatory research, linked to the participatory diagnosis and market research was implemented to evaluate integrated soil fertility management options for reversing soil fertility depletion and increasing crop productivity.

The focus of the experiments was to diagnose nutrient deficiencies (macro- and micro-nutrients) and determine nutrient application rates required for efficient and economic fertilization of main food security and cash crops for irrigated and rain-fed plots. The experiments are also exploring best strategies for crop diversification at the landscape level, taking into account access to irrigation and the variability in soil fertility at the plot, farm and village levels. Main crops selected for experimentation by farmers include rice, maize, groundnut, common bean. The current management practices by farmers are presented in **(Table 39)**. The potential of different ISFM technologies, including rotation of cereal and grain legume crops and combined application of mineral and organic nutrient resources, to restore and maintain soil fertility is also being tested under irrigation and rain-fed conditions. Availability of irrigation facilities allow farmers to grow at least two crop per year and experiment were designed to compare strategies for soil fertility management for crop grown during summer (rainfall supplemented with irrigation) and winter irrigation (irrigation).

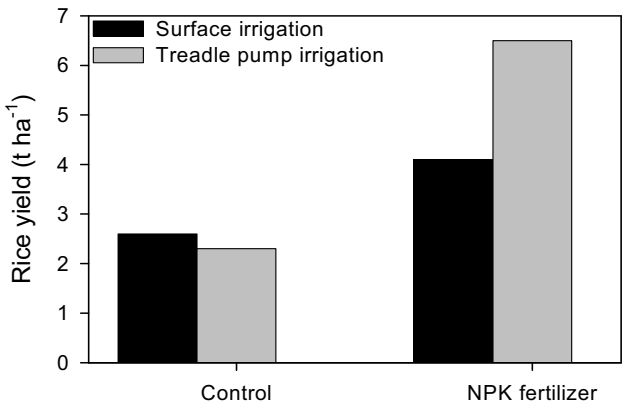
For the main crops grown during summer under supplementary irrigation, rice was more productive under surface irrigation than under treadle pump irrigation. Under surface irrigation, sufficient water was supplied to meet the high water requirement of rice, whilst under the laborious manual driven treadle pump irrigation yields were limited strongly by insufficient supply of water. For both irrigation systems, greatest yield responses to supply of fertilizer N were observed when N was supplied at 30 kg ha^{-1}. During the dry winter period, water scarcity in Nkathe led to a drastic reduction in rice productivity. Analysis of gross margins revealed that rice yields of ~5 t ha^{-1} were required make profits. The results suggest that rice can only be viably produced during summer with supplementary surface irrigation.

Maize was most productive under rain-fed and treadle pump irrigation than under surface irrigation. The maize crop produced under surface irrigation was reduced by severe water logging as a result of excessive rains received during the summer season. Productivity of maize under surface irrigation was high during the dry winter period, as water supplied by irrigation was optimal for maize growth. Maize is mainly produced as a food security crop – results show that maize production in summers under surface irrigation is risky, and focus should be placed on production the crop under rain –fed or treadle pump.

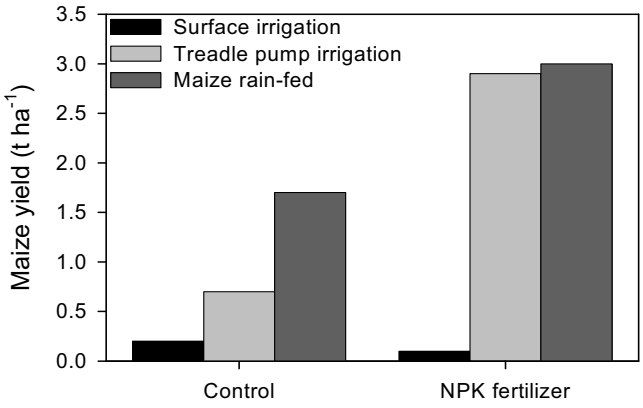
Groundnut and bean were selected by farmers as test grain legumes for improving food security, income and the N budgets through biological N_2-fixation. Productivity of groundnut and bean and their response to application of P under rain-fed conditions and winter irrigation respectively was high, indicating that these crops have good potential for diversification of the rice and maize dominated cropping systems in Nkathe and Mkondezi. Gross margin analysis indicated that under winter surface irrigation, bean was more profitable than maize and rice and economic performance of the irrigation scheme can be substantially enhanced by shifting from maize and rice production to bean. Decisions on choice of crops is however driven by complex factors other than profitability, such as labour demand, farmers' need to produce their own food crops and market risk. Analysis of the interaction of different factors and their implications of farmers' decisions is currently being carried out using farm-scale model-based decision support tools **(Table 39).**

Table 39: Crop management strategies commonly used by farmers in Nkathe and Mkondezi area

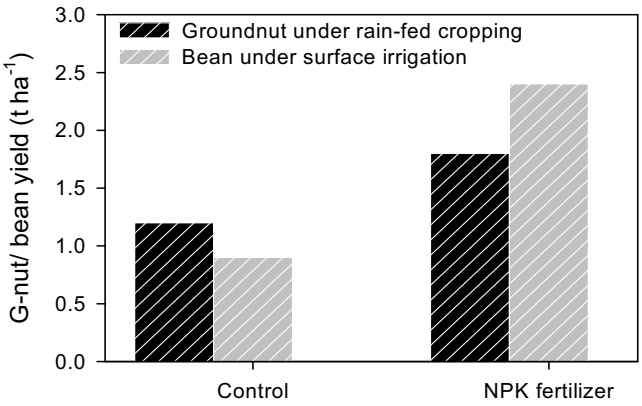
Crop	**Water management**	**Fertilizer and soil fertility management**
Rice	Surface irrigation	NP basal fertilizer, topdressing with urea. Crop residues burnt *in-situ*
	Treadle pump irrigation	NP basal fertilizer, topdressing with urea. Crop residues burnt *in-situ*
Maize	Surface irrigation	NP basal fertilizer, topdressing with urea. Crop residues burnt *in-situ*
	Treadle pump irrigation	NP basal fertilizer, topdressing with urea. Crop residues burnt *in-situ*
	Rain-fed	No fertilizer used. Crop residues incorporated
Groundnut	Rain-fed	No fertilizer used. Crop residues incorporated.
Bean	Irrigation	NP basal fertilizer.



Productivity of rice under different fertilizer and irrigation systems



Productivity of maize under different irrigation systems



Productivity of bean and groundnut under different fertilizer and irrigation management

McKnight climbing bean project suitability assessment report.

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Introduction

The Climbing Bean project is a research program managed under The McKnight Foundation Collaborative Crop Research Program which seeks to increase food security in developing countries. The program supports agricultural research aimed at improving food production and the nutritional content of crops important to the developing world (http://mcknight.ccrp.cornell.edu/). The main research focus of the Climbing Bean project is to diversify agricultural production by introducing and testing new varieties of high yielding low-altitude climbing beans together with proven agroforestry technologies that improve soil fertility in two strategic transects across the Malawi- Mozambique border. Eighteen pilot sites have been chosen in the two transects based on prior knowledge of rainfall and altitude conditions and areas already growing the climbing beans.

Linked to spatial analysis, the first specific objective of the project is to increase efficiencies of production through cultivation of high yielding climbing beans linked to agroforestry technologies for soil fertility improvement and provision of staking materials. Spatial analysis is the process of applying analytical techniques to geographically-referenced data sets to extract or generate new geographical information. Spatial analysis may be used to model complex geographical interactions, and is useful for investigating site suitability and predicting future events. (http://www.digimap.gg/glossary). In this project spatial analysis comes in to provide a basis for evaluation of beans and suitability over a larger area. This will allow partners to critically evaluate, altitude x rainfall x germplasm interactions and to identify combinations of environments suitable for particular climbing bean varieties grown in association with agroforestry technologies. These experiences and the use of GIS tools allow for identification of other areas in Southern Africa where the climbing beans/agroforestry systems can be targeted. However more analysis will be done when a few seasons of production data are available (i.e. assessing performance based on the domains and scaling out the best options).

Some of the research questions being addressed by spatial analysis are: -

1. What rainfall x altitudes regimes are prevalent in the project pilot sites?
2. Are the rainfall x altitude regimes related to project pilot sites?
3. Where beyond project pilot sites, could specific climbing bean- agroforestry systems be promoted?

M**aterials and methods**

Study site description: The project is being implemented in two strategic transects across the Malawi-Mozambique border, Dedza/Angonia and Zomba/Gurue. The two transects have contrasting rainfall potential (700-900mm yr^{-1} and 1300-1600mm yr^{-1}) but cover a similar range of altitudes (800-1600m).

Study Methods and Data: The methodology used to assess the suitability of land for climbing beans consisted of three steps: 1) identifying the most appropriate datasets; 2) defining thresholds in the key variables, and; 3) creating domains of the combinations of the key variables.

Step 1: Sourcing the datasets required to carryout spatial analysis for assessing the climbing bean suitability. The source for the rainfall data is the WorldClim database (Hijmans et al, 2005) which is available at a resolution of 1km2. This data are interpolated and are based on 48 000 rainfall stations worldwide with a good coverage for eastern and southern Africa. The WorldClim database gives monthly mean values for rainfall and temperature but there are no data on the year to year variability of annual rainfall totals. This data was used due to incomplete rainfall datasets especially for Mozambique. The altitude data was obtained from the SRTM digital elevation model (DEM).
For the sites chosen based on prior knowledge, field visits were conducted to determine the cropping season for the climbing bean varieties being grown and where possible the meteorological data. The coordinates and altitude for the respective sites were also determined using a Global Positioning System (GPS).

Step 2: Based on stakeholder suggestions, defining the rainfall and altitude thresholds to be used in the land suitability assessment **(Table 40).**

Table 40: Thresholds used to classify each input requirement variable.

Requirement/Variable	Very low	Low	Moderate	High
Rainfall (mm)	< 700	700 – 900	900 - 1300	> 1300
Altitude (masl)	< 700	700 - 1000	1000 - 1400	> 1400

These were applied on the rainfall and altitude datasets used in the development of the recommendation domains.

Step 3: Domains were defined based on key criteria (rainfall x altitude) using spatial analysis. There are two input variables and the number of classes for each variable was set to four. Each variable is classified as Very Low, Low, Moderate and High and when combined there are 16 possible combinations.

Results
The domains were used in the identification of two additional pilot sites in Mozambique. A total of twenty pilot sites for growing the climbing bean were identified using prior knowledge and the domains **(Figure 34)**.

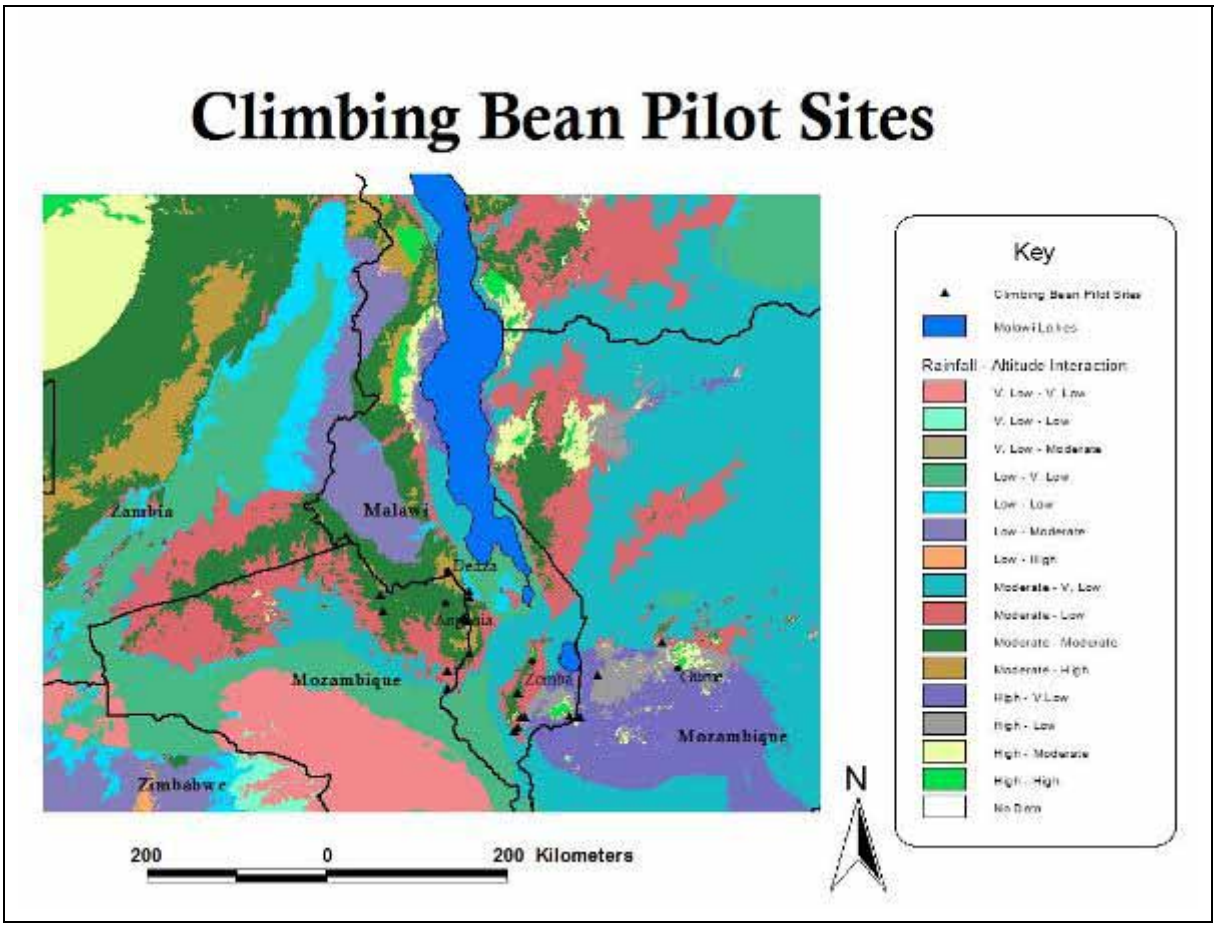

Figure 34: A Suitability Assessment map showing climbing bean pilot sites.

Of the 16 possible domain classes, ranging from V. L V. L to HH only 9 are encountered in the study area and 8 in the pilot sites **(Table 40)**.

