Africa Research in Sustainable Intensification for the Next Generation

Sustainable Intensification of Key Farming Systems in East and Southern Africa

Book of Abstracts
Africa RISING East and Southern Africa project Phase 1 Legacy

June 2016

The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment. http://africa-rising.net/

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This book of abstracts has been produced as a working reference material for writeshop participants attending the Africa RISING East and Southern Africa (ESA) phase 1 legacy review meeting from 30 June – 2 July, 2016. The abstracts presented herein therefore provide an overview of peer reviewed publications being written by the project research team as a contribution to the scientific legacy of Africa RISING ESA phase 1.

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Below-and above-ground pigeonpea productivity in a novel doubled-up legume cropping system across three agro-ecologies in central Malawi

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Abstract
Smallholder farmers in Malawi face many challenges which include a degrading soil resource base. Pigeonpea is one legume that has shown promise in Malawi in terms of improving soil fertility but its below and aboveground productivity is not fully understood. On-farm trials were set-up between 2013/16 across three agro-ecologies in central Malawi. Pigeonpea was planted as a sole crop or in an additive intercrop system with soyabean, groundnut or maize (farmer check system). The objectives of this study were to (1) assess the effect of cropping system and soil texture on pigeonpea root and shoot biomass and (2) to evaluate variability of pigeonpea growth within a smallholder farm context. For two cropping seasons, destructive harvests were conducted six months after planting to evaluate shoot parameters, and roots of the same plants were excavated from 0– 60 cm. Cropping system and soil texture influenced shoot and root biomass (α=0.05). Sole pigeonpea had the highest shoot biomass at 11.83 Mg/ha, root biomass at 1.56 Mg/ha and pigeonpea/maize had the lowest shoot biomass at 3.57 Mg/ha root biomass at 0.53 Mg/ha. Root biomass was largely confined to the 0-20 cm topsoil. The results confirm that intra-specific competition in a pigeonpea/maize intercrop is large, while pigeonpea productivity in pigeonpea/groundnut intercrop is comparable to sole cropped pigeonpea, with additional groundnut grain benefits. Promoting the later cropping system can enhance land productivity on the small farms that are often acutely constrained by their sheer small size as viable farming units.

Characterisation of crop residues for livestock feed as an option for enhancing intensification on smallholder farms in Babati District, Tanzania

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Abstract
Babati district in Manyara region is a high potential mixed crop livestock production area producing crop and animal sourced foods for major urban areas in northern Tanzania. With expansion of arable land and resultant decline in grazing resources, crop residues are becoming an increasingly important component of livestock feeds and a key livelihood resource in these systems. Although farmers in Babati district already practice diversified farming system, the crop and livestock components co-exist more or less independently from each other. A series of studies were conducted to characterize the use of crop residues for livestock feed as an option for enhancing intensification on smallholder farms. In 2013, we used the feed assessment using the FEAST tool to document the availability and use of crop residues for livestock feed in three villages. In 2014, we conducted a study on selected farms to assess available types, quantities and nutritional quality of crop residues used for feeding livestock on farms. In addition, the study aimed to understand how cereal and legume crop residues are harvested, stored, processed and used in different farms. Overall these studies aimed to identify constraints and opportunities of enhancing the management and use of crop residues on farms. Results showed that crop residues contribute 34% of the total feeds available on farms in Babati district while grazing and collected feeds contributes 53% and 13% respectively. Crop resides contribute 14-16% CP and 14-14% ME respectively of the total nutrients in the system. The most dominant cereal crop residues are maize stover (57%) and rice straw (20%) while the most common legumes straws are pigeon pea (4%); bean (12%), groundnut (5%) and cow pea (2%) haulms. There is poor harvesting, storage and use of crop residues on most farms mainly due to knowledge gaps and lack of appropriate technology. Most of the cereal crop residues are of poor quality i.e. maize stover (5.9% CP; 39.8 INOMD), rice straw (4.3% CP; 28.8% INOMD) and sorghum straw (8.3% CP; 55.4% INOMD) while most cereal based crop residues are of high quality i.e. pigeon pea haulms (10% CP; 56% INOMD), cow pea haulms (13.9% CP; 64.9 INOMD) and bean haulms (8.8% CP; 55.6 INOMD). On average majority of farmers obtained maize stover yields of 1.5 and 4.5 t/ha. The yield of maize stover from a hectare of land can sustain one TLU of livestock for 247 days.

Key words: Crop-livestock systems, cereals, legumes, crop residues, maize stover, haulms,

Characterization of local chicken production and management systems in Tanzania

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Abstract
Most of rural people keep the local chickens basically as source of nutrition and income. However, the chickens are characterized with low productivity and high mortality rate prior maturity, indicating lack of general poultry husbandry knowledge. A study was then conducted to generate baseline information required for designing improved nutritional management for rural chicken production in Babati District of Tanzania. Data were collected in a survey that included both individual interview and a participatory group discussion. A total of 141 households from four different wards were interviewed and four group discussions were held. The questionnaire was designed to collect data covering general information on rural chicken production such as production status, population structure, nutritional and health management. The findings showed that 96.5% of the chickens kept in Babati district are local strains and they are mostly owned by women at an average number of 5 birds per household. Production of meat and eggs for home consumption is the primary function of chickens, followed by selling of both eggs and live birds as a source of income. Most of the village households (53.2%) were keeping their chickens under scavenging feeding system where chickens are left to search for their feeds with rare supplementations of a handful, unbalanced feeds comprised of maize bran, sorghum or sunflower seed cake. The kitchen left-overs were the dominant supplement throughout the year. Other systems were the semi-scavenging (36.9%) and confinement with fully indoor feeding systems (9.9), but these too faced unbalanced feeding challenge. Absence of vaccination programs leads to high risk of exposure of chickens to disease. Ultimately, all the three production systems revealed similar characteristics of high mortality rates (60%) mainly due to malnutrition, diseases, predators, and environmental hazards associated to poor housing. The hens produced an average of 13 eggs per clutch with only 3 clutches per year. The farm gate price of chickens fluctuated over the year mainly due to disease incidences and festival seasons such as Christmas and Easter. The results point to the need for interventions in improved strategies for nutrition and health management of the rural chickens in order to enhance their productivity.

Key words: Rural chickens, management characterization, production performance, feed resources.

Characterization of Livestock Grazing Management Systems in Semi-arid Kiteto and Kongwa Districts of Tanzania

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Abstract
Agro-silvo pastoral technologies, such as traditional *in situ* natural regeneration systems, represent strong pathways to alleviate livestock feed shortages during dry seasons in the tropical region, including