Table 40: Number of sites in each domain class

Domain: Rainfall - Altitude	**Number of sites**
Moderate - High	5
Moderate - Moderate	4
Moderate - Low	4
High - Low	3
High - Very Low	1
Moderate - Very Low	1
Low - Very Low	1
High - High	1
V. Low - V. Low	0

The domain class with the highest number of sites (5) is the region that receives 900 – 1300mm of rainfall annually and has an altitude in excess of 1400masl. This domain is found in the Dedza – Angonia transect. The domain classes which follow in terms of number of sites (4) are those which receive 900 – 1300rainfall and have altitudes ranging between 700 – 1000masl and 1000 – 14000masl. The domain class which receives an excess of 1300mm of rainfall and with altitude of 700 – 1000masl has 3 sites. The domain classes which are least represented are: HV.Low, HH, MV.Low and LV.Low. The domain class which has not been evaluated receives less than 700mm of rainfall and has an altitude below 700masl **(Table 40)**. The Zomba – Gurue transect is not well represented in terms of number of sites in each domain class.

Discussion

This report presents results from the pilot sites selected at project inception, more project sites representative of each domain class are to be selected in the next project year. This report can be used as a basis for selecting more sites in each domain class especially in the Zomba – Gurue transect.
When production data (i.e. yields) from three or four seasons are available performance assessment based on the domains will be carried out. Deductions on rainfall x altitude x germplasm interactions in each domain class will be made.

Scaling out using Homologue

Along with the physically- based (process) models based on mathematical descriptions, the data-driven models are becoming popular (Solomatine et al, 2005). They are based on the use of methods of computational intelligence and machine learning, and assume the presence of considerable amount of data describing the modelled phenomenon. The advantage of data-driven methods is that they are based on solid evidence and avoid any type of estimation which can either be biased or even wrong. Homologue software (CIAT 2004) is one such method and will be used to search for environments similar to those encountered in each of the pilot sites, hence determining likely areas of adaptation. This will only be possible when performance assessments have been carried out to determine the environments where the different varieties are doing well and we would want to scale-out the results.

Comparative analysis of the production potential and efficiency as determinants of investment choice in the production of cotton, maize, soybean and sugarcane in the farming systems of Matungu division, Mumias district, Kenya.

C. C. O., Ogwan'g[1], W. Otieno[1], J. Adari[1] and J.Chianu[2],
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Introduction
Available resources for agricultural production are limited in relation to the production needs of competing enterprises. As a result, choice of enterprises has to be made on how to allocate these limited resources. Preference and choice in the use of available resources affect the level of agricultural production and total benefits from production. For example, allocation of more resources in the production of cash crops may in the long run lead to food crisis in the society. Some enterprises give more income over time than others.

As a result, enterprise selection should be done based on profitability and social benefit. However, a farmer would at times be comfortable with an enterprise that earned him less profit but sustainable rather than a more profitable enterprise with a high degree of income variation. In other words, a farmer who does not want to take a lot of risk may decide to settle for a lower profit. The objective of this study is to conduct economic analysis of cotton, maize, soybean and sugarcane enterprises in order to sharpen related recommendations to farmers with respect to adoption and investment of the limited farm resources.

Methodology

The study area is Matungu division in Mumias district of Western Kenya. Primary and secondary data are being collected on resource allocation to and the production of cotton, maize, soybeans and sugarcane. These crops are clearly competing for the farmers' resources (land, labor, capital and management). Social benefits from each crop are being considered to judge how each benefits the society as a whole.

For sample selection, the farmers were, among others, classified on the basis of the crops they grow and their scale of farming. Data are being collected on input uses and costs, production, and output and output prices. Policy issues directly or indirectly affecting the productivity of each crop are being examined in order appropriately inform or make proper good recommendations on enterprise selection. Multi-stage and random sampling methods were used in sample selection. Data collection is through self-administered questionnaires by the principal investigator complemented by on-farm field surveys, internet research, and secondary data exploration. Data collected would be presented in charts, graphs, tables, pictures and other reporting and other means of information communication.

Among others, gross margin, cost-benefit, and farm budgeting analyses would be explored. In addition, data for use in running regression analysis on determinants of farmers' decision to allocate various factors of production to the different crops are being collected. By so doing, we shall understand and be able to explain possible disparity in resource allocation to the different enterprises. Relationships among variables will also be ascertained using correlation analysis.

Preliminary results

Field and survey data collection is still ongoing.

A comparative economic analysis of maize, soybean, sugarcane and tobacco enterprises in the farming systems of Uriri division, Rongo district, Kenya.

O. S. Bonyo[1], J.Adari[1], J.Chianu[2], and W. Otieno[1]

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Introduction

The contribution of agriculture to economic development largely depends on diversification and commercialization of agricultural production. Alternative options are often available for farmers interested in cash income generation. However, the inability of many farmers to use economic techniques and tools in enterprise choice has hindered them from making informed decisions on choices.

This study has identified enterprise choice as a problem in farm decisions among farmers in, Kenya. The objective is to carry out a comparative economic analysis of the production of four important cash generating crops (maize, soybean, sugarcane and tobacco) in the farming systems of Uriri division in Rongo district. These four crops are 'cash crops' and have commercial indices (i.e., proportion of total production that is actually sold for cash) compared with the other crops in the farming systems of the study area. The study also plans to investigate the factors that influence farmers' decisions to invest in these crops. The hypothesis being tested is "whether farmers' choice of cash crops is influenced by enterprise profitability". The outcome of the study is expected to benefit farmers in the study area and similar environments through the education that will result from increased farm productivity and profitability as well as the development of appropriate agricultural diversification strategies at policy level.

The Effects of Soybean and Pigeon Pea on the Nutritional Status of School Children in Suba District, Kenya.

O. Ohiokpehai[1], D. Mbithe[2] and J. Kamau[2]

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Introduction

School children from households affected by HIV and AIDS often experience malnutrition due to different reasons such as the absence of food in the household. Nutrition interventions such as supplementation can be used to address malnutrition among such populations. Research has continuously shown the potential of using high yielding legumes to alleviate malnutrition especially Protein Energy Malnutrition (PEM) and micronutrient deficiency. Such legumes include the soybean and pigeon pea which are nutrient dense especially when dried and processed to add value and counter the effects of anti-nutrients such as phytates (Jambunathan (1980)).

While no food is exactly similar to another in nutrient value this study sought to experiment through feeding trials the effect of these two legumes in addressing malnutrition among school children in Suba District, Nyanza Province, a district that has continually reported high levels of malnutrition, poverty, food insecurity and a high burden of HIV and AIDS in a background of deepening hunger (KDHS, 2003, GoK, 2005). Orphaned school children (as a result of HIV/AIDS) and those with ailing parents have been worse hit (De Wagt and Connoly, 2006). Also, pigeon pea is culturally eaten in Kenya It was on the basis of this that the study targeted school children from households affected by HIV and AIDS between 6 and 9 years, who are likely to bear the toll of malnutrition and effects of HIV and AIDS. While the ecological situation in the study area (Suba District) may not favour the production of both these legumes, documentation of effects of these legumes in addressing malnutrition was deemed necessary in helping project planners select interventions both for soil improvement and food that are sustainable and cost effective.

Materials and Methods

Study design: A pre-post experimental study was conducted to establish the effect of corn soy blend and corn pigeon pea blend on the nutritional status of school children in Suba District of Nyanza province.

Sample size and sampling: Two schools (Mbita and Ong'ayo primary schools) were purposively selected for the feeding trial due to the HIV and AIDS burden from pupils' households. Systematic sampling was used to select pupils by age and their vulnerability status with children aged 6-9 years included in the study. About 49 children were selected from Mbita primary school and another 52 from Ong'ayo primary school bringing the total number to 101.

Description of the intervention: Pupils from Mbita primary school were fed on porridge made from corn soy blend for five months and monitoring was done after every month of feeding. The porridge was given daily at mid-morning. At the end of the five months, evaluation was done to determine the effect of soybean on their nutritional status Those aged 6-9 years from Ong'ayo Primary school were given porridge made of corn pigeon pea blend at school every day during mid morning break for similarly five months. Each of the study children received 100 grams corn soy blend/corn pigeon pea blend in form of porridge per day for a period of five months. According to FAO-WHO (1985), 100g of soybean per day in combination with a cereal will provide most of the daily protein requirement of 40g per day. In this regard, the ratio of carbohydrate to soybean/pigeon pea was 3:1. The corn soy blend with some added oil (5g) provided 363.8 kilocalories and 23.7 grams protein while the corn pigeon pea blend provided 373 kilocalories and 11.4grams protein. The protein content of the mixes was adjusted to between 12-14 percent for each of the mixes. Therefore the mixes supplied the same amounts of protein and vitamin and mineral mix as recommended by WFP.

Preliminary results

Differences in malnutrition levels within schools before and after the feeding trials

The results from Mbita Primary school which was fed with corn soy blend porridge indicate no significant differences ($P>0.05$) in Height/Age (stunting) levels reporting 21.6% and 16.4% before and after the intervention respectively. Results from Ong'ayo primary school (which was fed on corn pigeon pea blend porridge) show a similar trend. Differences in stunting levels before and after intervention were not significant ($P>0.05$).

Underweight levels reduced significantly ($p<0.05$) in both schools after the intervention. In Mbita primary school weight/Age levels (underweight) reduced significantly ($P<0.05$) from 9.8% before intervention to 4.3% after intervention. In Ong'ayo school there was slightly weak significance ($P=0.045$) improvement. Wasting levels similarly reduced significantly by almost half for both schools (5.4% to 2.2% and 9.5% to 4.3% for Mbita primary school and Ong'ayo primary school respectively **(Table 41).**

Data analysis is continuing.

Table 41: Differences of malnutrition levels within schools before and after the intervention

Forms of Malnutrition	Mbita Primary School corn soy blend porridge			Ong'ayo Primary School corn pigeon pea blend porridge		
	Before % N= 54	After % N= 49	*Sign. (P<0.05)	Before % N= 54	After % N= 53	*Sign. (P<0.05)
Stunting (Z score <2SD)	21.6	16.4	**0.101	21.5	18.8	**0.139
Underweight (Z score <2SD)	9.8	4.3	**0.039**	14.3	7.5	**0.045**
Wasting (Z score <2SD)	5.4	2.2	**0.028**	9.5	4.3	**0.030**
*Chi-square Test	**Differences not significant					

Effect of Soybean (Glycine Max.) Supplementation on The Nutritional Status Of HIV/AIDS Affected Children Aged 6-9 Years In Suba District, Kenya.

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Introduction

The HIV/AIDS pandemic is a global crisis with impacts that will be felt for decades to come. The epidemic is no longer just a health problem but has become a major threat to economic, social and political development. Sub-Saharan Africa is the region worst hit by this pandemic which is depleting the continent of its food producers, cutting food production and generating a spiral of acute poverty.

In 2006, UNAIDS estimated that 2.9 million people had died of HIV/AIDS while 4.8 million were infected bringing to 38 million people the number of people living with the virus world wide. According to the World Health Organization, approximately 8 million children had acquired the AIDS causing virus globally by the year 2000 since the epidemic begun and 3.6 million already died of (WHO, 2002). The prevalence rate in Kenya is 6.7% while that of Suba district is 41% the highest in Kenya (Kenya Demographic & Health Survey, 2003). According to the Kenya National HIV/AIDS Strategic Plan 2005/2006, there are 100,000 children living with HIV in Kenya. Approximately 11% of children below 15 years are orphans (Kenya Demographic Health Survey, 2003), while 2% are double orphans. In Nyanza province, 6% of orphaned children are mainly due to HIV/AIDS (NACC, 2005).

According to UNAIDS (2006) and Jackson (2002), 12 million children have been orphaned by losing either one or both parents to AIDS with 1.1 million in Kenya alone. Many house holds in Suba district are affected by HIV/AIDS and the number of orphans and other vulnerable children in the district is estimated to be 5,072 (KDHS, 2003).

In Kenya 47% of the population does not have secure access to food resources to adequately meet their daily needs. The high level of food insecurity is due to poverty and a reduction in agricultural production. HIV/AIDS reduces the household's ability to produce and buy food. Adults with HIV are less able to work on their land or earn an income from other activities (GOK/MOH, 2006). Generally, studies indicate that HIV affected communities and households are food insecure hence a decline in the nutritional status of small holder farmers and their families. This has an impact on the nutritional status of children.
One of the approaches towards mitigating the impact of HIV/AIDS is the provision of nutritional support and care. Sound nutrition practices reduce the rate of infection hence delaying the progression of opportunistic infections as well as boosting the immune system. In addition, the efficiency of most drugs is enhanced by better nutrition (UN, 2003). HIV/AIDS increases the risk of malnutrition hence demand for nutrient dense foods for maintenance of body weight, muscle mass and overall improvement of quality of life.

Africa is endowed with a variety of food sources which are high in protein and energy hence beneficial to malnourished individuals and people living with HIV/AIDS. Feeding on such foods may improve their nutritional status and reinforce the medical treatment. Soybeans provide food of choice for the nutrition of malnourished individuals. Besides being a cheap source of protein locally produced, they contain high protein, energy and their micronutrient content is higher than other locally produced legumes. Additionally, according to Kraak (2001) until prophylactic medications become available and accessible to all people affected and infected with HIV/AIDS life sustaining foods and safe fluids are the only realistic cost effective approaches to mitigate the impact of HIV/AIDS.
This paper presents results of a randomized feeding trial in which HIV/AIDS affected children aged 6-9 years were provided with a nutrient dense porridge made from corn-soy blend to supplement their diets, every day for a period of 3 months and their nutritional status monitored every month after the feeding trial for 6 months by use of anthropometric measurements. A control group which was not on the feeding trial was included for comparison purposes.

Rationale for soybean supplementation
Dilger et., al (2004) showed that soybeans contain very high nutritional content yet simple and cheap to produce. Dry soybeans contain about 40% protein, 20% oil, 35% carbohydrate and 5% ash. This is much higher than the average 20-30% protein found in other grain legumes. Soybeans contain a large amount of essential amino acids such as glycine, tryptophan, cysteine, glutamine and hydroxyproline (Takahashi, et, al, 2003). They also contain adequate B group vitamins especially thiamine, pyridoxine and folic acid, iron and selenium (Forster, 2006). Soybeans are one of the non-fish sources of essential omega-3 fatty acids which help to reduce the risk of coronary heart disease. The fat contains no cholesterol thus improving heart function. Soybeans also contain phytoestrogens particularly isoflavones (genistein and daidzen) and lignans. These lower free oestrogen levels in plasma and inhibit growth of cancer cells and tumors. Further, isoflavones improve health and reduce osteoporosis through bone density (Kessel, 2002).

Materials and methods

The experimental research design was employed in this study. Three schools Sindo and Ong'ayo primary schools in Central location while Lambwe primary school in Lambwe location was identified for this study. A sampling frame of 565 HIV orphaned children was constituted as follows; 125, 200 and 245 children from Ong'ayo, Lambwe and Sindo primary schools respectively. From these, 50 respondents were selected from each school using the simple random sampling strategy. A total of 150 HIV/AIDS affected children formed the study sample. These children aged 6-9 years were orphaned by HIV/AIDS. The children in the experimental schools, Lambwe and Sindo were provided with porridge made from corn-soy blend of 100gm daily for three months (Feb-May, 2007), while children in the control school, Ong'ayo did not receive any food. However, the parents and guardians in this school received complementary nutrition education. All the children were monitored each month and anthropometric measurements taken.

Pilot testing was carried out on 5% of the children not involved in the study. Structured questionnaires were administered by research assistants to mothers and guardians of the children. Data on socio-economic, food production and consumption and dietary habits was gathered here.

Anthropometric measurements specifically height, weight and mid-upper-arm circumference were carried out by the researcher on the index child using standard anthropometric equipment and procedures as described in the anthropometric indicators guide (Cogill, 2003). Body weight measurements were taken with minimum clothing to the nearest 0.1kg using an electronic scale (Camry, Model BR9012, Germany) to the nearest 0.1 kg. Height was taken while the child was standing straight using a portable stadiometer (Model 26SM 200cm, Germany) to the nearest 0.1 centimeter. A non-stretchable arm circumference tape was used to take mid-upper -arm circumference (MUAC) to the nearest centimeter. Each measurement was taken three times and the average considered adequate for analysis. Dietary assessments involved use of the 24 hr recall.

Cut off points

Height and weight measurements were used to compute height-for-age (HA), weight-for-age (WA) and weight -for -height (WH) z-scores according to the National Centre of Health Statistics-World Health Organization (NCHS-WHO, 1997) growth reference curves as indicators of the nutritional status of children. A child with WA, HA and WH values falling below -2 standard deviations of the reference population were considered malnourished. Those falling below -3 standard deviations of the reference population were considered severely malnourished. Cut off points for MUAC as advised by Gibson (1996) were applied here, and used as a guideline in identifying the trend of MUAC scores. A probability value of <0.05 level was considered significant.

The intervention

A nutrient dense porridge made from corn-soy blend was used to supplement children's diets with a view to improve their nutrition status. In addition, all the children in the study were de-wormed, given vitamin A supplements and long lasting insecticide treated mosquito nets for control of malaria; malaria is an endemic disease in the region.

This is guided by principles of Essential Package of Nutrition and Health of WFP/UNICEF (2006) which includes nutrition, education, hygiene, breastfeeding, food interventions, micronutrient supplementation, household water treatment and parasite control in particular de-worming. In addition community members including parents/guardians of the school children were trained on soybean processing and utilization and sustainable agriculture (Conservation agriculture) for sustainability of the program and to enhance soil improvement and food security in the area. The intervention was packaged to demonstrate that legumes improves soil health and provides good quality food for holistic food/nutrition security.

Composition of the corn-soy blend

The corn-soy blend was prepared and packed by Nutro-Food Company situated in the Export Processing Zone (EPZ) Athi River, Kenya. The composition was according to WFP recommendation ratio of carbohydrate to soybeans which is 3:1 thus 75 gm of maize was blended with 25 gm of soybeans. Each child on the feeding trial was served with 100gm of corn soy blend soy blend prepared as porridge and served as a mid-morning snack in school everyday for three months between Feb-May, 2007. This yielded Kcal 363.8 and 23.7 gm of protein. At the end of the week each child was provided with 500 gm of CSB flour as a take home ration. This would be prepared for the child and four other vulnerable children at home during the weekends to ensure continuity of the feeding trial as an addition of a quality one meal a day.

Preliminary results

(Table 42) shows results of anthropometric measurements taken of the children at baseline and three months after the intervention.

Table 42: Comparison between mean z-scores for each school studied

Primary School	**BASELINE data (Before the intervention)**				**3 months into the Intervention period**			
	HAZ	WAZ	WHZ	MUAC	HAZ	WAZ	WHZ	MUAC
Sindo pri. sch.	-.63	-.38	.64	16.70	-.26	0.86	0.20	17.40
Lambwe pri. Sch	-.23	-.71	-.89	16.34	0.20	-0.14	-0.41	17.6
Onga'yo pri. sch.	-.31	-.36	-.27	16.74	-.25	-.63	-.69	16.7

Children in Sindo and Lambwe primary schools were on the feeding trial while those in Ong'ayo primary school were not on the feeding trial but were included for comparison purposes.

Results for Sindo primary school show a positive trend in mean z-scores for the three indices under study; the mean height-for-age z-score improved from -0.63 at baseline to -0.26 after three months of the intervention. The number of children who were stunted reduced from 16% at baseline to 6.3% after the intervention.

Likewise, there was an improvement in mean weight-for-age scores from -0.38 at baseline to 0.86 after the intervention, the number of underweight children reduced from 9.3% at baseline to 6.1% after the intervention. Weight-for-height mean score improved from 0.64 at baseline to 0.20 after 3 months of the feeding trial. The number of children who were wasted reduced from 7.4% at baseline to .01% after 3 months. MUAC means improved by 0.73 cm from 16.70 at baseline to 17.4. There were statistically significant differences between baseline and after the intervention in all the indices studied [WA p=.000, t=-7.99; HA p=.000, t=-5.184; WH p=.029, t=-2.256 and MUAC p=.000, t=-7.6].

From the table, there was a steady improvement in mean z-scores for Lambwe primary school from the baseline to the third month. The mean height-for age z-score improved from -0.23 at baseline to 0.20 after the intervention hence stunting reduced from 11.8% at baseline to 4.1% after the intervention. The mean z-score for weight-for-age improved from -0.71 at baseline to –0.14 after the intervention, the number of underweight children reduced from 7.8% to 2% after the intervention. Mean z-score for weight-for-height improved from -0.89 at baseline to -0.41, the number of children wasting reduced from 7.8% to nil. The intervention resulted in the increase of MUAC mean by 1.26 cm from 16.34 to 17.6. This means that there was an overall improvement in all the nutrition indicators. There were statistically significant differences in all the indices studied $p<0.05$. [WA p=.000, t=-8.852; HA p=0.002, t=-3.324; WH p=.000, t=-3.722; MUAC p=.000, t=-13.59].

Results for Ong'ayo primary school show a reduction in the mean z-scores for weight-for-age and weight-for-height -0.36 to -0.63 after 3 months and -0.27 to -0.69 respectively. This means that the number of children who were both underweight and wasted increased over the three months thus underweight increased from 11.4% to 13% while wasting increased from 9.3% to 14.3% after three months. However, height-for-age mean z-score improved slightly from -0.31 to -0.25 indicating a slight reduction in stunting. MUAC mean data reduced by 0.04 cm from 16.74 to 16.70. There were no significant differences in height-for-age and weight-for-age scores between baseline and the third month of the intervention $P>0.05$ [HA p=0.866, t=0.170; WA p=0.051, t=3.69].

The experimental schools in the feeding trial were followed up each month after the feeding trial for 3 months. The purpose of this follow-up was to measure any changes in the nutritional status after the intervention for proof of the importance of the soybean one meal a day to the family food basket.

Table 43: Follow–up at 3rd and 6th month after the intervention

Primary school	**3 months into the intervention period**				**3 months after the intervention (6th month)**			
	HAZ	WAZ	WHZ	MUAC	HAZ	WAZ	WHZ	MUAC
Sindo primary	-.26	0.86	-.20	17.40	0.24	0.21	0.38	17.40
Lambwe primary	0.20	-.14	-.41	17.61	-.17	-0.42	-0.14	17.50

For Sindo primary school the results indicated that the mean z-score for HA improved slightly from -0.26 to 0.24 at the 3rd month after the feeding trial. Hence stunting reduced from 6.3% to 4.2% after 6 months. The mean z-score for weight-for-age reduced slightly from -0.86 to 0.21, the number of children underweight was 6.3% up from 6.1 % at three months. Weight-for-height mean z-score was -.20 to 0.38 there was an increase in wasting from .01% at three months to 3.7%. MUAC mean z-score remained the same and there was no significant difference as $p > 0.05$. The differences in the indices studied between 3 months and at 6 months were statistically significant as $p<0.05$. [HA p=0.11, WA p =0.00, WH p=0.00].

For Lambwe primary school, mean z-score for weight-for-age and height-for-age reduced from -0.14 at 3rd month during the feeding to -0.42 and 0.20 at 3rd month during feeding to -0.17 respectively. The number of children underweight dropped slightly from 2% to 1.9% at the 6th month while that of stunted children also reduced slightly 4.1% at 3 months to 2.9% at 6 months. Mean weight-for-height score improved from -0.41 at 3 months to -0.14 at 6 months with wasting increasing slightly from nil at 3 months to 1.9%. MUAC mean reduced from 17.6 - 17.50. There were statistically no significant differences in HA (p=0.798) and WA (p=0.096) however, WH recorded a significant difference as $p<0.05$.

Preliminary Discussion

This study sought to establish the effect of soybean supplementation on the nutritional status of HIV affected children in Suba district. Children in the experimental schools; Lambwe and Sindo had their diets supplemented with porridge made from corn-soy blend for three months while the control school Onga'yo did not have any supplementation. However, parents in this school received complementary nutrition education. **(Table 44)** showed the percentage distribution of the nutrition indices studied between baseline and at 6 months after the intervention.

Table 44: Percentage distribution of nutrition indices studied

Primary sch	Baseline			3rd month			6th month		
	stunting	Under-weight	wasting	stunting	Under-weight	wasting	stunting	Under-weight	wasting
Sindo	16.7%	9.3%	7.4%	6.3%	6.1%	.01%	4.2%	6.3%	3.7%
Lambwe	11.8%	7.8%	7.8%	4.1%	2%	0%	2.9%	1.9%	1.9%
Ong'ayo	19.8%	11.4%	9.3%	17.4%	13%	14.3%			

The results show that children in the experimental schools, Sindo and Lambwe showed a positive increase in the anthropometric indices measured. This change could be attributed to the corn-soy blend fed to the children.

From the results, there was an evidence that the children's' nutritional status improved a great deal during the feeding trial; percentage of children who were malnourished tended to reduce as seen from the **(Table 44).** However, there were some slight changes at the 6th month with underweight and wasting increasing in Sindo primary while wasting increased in Lambwe. This could be attributed to the fact that the children's diets were no longer being supplemented with corn-soy porridge.

Therefore, depending on the traditional meals provided at home as shown from the 24 hr recall were not adequate (Ohiokpehai-Nutritional Baseline Survey Report, 2006). Generally the number of malnourished children in the experimental schools showed a downward trend; between the 3rd and the 6th month.

Differences in anthropometric measurements in farming (Lambwe primary school) and fishing (Sindo primary school) areas

Although children in both Lambwe and Sindo primary schools were in the feeding trial there were slight differences in overall anthropometric data, yet they all received an equal amount of corn-soy blend daily. Generally, children in Lambwe primary showed a positive and steady progression as compared to Sindo primary school. Sindo primary school is situated in a fishing area and most parents or guardians are predominantly engaged in businesses outside the home. Whereas there is a ready availability of fish to the house hold diets, the parents mainly depend on buying food instead of growing them (Ohiokpehai et. al-Suba Nutritional Baseline Survey Report, 2006). Most of the food sold in the local market is imported from neighbouring districts and tends to be too expensive for the parents purchase in large quantities. Lambwe primary school is situated in a farming area and the climatic conditions favoured agricultural production, hence availability of a variety of foods to the households. In fact though our soybean promotion project started in the Fishing area (Sindo Primary school), but the progress is better in the farming area (Lambwe Primary School).

Nutritionally, soybeans (or any other legumes) are valued for their soil improvement capability, protein and fat content. A study by Dilger et, al (2004) showed that soybeans contain protein 40%, oil 20%, carbohydrate 35% and 5% dietary fiber. These data are lower for common beans, but better for than for cereals and other staples. Takahashi (2003) showed that soybeans are rich in essential amino-acids such as cystein, tryptophan and glutamine therefore good for growth and development of young children and vitamin B6 and selenium. Soybeans are easy to digest especially for people living with HIV and selenium had been implicated in the prevalence and progression of HIV.

From the literature, when soy protein was used in the production of soy formula it is particularly useful to children who are allergic to dairy protein and suffer from lactose intolerance and is widely known to be nutritious. Infact, soy protein is commonly used in food AID programs by WFP, USDA and UNICEF, and provide soy milk as a mid-morning snack in school lunch programs and breakfast programs to children who do not drink cow's milk and has proved to be beneficial to children's health (SIN, 1995; RonHeck, 2004).

Fakande and Malomo (1998) studied 15 HIV patients, 10 females and 5 males. These patients were provided with soy meal diet added to a carbohydrate meal of choice in the ratio 3:1 and their body weight taken for a period of 6 months daily and recorded. The male average weight gain was 5% monthly while the females was 2.5% ($p<0.001$). This program not only helped prolong the lives of the HIV patients but for the terminally ill too. Further, soybean is a primary ingredient in most supplements given to HIV patients in the USA. This could be attributed to the phyto-chemicals which are responsible for immune boosting (Dilger et al, 2004). Forster (2006) showed that taking phytosterols maintained a stable immune cell numbers over 2 years but controls not receiving phytosterols showed CD 4 cell loss. Sanginga et al, (1999) in study in Nigeria showed that soybeans can improve soil health.

Also the demonstration in the introduction of soybeans in the local diets which led to improved nutritional status of children and their families in particular; led to an increase in soybean production, market development and change of attitude towards soybean and its products.

Preliminary Conclusion

From the study it is evident that children whose diets were supplemented with corn-soy blend had improved nutritional status compared to those whose diets were not supplemented. This information convinced the parents that it was indeed necessary to grow soybeans (or any other legumes).

The determination of the necessary impetus for the sustainable soybean Utilisation in the farming systems of Kenya.

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Introduction

Soybean was introduced in the farming systems of Kenya many decades ago. However, the crop has remained a minor crop despite its great potentials for improving household food and nutrition security (through quality food supply), household cash income (through the sales of soybean and soybean products), household health (through the provision of high quality protein-rich food), and soil fertility improvement (through its atmospheric nitrogen-fixing ability). Lack of how to process and the knowledge of the goodness and the necessary market for the output are reasons given by farmers for not giving much attention to soybean production. These imply that without proper processing know-how and market development, all efforts towards soybean development and promotion in East Africa will amount to nothing.

Objective

This study aims at identifying various ways of developing soybean use at different levels (household-level, and community-level, by linking farmers with industries that use soybean) in the farming systems of Kenya.

Methodology

Data from many studies currently being carried out will contribute to this. These include (i) the baseline household-level survey of soybean in the farming systems of western Kenya, (ii) the baseline community-level survey of soybean in the farming systems of western Kenya, (iii) Follow-up survey of vulnerable school children selected from different primary schools in Suba, (iv) survey of large scale food and feed industries in Kenya, (v) key informant interviews in Suba and Butere among others. All these surveys are being executed using structured questionnaire and chechlists.

Apart from the above, the processes that we are using to develop the soybean market development at household-level include (i) awareness creation on the goodness of soybean, (ii) effective promotion through participatory training and development on the processing of ready-to-eat soybean products and the associated recipes. At the community-level, our efforts are centered on the *VitaGoat* and/ or SoyCow System (machines used in soymilk production).

At the industrial level, our activity is on linking farmers and producer groups to large-scale food and feed industries (to ensure the existence of market opportunities that can mop up production levels that are beyond the absorptive capacities of the household- and community-level demand and help in import substitution that can save the huge foreign exchange often spent by these industries to import soybean for processing/manufacture of products in Kenya

Preliminary results

The awareness creation has led and is currently continuing to lead to widespread adoption of soybean production among the communities in CIAT-TSBF action sites in Suba, Butere-Mumias and Migori and numerous other districts that have joined the soybean promotion work. Two VitaGoats and one SoyCow have been imported from India and Canada respectively Many industrial processors of soybean in Kenya, including NUTRO EPZ and SoyAfric have agreed to import substitution and to clear the market for whatever soybean that the Kenyan farmers produce and at Kshs. 26 per kg. They have kept this promise and have been purchasing soybean from farmers and farmers' groups. They encourage farmers and farmers' groups to bulk as from 5 tons before arranging to supply them. This will also assist in enabling the farmers to tap some of the advantages associated with the economies of large scale, especially those related to cheap transport per unit of sales. The VitaGoat at AMPATH is being used to supply soymilk to patients attending their hospitals/clinics/ and food distribution centres.

The data from the research group from the school feeding and the soybean/amaranth work will further act as a catalyst to farmers and demonstrate the goodness of soybeans (and other legumes) in production systems, and as food.

Training (capacity building) in Soybean processing and utilisation: a vehicle of knowledge dissemination and scale-up.

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Introduction

The proven and tested technologies through the project were continued being shared with partners, patients and farmers. This sharing of knowledge was used as a method of scaling up and strengthening alliances.

Materials and Methods

Training was carried out in Eldoret, Butere, Mumias, Migori and at Suba District by introducing soybean processing and utilization. For all the sites **(Figure 35)**, we used different training techniques, depending on the community's practices and preferences. Soybean introduction vis-à-vis processing was combined with hygiene and sanitation (HACCP) and processing of food products. The following topics were included: HIV/AIDS and Nutrition awareness, basic business management, and Money issues. However the following topics were covered during the ToT to improve on finished product quality: (i) Hygiene and sanitation, (ii) Basic business management, (iii) Nutritional education, (iv) Nutrition as it relates to HIV, (v) Entrepreneurial awareness, (vi) Gender issues, (vii) Money matters, and (viii) Packaging and labeling.

As shown in **(Figure 35)** – In **Eldoret** for HIV patients the training adopted training of every two weeks for one full day. The patients would come in to the farm and they would be taken through a training session for a whole day. This method was adopted as the patients could not be saddled with a heavy training schedule continouosly for a day. At the end of four or five trainings, the patients were issued with certificates of attendance. This was a form of motivation to the patients to increase their interest in soybeans. The training is continuing in AMPATH focusing on hygiene, sanitation and infant feeding with children whose mothers are HIV positive.

Objectives of the training at AMPATH

1. To improve household soybean utilization among AMPATH clients through sensitization and training on different soybean uses at household level.
2. To further promote soymilk consumption in order to ensure continuous large-scale soymilk processing activity using soymilk processing machine (VitaGoat) that was launched earlier last year but has not been fully operational.
3. To increase soybean production among AMPATH clients towards increasing food security, income generation and soil fertility levels.

The following are the approaches and methods used:

1. Promoting soybean production by adopting highly feasible soybean production techniques.
   This was carried out by introducing viable farming innovations i.e. intercropping, crop rotation and conservation tillage among clients within major AMPATH's sites. Field visits were made together with FPI field extension and social workers and detailed explanation on different farming technologies given to farmers. Pamphlets were offered for further reading on Conservation Agriculture and Intercropping. Similarly, other high value crops like indigenous vegetables i.e. grain amaranth and indigenous fruits were also promoted during the field visits. Advantages of incorporating soybean into current farming systems especially due to its soil replenishing properties were greatly emphasized.
2. Soybean processing and utilization (nutrition-based promotional approach)
   This was carried out at the main food distribution site at AMPATH center everyday for 30-45 minutes as the clients waited to collect food. A single topic would be taught everyday for a week since there were different groups of clients collecting foodstuff everyday. Recipes for different soy products were developed in Swahili were distributed among clients as some would not be able to attend the subsequent classes. Together with social workers, home visits were made to clients who were too weak to collect food and similar information on how to process and utilize soybeans offered. Immediately the soybean promotion started high turnouts of clients collecting food was recorded averaging about 70 persons per day, majority of whom were women.
3. Other topics covered during training included:
   -Hygiene and sanitation. This included personal and household hygiene in regard to food processing in order to avoid contamination or food poisoning.
   -Basic business management that included marketing approaches and techniques one might use when introducing new food products to any market.

-Packaging and storage of the processed foods, and maintenance of the cooking and or food processing equipments. -Nutrition education on other nutrient dense traditional foods in the area i.e. pumpkins, sweet potatoes, grain amaranth e.t.c.
-HIV/AIDS in relation to nutrition and food.

Achievements

1) There was a positive response in adopting conservation agriculture due to the high labor reduction associated with the farming technology. Similarly, a fair number of clients were willing to also try out intercropping and rotation of soybean with the major cereal in the region which is maize. FPI had its extension workers plan for extension services on these farming innovations during the next growing season starting March 2007.
2) Recipes developed came in handy as they were in Swahili and offered most of what the clients were unable to learn due to the limited time available during training.
3) The presence of the soymilk processing machine (VitaGoat) at AMPATH was a huge success since the clients can now access soymilk (500ml each) and alternate it with cow's milk at different times of the month.
4) Family Preservation Initiative (FPI) processed the first soybean milk on large-scale basis on Tue. 4th Dec. 2007 and taste testing carried out by majority of AMPATH' s client a
5) Among the soy products being promoted, soymilk received the most attention because:- .
    - It was already processed and it is in a 'ready – to - drink' form.
    - The thickness and sugar content was acceptable to many. No flavors were added as it did not have the 'beany' smell.
    - Soymilk would form a major ingredient in many soy recipes i.e. soy yoghurt, soy porridge, soy ugali e.t.c.
    - Soymilk was easy to consume since the clients could easily take it even when having wounds/ulcerations in the mouth/throat.
    - Soymilk was found to be more effective for weaning off babies as it did not cause allergic reactions compared to other dairy products.
    - The presence of VitaGoat at FPI would lead to other projects like poultry and fish rearing as the pulp would be used to make chicken and fish feed which is otherwise expensive to buy.
    - FPI soymilk processing unit would is creating demand for soybean grains hence the clients now has a reason for increasing acreage under soybean production due to the readily available market in the community.

Challenges /issues arising

- Different groups of clients receive food aid at different days of the week so only a single topic could be taught per week. This limited the contents taught.
- There was limited time for offering soybean nutrition classes since majority of AMPATH clients are women who have many chores back home. Therefore, classes could only be carried out for a maximum period of 30-45 min a day as they waited to collect food. This meant that practical sessions could not be carried out hence brief handouts on soy processing and utilization and soy recipes written in Swahili were issued for further reading. In addition, questions arising could not be thoroughly answered.

- Most clients complained about processing soy flour and soymilk (the major ingredients for soy products) at home as being a tedious activity since their bodies are weak due to ARVs effect and constant illnesses and requested for 'ready to use' soy products.
- Being a pilot project, FPI lacks enough soybean seed for distribution among AMPATH clients and therefore cannot produce enough soybean grain for continuous soymilk processing and supply. This meant that some clients have to wait longer to be supplied with soymilk.
- After the training, the demand for soymilk increased. However, AMPATH has only one soymilk processing machine which is not enough to process soymilk for all its clients located at different sites in Western Kenya.
- Perception studies must be conducted to ascertain the level of need for AMPATH clients.

Conclusions

Increased production of soybean among AMPATH clients can be stimulated by increased demand for soybean grains by FPI since they need about 14.7 tones of soybean grains to be able to supply soymilk for the currently enrolled 36,628 AMPATH clients per day. This is so since they are currently processing 15 liters of soymilk from 2 kg soybean grains.

However, promotion of soybean at farm/family level should simultaneously be accompanied by the promotion of processing and usage by families to enhance the nutritional values.

This in return will form a basis for inputs into other agro-based industries i.e. production of animal feed from soybean processing hence initiate other projects like poultry and fish rearing towards sustainable agriculture.

Butere/Mumias – In Butere/Mumias **(see Figure 19)** the farmers met prior to the training days and planned for the activities facilitated by a trainer. The training was carried out for two days. The farmers supplied the utensils used as per our advice. The topics covered during the training sessions included: (i) Food safety and Hygiene, (ii) Soybean and vegetable processing and utilization, (iii) Nutritional education, (iv) Basic business, (v) Packaging, and (vi) Labeling.

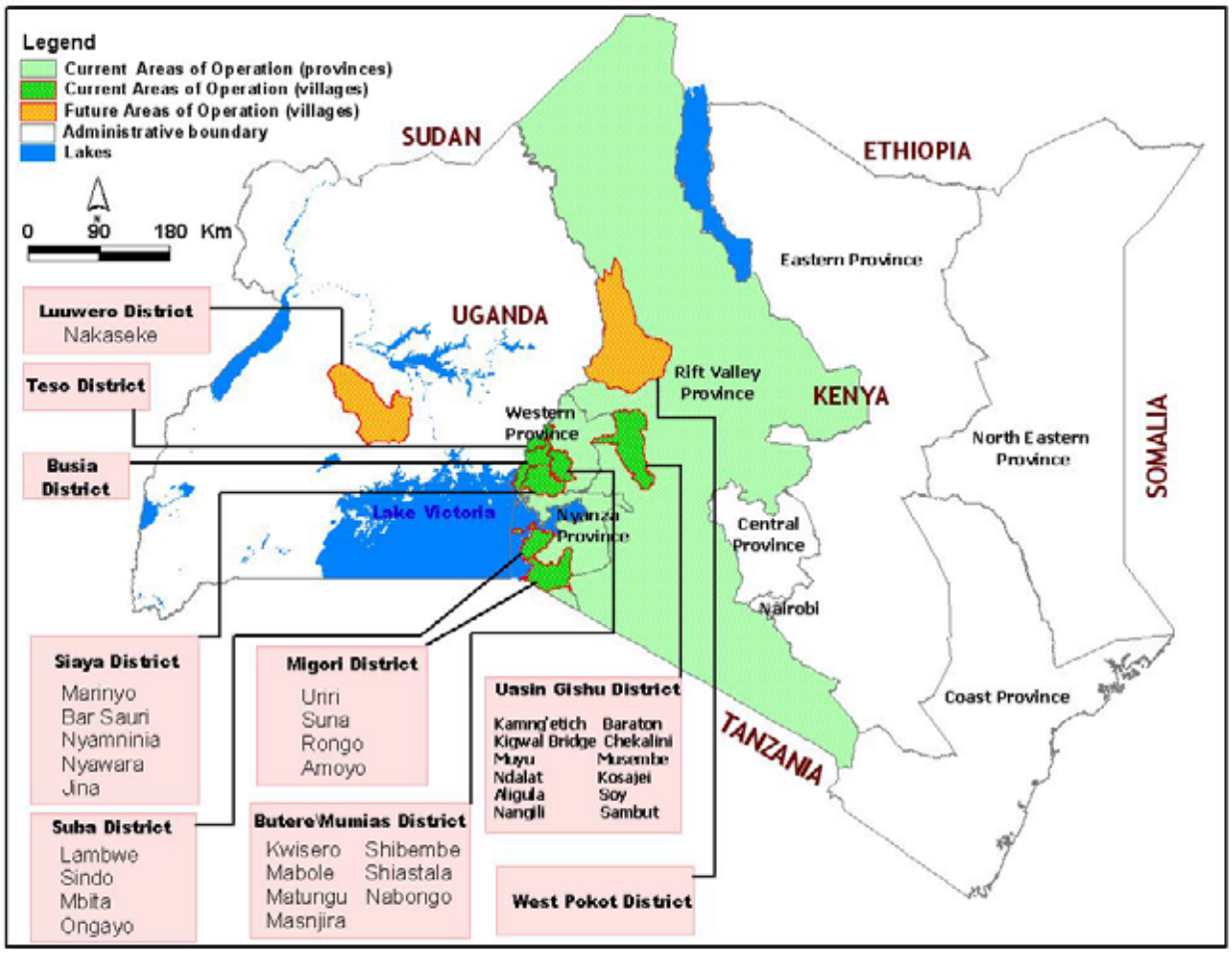
Migori District – In Migori **(see Figure 19)** we identified eleven groups of farmers' cooperatives. Training commenced with four cooperative societies, with 60 or more farmers trained on soybean processing and utilization. CIAT-TSBF worked with facilitators trained previously in Butere/Mumias. Also, farmers were chosen as trainers to demonstrate to their fellow farmers that they had been trained in processing and utilization of soybeans, as they had adopted consumption of soybeans, and it was possible to process soybean.

The farmers from Migori were identified through a sister project "Exploring multiple potential of soybeans in enhancing rural livelihood and small industry in East Africa." These farmers had already planted and harvested soybeans, and were waiting to be trained on soybean processing. Before such ToF took place, participatory planning was carried out. For each training session the facilitators went into the villages and met with some of the participants and officers of the cooperative groups who participated in one or two-day planning. Decisions on venue, budget, utensils needs for the training, and other logistic issues were discussed during the planning.

Preliminary results

Several HIV patients, farmers were trained in Eldoret, Suba and Butere/Mumias and Migori respectively. For all the sites, we used different training techniques, depending on the community's practices and preferences. Soybean introduction vis-à-vis processing was combined with hygiene and sanitation and processing of food products. The following topics were included: HIV/AIDS and Nutrition awareness, basic business management, and Money issues. However the following topics were covered during the ToT to improve on finished product quality: (i) Hygiene and sanitation, (ii) Basic business management, (iii) Nutritional education, (iv) Nutrition as it relates to HIV, (v) Entrepreneurial awareness, (vi) Gender issues, (vii) Money matters, and (viii) Packaging and labeling. In recent times the training had been redesigned to cater for the advanced entrepreneurs as follows: Soybean processing and Nutrition, Hygiene and sanitation – HACCP; Packaging and Labeling (supported by Sealed-Air, Italy), Business management and Entrepreneurship.

Figure 35: Current Areas of operation



Output target 2009

- ***Validated intensive and profitable systems are being demonstrated, promoted by partners and adopted by farmers in 10 countries***

Published work

Kolawole[1], G.O., Diels[1], J., Manyong[1], V.M., Ugbabe[2], O., Wallays[5], K., Dercon[1], G., Iwuafor[2], E.N.O., Falaki[2], A.M., Merckx[3], R., Deckers[3], J., Tollens[4], E., Vanlauwe[5], B. and Sanginga[5], N. Balanced Nutrient Management System Technologies In The Northern Guinea Savanna Of Nigeria: Validation And Perspective Challenges and Opportunities, 669-678

[1]IITA, Ibadan, Nigeria; [2]Institute for Agriculture Research, Ahmadu Bello University, Nigeria; [3]Laboratory of Soil and Water Management, Katholike University, Leuven, Belgium; [4]Centre for Agriculture and food Economics, Katholike University, Leuven, Belgium; [5]CIAT-TSBF, Kenya

Abstract: Based on experimental evidence that combining mineral fertilizers with organic matter may address poor soil fer-tility status and result in added benefits, farmer-managed demonstration trials were initiated in 9 villages in the northern Guinea savanna (NGS) of northern Nigeria. The trials had four treatments: (i) a farmers control in which the farmer grows maize according to his usual practice, (ii) the maize technology being promoted by the NGO Sasakawa-Global2000 (SG2000), involving hybrid seeds, proper plant density and fertilizer application practice, and fertilizer application rates that are relatively high for the region (136 kg N, 20 kg P, and 37 kg K ha^{-1}), (iii) the Balanced Nutrient Management Systems (BNMS) manure technology that follows the SG2000 package for maize, except that part of the fertilizer quantity is replaced by animal manure; and (iv) a soybean-maize rotation, again with reduced fertilizer rate to the maize. Results from the full 2-year cycle indicated that the improved systems out-yielded the farmers' control treatment by about 1000 kg ha^{-1}. Maize after soybean gave yields similar to those obtained with the combined application of fertilizer and manure (BNMS-manure) to maize but slightly higher than the fertilizer-only practice (SG2000). There was large variability in the quantities of manure and fertilizers applied and maize yields obtained among farmers. Over the 2-year cycle, the improved soybean/maize rotation system was economically superior and dominated all the other systems because of its lowest variable costs and highest gross margins. At the end of the season, using an overall satisfaction score based on eight criteria, 94% of the farmers were satisfied with the soybean-maize rotation, 83% with the BNMS-manure treatment, and 29% with the SG2000 treatment. Farmers indicated manure availability as the main constraint for the BNMS-manure system; therefore, further research should focus on closed systems with crop-livestock integration in order to increase the manure availability within the farm. As many farmers were enthusiastic about the soybean-maize rotation treatment, SG2000 in partnership with the Agricultural Development Projects (ADPs) have started promoting this system alongside the SG2000 maize package to farmers in northern Nigeria

Ndufa[1], J.K. Cadisch[2], G., Poulton[2], C., Noordin[3], Q. and Vanlauwe[4], B. (2007) Integrated Soil Fertility Management and Poverty Traps in Western Kenya. Challenges and Opportunities, 1055-1069

[1]KEFRI, Kenya; [2]Department of Agricultural sciences, Imperial College, London; [3]ICRAF, Kenya; [4]CIAT-TSBF, Kenya

Abstract: Based on agro-climatic conditions, the highland districts around Lake Victoria in western Kenya should be a food surplus area. In practice, they are heavily dependent on food imports, whilst national poverty surveys consistently show them to be amongst the poorest in the country. At the root of this problem are high population densities and, therefore, small land holdings, and limited access to markets. As a result of continuous cropping with very little investment in soil fertility replenishment, the soils have become severely depleted. Many poor households in these districts are now caught in a "maize-focused poverty trap", whereby their first agricultural priority is to provide themselves with maize for home consumption, yet yields are low and returns are insufficient to support investment in either organic soil fertility enhancement technologies or inorganic fertilizers. Thus, despite that the majority of average household puts large portions of its land under maize during both cropping seasons, it is still unable to feed itself for several months of the year. In addition to the problem of low soil fertility, continuous cropping of maize has also led to an endemic infestation of the striga weed throughout these districts, further depressing maize yields. To invest in soils, most households (unless they have a reliable source of non-farm income) need to diversify into higher value crops than maize. However, the combination of small land holdings and existing maize deficits mean that they will only plant other crops if they can simultaneously raise their maize yields.

Achieving this requires that a number of conditions must be in place. Firstly, households must be linked to markets, so that they can identify higher value cropping opportunities and be able to market their crops once they have grown them. In the western highlands, most producers are only familiar with local markets (where opportunities are limited) and they can initially only offer small quantities of produce, which reduces their attractiveness to potential buyers. Secondly, they need technical knowledge, on best cultural practices for the new crops and, critically, on how to manage their natural resource base, so as to increase their yields both of maize and of the new crops. Thirdly, they need to be able to access good quality seeds of crop varieties that are both suited to their local production conditions and are demanded in the market-place. Finally, most will also need access to credit, so as to be able to acquire inputs for more intensive maize production. This credit can then be repaid out of the sale of the additional crops later in the year. Critically, all these conditions need to be in place within their local area before poor households can hope to shift from a maize-only production system to one that delivers enhanced food and cash, whilst simultaneously enhancing the soil fertility on which future production depends. This paper reports the experience of a DFID funded action research project that, since 2001, has been exploring the potential for coordinated development interventions to enhance livelihoods through the promotion of integrated soil fertility management in collaboration with national and international institutes and extension services.

Experiences with the provision of technical advice, the development of a community based credit scheme for agricultural inputs, initial steps towards linking farmers to new markets and making new seeds available to producers are reviewed and constraints identified, along with initial indications of the impact that coordinated service provision could have on agricultural production and livelihoods. Finally, the over-arching challenge of how to coordinate the provision of these services on a sustainable basis is considered

Completed work

Determinants of the decision to adopt or not to adopt soil fertility replenishment resources in the central highlands of Kenya. Nutrient Cycling in agro-ecosystems, submitted.

J. Mugwe[1], D. Mugendi[2], M. Mucheru-Muna[2], R. Merckx[3], J. Chianu[4], and B. Vanlauwe[4],
[1]Kenya Forestry Research Institute, Kenya; [2]Kenyatta University, Kenya [3]Katholeike Universiteit Leuven Belgium; [4]CIAT-TSBF, Kenya

Soil fertility degradation has been a major cause of declining per capita food production and availability on smallholder farms of sub-Saharan Africa (SSA). This study attempted to provide an empirical explanation of the factors associated with farmers' decision to adopt or not to adopt newly introduced integrated soil fertility replenishment technologies (SFRT) consisting of combinations of organics and mineral fertilizer in Meru South district of the central highlands of Kenya. A total of 106 households, randomly selected from a list of farmers who had attended field days in a demonstration site to learn about the new SFRT from 2000 to 2002 (six cropping seasons), were interviewed in May 2004. Out of these, 46% were classified as 'adopters' while the rest, 54% were classified as 'non-adopters'. The classification was based on presence of the SFRT on farmers fields and an adopter was a farmer who had practiced at least one of the introduced SFRT consistently for three seasons. Logistic regression model was used to determine factors determining farmers decision to adopt or not to adopt SFRT as well as to predict the likelihood of adopting SFRT. The factors that significantly influenced adoption positively were farm management, ability to hire labour, and months in a year households bought food for their families while age of household head and number of mature cattle negatively influenced adoption. The implication of these results is that the adoption of SFRT could be enhanced through targeting of younger families where both spouses work on farm fulltime and food insecure households. It is also important to target farmers that lack access to other sources of soil fertility improvement. Examples include farmers that do not possess cattle or those possessing few and therefore have limited access to animal manure.

Work in progress

Rotation Effect of Soybean on the Production of the Subsequent Maize Crop.

I. Vandeplas[1], L. Driessens[2], S. Deckers[2], R. Merckx[2] and B. Vanlauwe[3]
[1]K. U. Leuven, VLIR-UOS, Belgium, CIAT-TSBF; [2]K.U. Leuven, Belgium; [3]CIAT-TSBF, Kenya

Introduction

During the short rains of 2006 a collaborative experiment on input cost and labour reduction for soybean production had been setup in Migori and Rongo districts. During the long rains of 2007, maize was planted here to look at the rotation effect of soybean on the maize yields.

The experiments were conducted in 10 fields spread over 4 "zones" of the Uriri Farmer Cooperative Society. The research looked at the effect of soybean on subsequent sole maize and on maize-bean intercrop, as the latter is the most common practice in the region.

Material and Methods

The experiments were conducted in 10 fields, of 19-24 plots of 8x8m to 10x10m depending on the available space. In 2006, soybean had been planted in all but two plots with different treatments of 'labour' and 'input'. Two plots had been kept for maize without input. In the second season, the long rains of 2007, the whole field was planted with maize, Kenya Seed Hybrid H513, with a planting distance of 0,25m * 0,75m. All plots were left without input, except one of the previous maize plots, which received 100kg di-ammonium phosphate (DAP), and 100kg urea per hectare. Yields were analyzed at harvest but the produce remained with the farmers. A field day was organized during the season to look at the maize crops standing, compare the performance of the maize after soybean or maize, and to discuss the previous soybean yields with the farmers.

Preliminary results

At present, agronomic data are still being processed. Analysis looks at the effect of soybean compared with continuous maize on the subsequent maize yields, and at the "fertilizing effect" of previous soybean compared to input application. Possible residual effects of the inputs used last season were also taken into account. Interesting results available are those of the farmers' votes during field days. Farmers voted for the "best" and the "worse" treatment. The results are given in **(Figure 36)**.

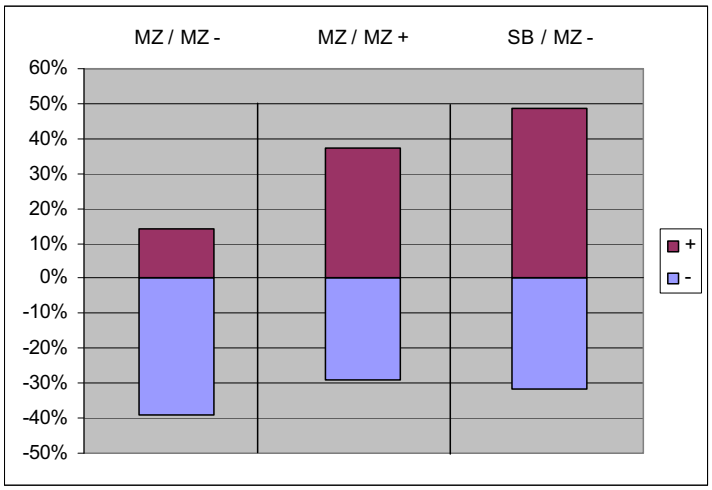


Figure 36: percentage of votes for "best" (+) and "worse" (-) averaged over the different field days. mz/mz- = maize after maize without input // mz/mz+ = maize after maize with input // sb/mz- = maize after soybean without input

The farmers' preference was divided between the maize with input after maize and the maize without input after soybean. Farmers explained that soybean was good because it reduced Striga weeds, because the soybean leaves fall on the ground and bring N to the soil, and also because the input given to the soybean last season remains in the soil and assists the maize. About the maize plots with DAP, farmers gave the negative comments that DAP helps Striga weeds to grow faster and that DAP is expensive. A farmer added that often, farmers have no money for DAP at the good moment and then wait before planting to be able to purchase it. This late planting causes loss of income, as rains are bad and prices of maize are lower when they harvest. Nevertheless, in case of good use, inputs will provide good yields, strong stems and healthy maize plants. The visible effect of the rotation was still small as this was the first rotation cycle. Nevertheless, in some fields the results were striking. Many farmers during the field days believed it was caused by soybean, with some exceptions, as shown in **(Figure 37).**

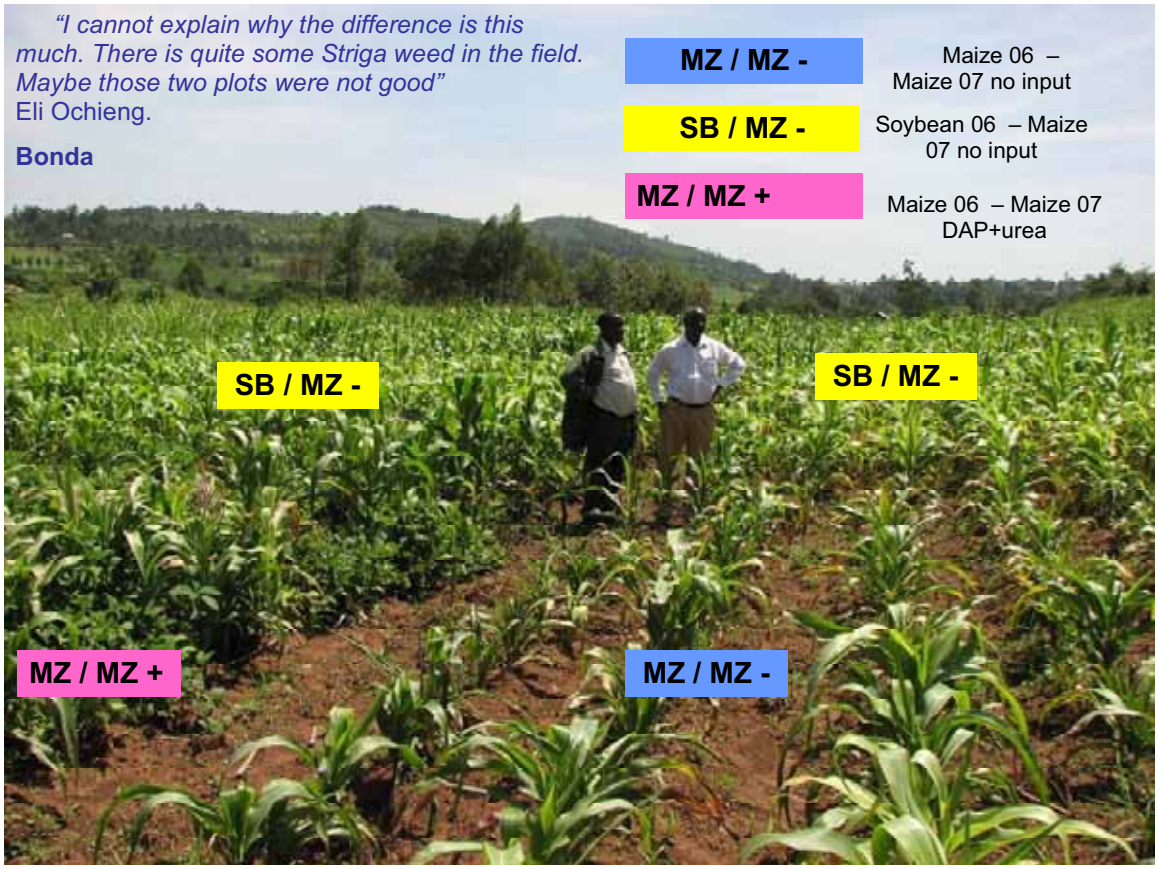


Figure 37: Some farmers don't yet believe it is because of soybean, but see the difference in the field

Preliminary conclusions
This first rotation cycle showed some initial improvement of the soil fertility by soybean rotation. This effect will increase with time as 1) the soybean season in 2006 was very poor due to low rainfall and 2) nodulation of soybean is weak when planted in land that has never been planted with soybean earlier, therefore 3) soybean biomass was little and N-fixation low last season and thus the effect of rotation must have been low.

Output targets 2009

- ***The contribution of multiple stress adapted germplasm in driving overall system resilience is understood for the conditions occurring in all mandate areas***

Output target 2009

- ***Products of the trade-off analysis are guiding the introduction and evaluation of alternative NRM options, better suited to the farmer production objectives and the environment of the actions sites***

Published work

Zingore[1,3], S., Murwira [2], H.K., Delve [2], R.J. and Giller [3], K.E. (2007) Influence of nutrient management strategies on variability of soil fertility, crop yields and nutrient balances on smallholder farms in Zimbabwe. Agriculture Ecosystems and Environment, 119: 112-126
[1]CIAT-TSBF, Malawi [2]CIAT-Zimbabwe; [3]WUR, The Netherlands
Abstract: An improved understanding of soil fertility variability and farmers' resource use strategies is required for targeting soil fertility improving technologies to different niches within farms. We measured the variability of soil fertility with distance from homesteads on smallholder farms of different socio-economic groups on two soil types, granite sand and red clay, in Murewa, northeast Zimbabwe. Soil organic matter, available P and CEC decreased with distance from homestead on most farms. Soil available P was particularly responsive to management, irrespective of soil type, as it was more concentrated on the plots closest to homesteads on wealthy farms (8–13 mg kg^{-1}), compared with plots further from homesteads and all plots on poor farms (2–6 mg kg^{-1}). There was a large gap in amounts of mineral fertilizers used by the wealthiest farmers (>100 kg N and >15 kg P per farm; 39 kg N ha^{-1} and 7 kg P ha^{-1}) and the poorest farmers (<20 kg N and <10 kg P per farm; 19 kg N ha^{-1} and 4 kg P ha^{-1}). The wealthy farmers who owned cattle also used large amounts of manure, which provided at least 90 kg N and 25 kg P per farm per year (36 kg N $ha^{-1}$and 10 kg P ha^{-1}). The poor farmers used little or no organic sources of nutrients. The wealthiest farmers distributed mineral fertilizers evenly across their farms, but preferentially targeted manure to the plots closest to the homesteads, which received about 70 kg N and 18 kg P per plot (76 kg N ha^{-1} and 21 kg P ha^{-1}) from manure compared with 23 kg N and 9 kg P per plot on the mid-fields (26 kg N ha^{-1} and 10 kg P ha^{-1}), and 10 kg N and 1 kg P per plot (and ha^{-1}) on the outfields. Crop allocation on the homefields was most diversified on the wealthiest farms where maize was allocated 41% of the area followed by grain legumes (24%) and paprika (21%).

Maize was allocated at least 83% of the homefields on farms with less access to resources. All the farmers invariably applied nutrients to maize but little to groundnut. Maize grain yields were largest on the homefields on the wealthy farms (2.7–5.0 t ha^{-1}), but poor across all fields on the poor farms (0.3–1.9 t ha^{-1}). Groundnut grain yields showed little difference between farms and plots. N and P partial balances were largest on the wealthy farms, although these fluctuated from season to season (-20 to +80 kg N per farm and 15–30 kg P per farm; average 21 kg N ha^{-1} and 8 kg P ha^{-1}).

The partial balances on the wealthy farms were largest on the homefield (20–30 kg N and 13 kg P per plot; >26 kg N ha^{-1} and >13 kg P ha^{-1}), but decreased to 10–20 N and 6–9 kg P per plot (<20 kg N ha^{-1} and 13 kg P ha^{-1}) in mid-fields and -7 to +10 kg N and -1 to +1 kg P per plot (<10 kg N ha^{-1} and <2 kg P ha^{-1}) in the outfields. N and P balances differed little across plots on the poor farms (-2 to +4 kg per plot; -5 to +4 kg ha^{-1}) due to limited nutrients applied and small off-take from small harvests. This study highlights the need to consider soil fertility gradients and the crop and nutrient management patterns creating them when designing options to improve resource use efficiency on smallholder farms

Completed work

Using the crop simulation model APSIM to generate functional relationships for analysis of resource use in African smallholder systems: aggregating field-scale knowledge for farm-scale models (accepted for publication in Agricultural Systems).

R. Chikowo[1], M. Corbeels[1,2,*], P. Tittonell[3,4], B. Vanlauwe[4], A. Whitbread[5] and K.E. Giller[3]
[1]UMR SYSTEM, CIRAD, France.;[2]CIAT- TSBF, Zimbabwe; 3WUR, The Netherlands;[4]CIAT-TSBF, Kenya;[5]CSIRO, Sustainable Ecosystems Australia.

Abstract: The efficiency with which applied resources are utilized in sub-Saharan Africa cropping systems is especially critical as the resources are generally scarce. Research efforts increasingly focus on whole farm productivity, scaling up from plot to farm level, emphasizing the importance of interactions and nutrient flows within the farm as well as the external inputs and outputs. Progress has been hampered by the complexity of the systems and a wide spectrum of management differences related to farmer resource endowment. Simulation modelling using summary farm models such as FIELD that utilize resource availabilities in relation to resource capture and resource utilization efficiencies can be useful tools to unravel this complexity. A detailed mechanistic model, APSIM, was used to generate parameters and variables that can be introduced as descriptive functions in simpler, summary models such as FIELD. We parameterized and tested the model based on several field experiments carried out on different soil types in western Kenya where nitrogen and/or phosphorus were applied. The model was further configured to generate N and P response curves as a function of soil condition (C content, clay content, P sorption characteristics) and the effects of alternative weed management scenarios depending on labour availability. Nitrogen, phosphorus and rainfall capture efficiencies ranged between 0.22-0.85 kg kg^{-1}, 0.05-0.29 kg kg^{-1} and 0.10-0.53 mm mm^{-1}, respectively, depending on soil nutrient and physical conditions. Variation in the fraction of radiation intercepted (FRINT) with plant density was adequately described by the function $y = 0.058x + 0.11$ within a range of 1.5-5.5 maize plants per m^2. Investigation of weed management using the model identified a weed-free period of at least five weeks from maize emergence for minimum

yield loss from weed-crop competition. The simulation exercises confirmed that resource use efficiencies sharply decrease on moving from relatively fertile 'close' to the homestead fields to degraded 'remote' fields within the same farm, giving impetus to expedite the search for better targeted management strategies for spatially heterogeneous farms.

Work in progress

Integrated evaluation of conservation agriculture (CA) technologies using multipurpose grain legumes (MGL) to improve productivity and sustainability of cotton-cereal systems in the Mid Zambezi Valley
PhD thesis Frederic Baudron

The main question leading the course of this PhD is:
"What is the potential of conservation agriculture (CA) alternatives using multipurpose grain legumes (MGL) in improving smallholders' livelihoods and mitigating environmental degradation in the Mid Zambezi Valley?" *(Can CA be a "win-win" strategy between production and conservation?)*

Agricultural expansion is one of the main threats to ecosystems of global conservation importance in the Mid Zambezi Valley. Introduction and expansion of cotton farming appears to be a major driver of change in cropping patterns, in fertility management and in overall farming systems. Modern conventional systems can only be sustainable if increased quantities of external inputs are used, combined with mechanical operations. However, structural adjustment programs, hyper-inflation and increased poverty of rural communities, combined with a general decrease in quantities of fertilizers used by farmers have forced most farmers to rely more and more on the natural fertility of their soils. Subsequent land degradation is also influenced by effects of immigration, fuelling agricultural expansion and loss of natural vegetation. As a response to the crisis of land degradation in the small-scale sector, more sustainable cropping systems using the principles of conservation agriculture (CA) have been developed in various parts of the world, including southern Africa. These technologies are often presented as offering a "win-win" situation for production and conservation. The present research work aims at "testing" this strategy in the particular case of cereal-cotton systems, with CA technologies based on multipurpose grain legumes (MGL) i.e. cowpea (*Vigna unguiculata*), lablab (*Dolichos lablab*), pigeon pea (*Cajanus cajan*) and soyabean (*Glycine max*).

Exploring options for integrated soil fertility management with the aid of simulation modeling. I. Model calibration and testing.
P. Tittonell[1], M. Corbeels[2], and B. Vanlauwe[1]
[1]CIAT-TSBF, Kenya;[2]CIAT, Zimbabwe;
Introduction
Simulation models may aid in exploring long term options for integrated soil fertility management, while considering soil heterogeneity and its biophysical and managerial drivers, and allowing to evaluate promising alternatives across a wide range of scenarios (e.g. climate change, changes in input/output price ratios). Modelling cropping systems in Africa is a challenge because (i) the size of stocks and flows is often small and rather unknown with precision and (ii) the availability of long term data to calibrate and test models is poor. We propose the use of simple models that rely on robust and known basic relationships to describe

crop/soil processes. The objective of this work was to test the ability of a simulation model of this nature to reproduce short term responses of crops to environmental conditions (light, water, NPK availabilities) and the long term changes in soil attributes and productivity brought about by different management practices.

Materials and methods

We calibrated and tested a simple dynamic simulation model, FIELD (Field-scale resource Interactions, use Efficiencies and Long term soil fertility Development – Tittonell et al., 2007), for tropical maize (*Zea mays* L.) against four independent datasets from the highlands of Kenya that included: (1) Data on soil organic C dynamics, from a chronosequence of agricultural fields of different age following forest clearance (up to 100 years of continuous crop cultivation) around the Kakamega National Forest Reserve in western Kenya; (2) Soil organic C and crop biomass data from a long-term experiment (1989-2003) on effects of manure application (5 and 10 t ha^{-1} $year^{-1}$) in maize-based cropping systems at Machang'a, Kenya; (3) Data on maize responses to increasing rates of manure application (0, 1.2 and 4 t C ha^{-1}) with and without mineral N applied at a rate of 120 kg ha^{-1} (in the presence of P and K fertilizers) from an experiment that was conducted during two consecutive growing seasons (long and short rains of 2005) at two localities in Aludeka and Nyabeda (c. 20 km from Emuhaya); and (4) Crop biomass and soil fertility data from an on-farm N-P-K (100:100:100 kg ha^{-1}) nutrient-omission trial with maize conducted on 18 farms in three localities in western Kenya: Aludeka, Emuhaya and Shinyalu.

Preliminary results

The model run with average rainfall from historical 30-year weather data (1635+/-218 mm $year^{-1}$) simulated an exponential decrease in soil C in the upper 20 cm from 140 to 27 t ha^{-1} over 100 years, with an average net loss rate of 1.13 t C ha^{-1} $year^{-1}$ (or 0.8% per year in relative terms) **(Figure 38 A)**. The comparison of observed vs. simulated soil organic C (0-20cm) produced a relative mean squared difference of 2.3 t ha^{-1} and a root mean squared error of 13.3 t ha^{-1}, with r^2 = 0.94 ($P < 0.01$). FIELD satisfactorily predicted crop biomass over the 26 growing seasons at Machang'a (dataset 2) with an overall RMSE 1.7 t ha^{-1} (r^2 = 0.51). By adjusting the annual humification coefficient for manure (0.27 $year^{-1}$), the model was able to fit simulated soil C to observed values **(Figure 38 B)** with RMSEs of 0.8, 2.1 and 3.8 t C ha^{-1} for the treatments receiving 0, 5 and 10 t manure ha^{-1}, respectively (overall r^2 = 0.66).

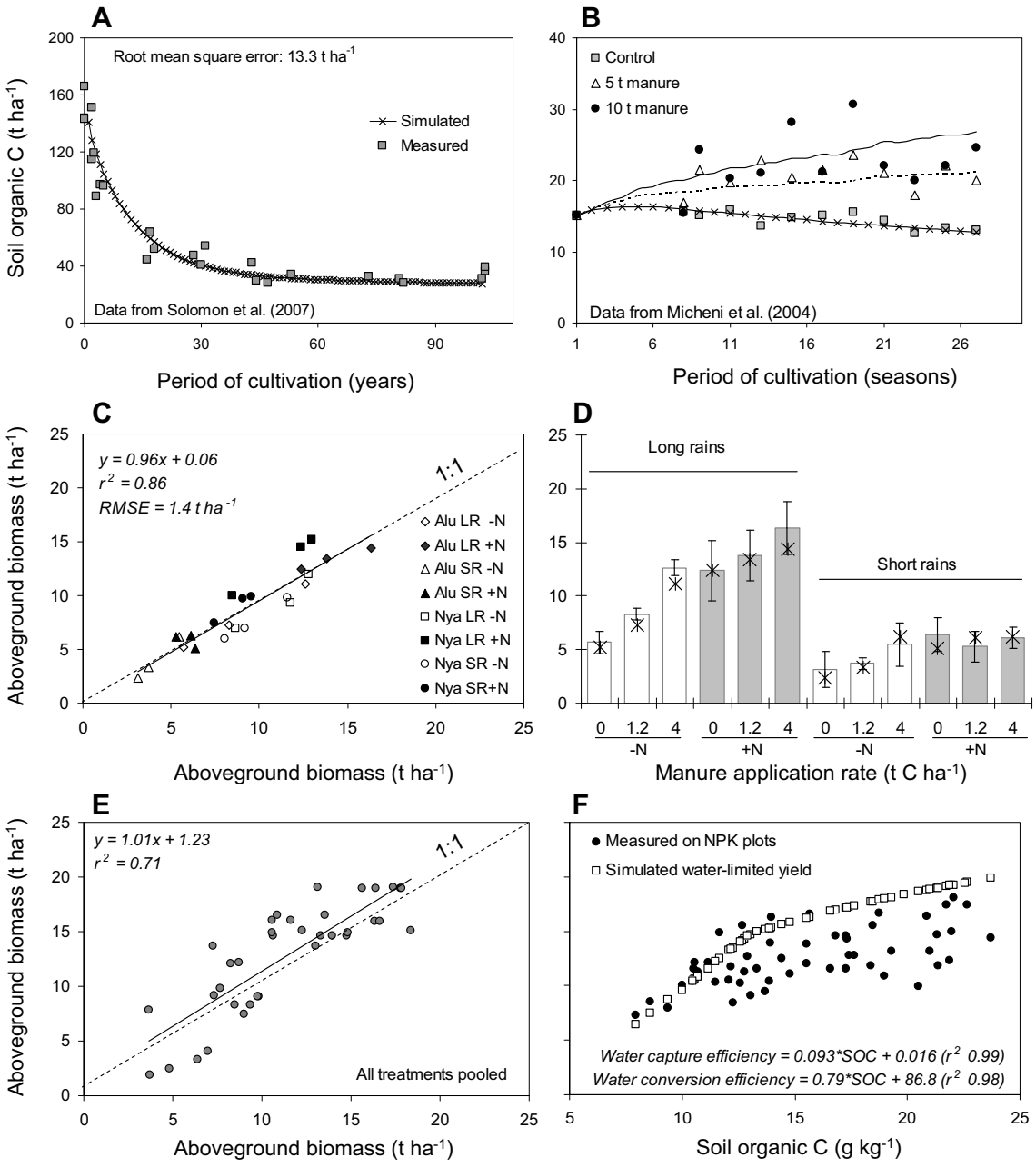


Figure 38: (A) Calibration of the model FIELD against soil C across a chronosequence of 100 years of cultivation around Kakamega Forest Reserve, western Kenya; (B) Simulated and measured soil C increase after 13 years (26 seasons) under 0, 5 and 10 t ha^{-1} manure applications in a Cambisol at Machang'a, central Kenya; (C) Observed (x-axis) and simulated aboveground biomass of maize in the long (LR) and short rains (SR) of 2005 with different rates of manure

and mineral N in Aludeka (Alu) and Nyabeda (Nya), western Kenya; (D) Aboveground biomass production of maize with application of manure (0, 1.2 and 4 t C ha^{-1}), with and without application of mineral N (120 kg ha^{-1}), during the long and the short rains of 2005 at Aludeka – bars: measured values (plus standard deviation), asterisks: FIELD simulations; (E) Observed (x-axis) and simulated aboveground biomass of maize in the case study fields with all combinations of N, P and K in the nutrient-omission trial; (F) Measured biomass yield of all NPK treatments and simulated water-limited yields as a function of soil organic C.

We then tested the model against the data on maize response to manure application (0, 1.2 and 4 t C ha^{-1}, corresponding to 3.4 and 11.4 t manure ha^{-1} year) in Aludeka and Nyabeda during the long and short rains of 2005 (data set 3). The humification coefficient (HC) of the manure was calibrated to match the observed crop responses at both sites, minimizing the value of the RMSE (resulting in HC = 0.53 $season^{-1}$, or 0.22 $year^{-1}$). Maize responses to increasing manure application rates were satisfactorily simulated **(Figure 38 C)**, although with a slight tendency to underestimate yields without N and overestimate response to N **(Figure 38 D)**. Finally, the model was parameterized for a combination of three localities × six farms per locality × three positions within the farm (home-, mid- and outfields) totalling 54 independent observations (data set 4). The model was run to simulate the experimental treatment: control, full N-P-K and three treatments with one of the nutrients (N, P or K) missing. Given the large variability in the data from the on-farm experiment, the performance of FIELD to simulate maize production was satisfactory (overall RMSE 2.8 t ha^{-1}; r^2 = 0.59), as illustrated in **(Figure 38 E)** for total aboveground biomass of maize. The water-limited yield calculated by FIELD increased as a function of increasing soil C, as did the maize yields measured in the full-NPK plots **(Figure 38 F).** However, a large number of fields receiving full-NPK and having between 10 and 20 g kg^{-1} soil organic C produced yields that were smaller (up to 40% less) than the simulated water-limited yield, suggesting that the application rates of N, P and/or K in the experiment were suboptimal.

Preliminary conclusions

The model FIELD showed ability to represent both short and long term crop/soil dynamics and to capture the effect of soil heterogeneity on maize responses to applied nutrients. This gives confidence for its use in the exploration of options for ISFM in smallholder farming systems, within the range of agroecological conditions and soil types tested here.

Exploring options for integrated soil fertility management with the aid of simulation modeling. II. Applications of manure and mineral fertilizers: P. Tittonell[1], M. Corbeels[1], and B. Vanlauwe[2]

[1]CIAT, Zimbabwe;[2]CIAT-TSBF, Kenya

Introduction

Realistic evaluation of integrated soil fertility management (ISFM) technologies for smallholder African farmers should consider: 1. Soil heterogeneity within farms; 2. Long-term dynamics and inter-annual variability; 3. Poor manure quality and availability; 4. Limited access to fertilizers; 5. Competing uses for crop residues. The objective of this study was to analyze options for ISFM within heterogeneous smallholder farms. A simulation model that was calibrated and tested against a number of experimental datasets was used it to analyze the potential of different ISFM strategies to maintain or build up soil fertility in the long term.

The following research question was formulated: If part of the crop residues are retained in the fields after harvesting, is it possible to maintain adequate levels of organic carbon in the soil through increased biomass production as a consequence of mineral fertilizer applications (with and without manure applications)?

Materials and methods

We used the simple dynamic simulation model, FIELD (Field-scale resource Interactions, use Efficiencies and Long term soil fertility Development), calibrated for tropical maize (*Zea mays* L.) against four independent datasets (cf. Part I) and parameterized for western Kenya farms to explore allocation strategies of manure and fertilizers. In the simulations we used manure of different qualities, from the best quality sampled on the experimental dairy farm of Maseno University to the worst manure sampled on farm E **(Table 45)**.

Table 45: Dry matter, C and nutrient content of manures from different sources

Manure origin	**Content (%)**				
	Dry matter	C	N	P	K
Machang'a experiment	80	26	2.0	0.48	n/a
Maseno FTC$^{\varphi}$	80	35	1.4	0.18	1.8
Exp. Dairy Farm	82	39	2.1	0.22	4.0
Farm A	56	30	1.2	0.32	2.0
Farm B	59	29	1.0	0.30	1.6
Farm C	77	25	1.0	0.10	0.6
Farm D	43	35	1.5	0.12	3.3
Farm E	41	23	0.5	0.10	0.6

Three farms from three localities in western Kenya: Aludeka division in Teso district (0° 35' N; 34° 19' E), Emuhaia division in Vihiga district (0° 4' N; 34° 38' E) and Shinyalu division in Kakamega district (0° 12' N; 34° 48' E) 4 were used as case study for scenario analysis. To represent common practices, we assumed that farmers concentrated the available manure in small portions of land, achieving application rates of 5 t dm ha^{-1} to restore soil productivity. The minimum mineral fertiliser application rates were set based on the assumption that a farmer was able to buy a bag 50 kg of DAP (18:46:0) and a bag of 50 kg of urea (46:0:0) to apply to one hectare of maize (equivalent to 32 kg N ha^{-1} and 23 kg P ha^{-1}). An application of (recommended) 60 kg N ha^{-1} and 30 kg P ha^{-1} was defined as 'basal fertilizer'. Application of 140 kg N ha^{-1} and 40 kg P ha^{-1} was defined as 'replacement fertilizer', as this provides roughly the same amount of N and P as a combined application of basal fertilizers + 5 t ha^{-1} of manure of average quality.

Preliminary results

Soils receiving manure plus fertilizers for 12 years stored 1.1 - 1.5 t C ha^{-1} $year^{-1}$ when 70% of the crop residue was retained in the field, and 0.4 - 0.7 t C ha^{-1} $year^{-1}$ with 10% retained **(Figure 39)**.

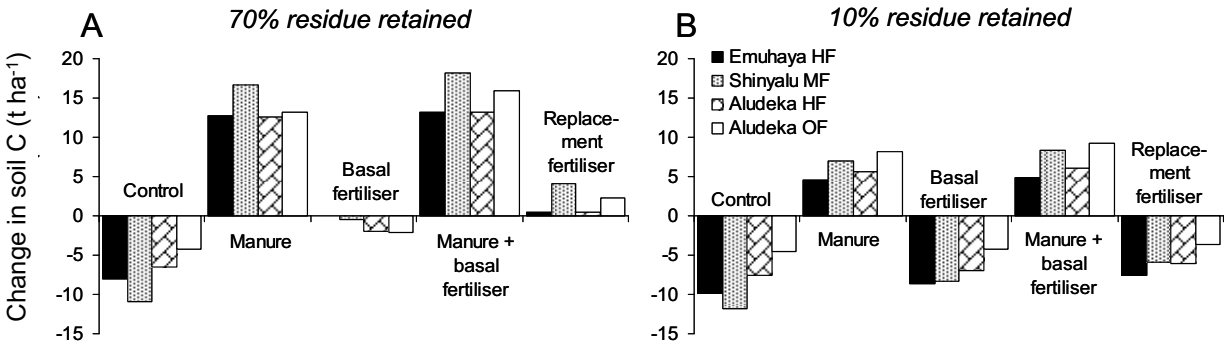


Figure 39: Simulated changes in soil organic C after 12 years of maize cultivation under different management strategies with retention of 70% (A) or 10% (B) of crop residues in the field after harvest, in fields with different responsiveness: non-responsive fertile field (Emuhaya homefield), responsive fields (Shinyalu midfield and Aludeka homefield) and non-responsive infertile field (Aludeka outfield).

The initial soil C contents can be practically maintained with basal fertilizer rates if 70% of the crop residue is retained in the field (assuming alternative uses for the remaining 30%), except in the poorly responsive fields (Aludeka OF in **(Figure 39 A**). In the latter, replacement fertilizer rates increased soil C by 2.3 t ha^{-1} after 12 years (24 growing seasons) with respect to the initial value. However, soil C needs to be increased in such fields and this was only achieved with manure applications of the best quality manure in Table 1 at 5 t ha^{-1} $season^{-1}$. If farmers remove most (90%) of the crop residue, as they commonly do, soil C is only built up by manure and root C inputs **(Figure 39 B)**. In such case, the use of fertilizers is insufficient to build soil organic matter. On the other hand, degraded fields could not be rehabilitated with manures of local quality (e.g., 23 – 35% C, 0.5 – 1.2% N, 0.1 – 0.3% P) applied at realistic rates for farmers (1.8 t dm ha^{-1} $season^{-1}$) for 12 years, without fertilizers. This suggest that, considering the average quality and availability of manure on smallholder farms, mineral fertilizers are necessary to kick-start soil rehabilitation through hysteretic restoration of biomass productivity, leading to higher C inputs to the soil.

Preliminary conclusions

In designing ISFM strategies both the quantity of manure available to farmers as well as their average quality should be considered. Although the effect of applying large amounts of manure to restore soil productivity may be of scientific interest, experiments should also test treatments with application rates that are more realistic and potentially meaningful to farmers.

Exploring options for integrated soil fertility management with the aid of simulation modeling. III. Rehabilitating degraded soils.

P. Tittonell[1], M. Corbeels[2], and B. Vanlauwe[1]

[1]CIAT-TSBF, Kenya; [2]CIAT, Zimbabwe;

Introduction

Within heterogeneous farms different fields exhibit a different pattern of responsiveness to applied nutrients. Those that underwent severe degradation/ nutrient depletion must be rehabilitated through long-term ISFM strategies, to achieve levels of soil organic matter that allow an efficient use of available resources and a degree of crop responsiveness to minimum inputs. A simulation model that was calibrated and tested against a number of experimental datasets was used it to analyze: (i) the effect of current soil fertility status on crop responsiveness and the efficiency of mineral fertilizer use and (ii) the capacity of different categories of fields to support responses in productivity when restorative measures are put in place. The following research questions were formulated: (1) How does maize – the major food and cash crop in the highlands of Kenya – respond to increasing rates of applied N and P within spatially heterogeneous farms?; (2) Assuming that an increase in soil organic matter would lead to improved resource use efficiency, better use of applied mineral fertilizers, and crop productivity, what is the capacity of different management interventions to restore soil productivity through soil organic matter build up for fields with different intensity of soil degradation? This 'capacity of soil restoration' or rehabilitation rate brought about by different management practices is referred to as '*hysteresis* of soil restoration', in analogy to the path-dependent process of hysteresis occurring in natural systems (e.g., in drying-and-re-wetting soils).

Materials and methods

We used the simple dynamic simulation model, FIELD (Field-scale resource Interactions, use Efficiencies and Long term soil fertility Development), calibrated for tropical maize (*Zea mays* L.) against four independent datasets (cf. Part I) and parameterized for western Kenya farms. Farms from three localities in western Kenya: Aludeka division in Teso district (0° 35' N; 34° 19' E), Emuhaia division in Vihiga district (0° 4' N; 34° 38' E) and Shinyalu division in Kakamega district (0° 12' N; 34° 48' E) 4 were used as case study for scenario analysis. Runs of 12 years without nutrient inputs followed by 12 years of 'rehabilitation' applying manure (1.8 t dm ha^{-1}) of different qualities (Part II) with and without application of minimum fertilizer rates (32N:23P). The results of the simulation were used to calculate the *hysteresis* of soil restoration in biomass yield units, and the number of years necessary for restoring the initial productivity of a certain field (i.e., the productivity at $t_1 = 0$, the beginning of the 12-year simulation).

Preliminary results

Maize response to application of N fertilizer from 0 to 180 kg N ha^{-1} (+/- 30 kg P ha^{-1}) distinguished fields that were: poorly-responsive fertile (grain yields: 4.1 to 5.3 t ha^{-1} without P. and 7.5 to 7.5 t ha^{-1} with P), responsive (c. 1.0 to 4.3 t ha^{-1} and 2.2 to 6.6 t ha^{-1}), and poorly-responsive infertile (c. 0.2 – 1 t ha^{-1} and 0.5 – 3.1 t ha^{-1}). Rehabilitation of infertile fields through restitution of soil organic matter was then investigated.

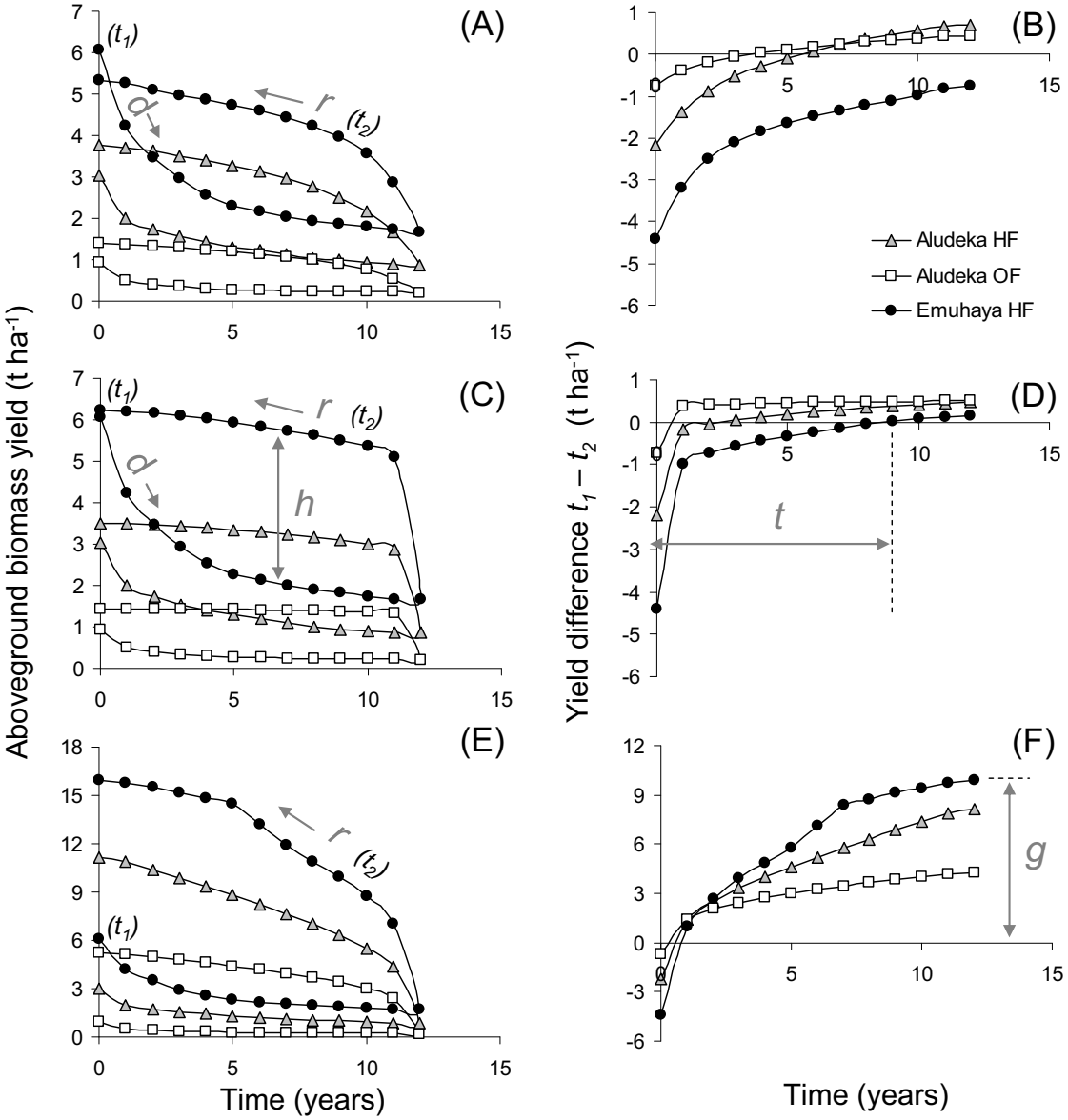


Figure 40: Hysteresis of soil restoration. (A, C, E) Simulated biomass yields during the degradation (*d*) and rehabilitation (*r*) phases and (B, D, F) absolute difference with respect to the initial yield (at t_1) over the years of rehabilitation (t_2), indicating the time needed to achieve initial yield levels (*t*) and the net productivity gain (*g*), for three fields in western Kenya (HF: homefield, OF: outfield). In A, C and E the rehabilitation phase was plotted inverting the direction of the time axis to indicate the magnitude of the hysteresis (*h*). Rehabilitation treatments included application of manure (A and B), N-P mineral fertilizers (C and D) and combined manure + fertilizers (E and F).

(Figure 40) shows FIELD simulations of crop productivity during 24 years: 12 initial years without inputs and 12 subsequent years with application of manure, mineral fertilizers or manure + mineral fertilizers (at rates of 32 kg N ha^{-1} and 23 kg P ha^{-1} and 1.8 t dm ha^{-1} of good quality manure), for a non-responsive fertile field (Emuhaya homefield), a responsive field (Aludeka homefield) and a non-responsive infertile field (Aludeka outfield). For simplicity, average instead of variable rainfall was used in these simulations. In **(Figures 40 A, C and E)** the 'rehabilitation' phase (*r*) has been plotted reversing the time axis, to illustrate the magnitude of the hysteresis (*h*). **(Figures 40 B, D and F)** show the number of years (*t*) necessary to achieve the initial production levels with the respective interventions, and the net productivity gains (*g*) that may be achieved. The rate of restoration was faster with mineral fertilizers (Figs. 1 A and B) than with manure **(Figure 40 C and D)** – at the simulated application rates – and much faster with combined manure and fertilizers **(Figure 40 E and F)** (note the differences in the scale of the *y*-axes). Taking the initial productivity as the threshold, however, is not always appropriate. In the case of the poor outfield of Aludeka, the low initial productivity is achieved after 3 years of manure application or after one year of fertilizer application. Likewise, the initial high productivity of the fertile homefield in Emuhaya is not achieved after 12 years of manure application. In these cases, a 'desirable' or 'achievable' threshold yield should be defined and used in the calculations.

Table 46: Hysteresis of rehabilitation (t dm ha^{-1}) brought about by application of 1.8 t ha^{-1} of manure of different qualities with and without addition of mineral fertilizer to fields of different initial fertility (responsiveness)

Field		Manure quality type					
	No manure	Exp. Dairy Farm	Farm A	Farm B	Farm C	Farm D	Farm E
No fertilizer							
Emuhaya HF	-	2.46	1.20	1.13	0.72	0.51	0.17
Aludeka HF	-	1.98	0.68	0.63	0.44	0.33	0.06
Aludeka OF	-	0.94	0.32	0.29	0.15	0.12	0.02
32 kg N ha^{-1} + 23 kg P ha^{-1}							
Emuhaya HF	3.73	12.26	7.51	7.18	5.97	5.79	4.52
Aludeka HF	2.14	8.89	4.35	4.18	3.65	3.70	2.75
Aludeka OF	1.15	4.62	2.47	2.38	2.04	2.11	1.50

Table 46: presents calculations of the hysteresis of restoration of the three fields with different responsiveness plotted in **(Figure 40)** after 12 years of cropping without inputs, using various manure qualities from farms in wetsren Kenya (Part II) applied at 1.8 t dm ha^{-1}, with and without minimum fertilizer rates (32 kg N ha^{-1} and 23 kg P ha^{-1}), and retaining crop residues in the field. The degree of hysteresis measured in biomass units varied strongly for the various types of

manure, with little reaction of the three systems to application of poor quality manures without fertilizer, and greater reactions to mineral fertilizers than to all manures.

Preliminary conclusions

The hysteresis of restoration will depend on the type of technology implemented to restore soil productivity (mineral and/or organic fertilizers, rotations with legume crops, soil erosion control measures, improved crop germplasm, etc.), on the inherent properties and initial condition of the soil, and on complementary management measures such as retaining crop residues in the field (or e.g. water harvesting measures in drier areas). The concept of hysteresis of soil restoration provides an integrative measure of the capacity of reaction/response of the system to restorative ISFM interventions in the long term – as much as the response of crops to applied nutrients does in the short term – reflecting both the effect of system properties (e.g. soil condition, rainfall variability, type of crops) and the performance of different rehabilitation technologies. In our case, the simulated reaction of degraded soils to the application of mineral fertilizers indicated almost immediate responses in the first year. In reality, it may take longer to restore soil productivity when degraded soils exhibit other limitations (e.g., physical degradation or acidity) that were not simulated by FIELD.

Exploring below ground biodiversity and related ecosystem services: prospects and perspectives. In proceedings of the 23rd conference of the Soil Science Society of East Africa, 20-24 November 2006

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The proceedings are expected to appear in 2008. This paper deals with trade-offs for management of belowground biodiversity, by identifying the importance of particular ecosystem services/processes for different management regimes (intensive and less intensive production systems) and by identifying the role of the various functional groups of soil organisms that contribute to the provision of the ecosystem services.

Output target 2010

- ***Improve linkages with the private sector to improve access to fertilizer and develop recommendation for its use by farmers and other stakeholders involved.***

Work in progress

Development and promotion of site- and crop-specific fertilizer management strategies for increasing crop productivity in southern Africa.

S. Zingore[1], R. Magreta[2] and R.J.Delve[2]

[1]CIAT, Malawi; [2]CIAT, Zimbabwe

In many southern African countries, recommendations for fertilizer use in smallholder farming systems general and mainly based on agricultural potential determined by rainfall. The blanket fertilizer recommendations ignore other key factors that have strong effects on returns to nutrients applied, such as soil type and fertility status, and availability of labour.

This often leads to low nutrient use efficiencies and uneconomical fertilizer use, discouraging intensification of smallholder crop production. Research activities in Malawi (Kasungu, Lilongwe and Chikwawa Districts), Mozambique (Angonia and Zobue Districts) and Zambia (Chipata and Chadiza Districts) are focusing on refining the blanket recommendations to develop site-specific recommendations that take into account variability in soil fertility within and across farms, availability of labour, production orientation and farmers' access to markets for inputs and outputs. To address problems of poor soil fertility in a holistic approach, integrated soil fertility management technologies including combined use of mineral and organic nutrient resources and rotation of cereal crops with dual purpose grain legumes (bean and groundnut). Emphasis is placed on the socio-economic aspects of ISFM including labour and economic viability and farmers' objectives to develop and promote technologies for soil fertility management that are suitable for conditions that exist on farms in different socio-economic categories. Partnerships have been created with NARES, development and private sector partners to supply and promote fertilizers with correct formulation to correct nutrient deficiencies at the different sites.

Experimental results show that soils at most sites are severely depleted in fertility, as most farmers practiced maize mono-culture with little or no fertilizer inputs. Substantial differences in crop productivity and fertilizer response were evident between fields with different management histories. As shown in **(Figure 41),** crop productivity varied substantially between depleted sand soils that had received no fertilizer previously, and more fertile soils that received frequent manure and mineral fertilizers in the past. On both soil fertility levels, balanced fertilizer use, including application of micronutrients significantly increased crop productivity. On the depleted soils, integrated use of mineral fertilizers and organic resources, such as compost and animal manures, was also required to restore fertility and obtain good crop response to fertilizer application. Current fertilizer recommendations and fertilizers available provide for N and P, but results from more than 50% of the sites indicated that crop productivity is strongly limited by deficiencies of micronutrients **(Figure 41).**

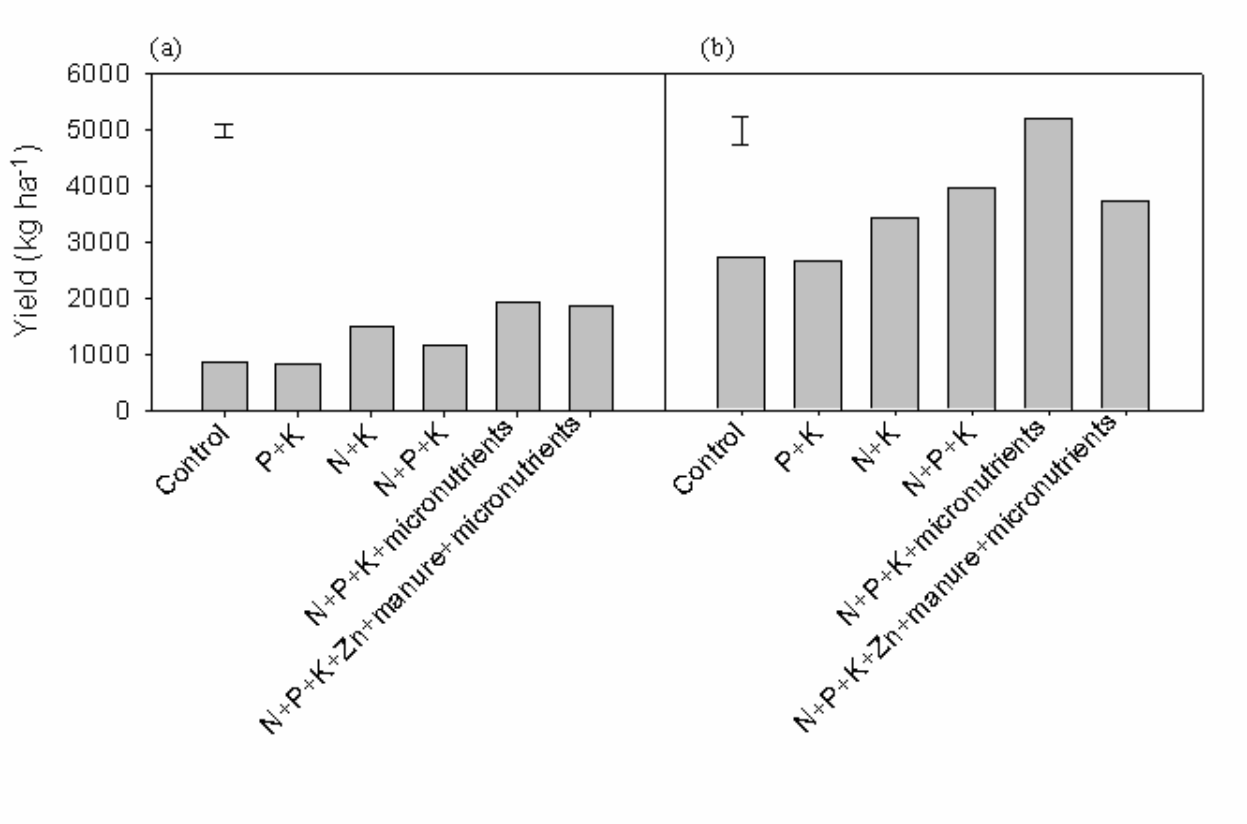

Figure 41: Impact of different nutrients and manure on maize productivity on a depleted soil (a) and fertile soil (b) in Angonia, Mozambique.

The impact of cultural and social differentiation on potential markets and product supply chains as well as on processes of information exchange evaluated

Progress towards achieving output level outcome

- *Partners promoting resilient production systems with multiple benefits (food security, income, human health and environmental services)*

Farmers in Africa are evaluating actively crop components and management technologies having benefits on food security, income generation and soil fertility. Improved lines of Cowpea and L*ablab purpureus* have been selected by farmer groups in Kenya and Uganda for their contribution to human consumption, increased fodder availability and improved soil fertility. Small farmers in the Cerrados of Brazil are increasing milk production by introducing drought-tolerant forage legumes in their pastures. Market-led crop options such as soybean and vegetables will play a major role in generating income for small farmers in Africa, provided that sustainable markets are developed and alternative uses explored. Preliminary results are promising. The combination of resistant maize varieties and improved soil fertility is showing potential to reduce Striga emergence in maize fields in western Kenya.

Progress towards achieving output level impact

- *Improved resilience of production systems contribute to food security, income generation and health of farmers*

The new production systems under development by the TSBF team and their collaborators in Africa will have a positive impact on crop productivity and profitability in the short term. This will be translated into improved food availability at the household level and greater chances to link agricultural production of smallholder production systems with market demands. Soybean crop will become an important component of production systems if production, processing and marketing bottlenecks are solved.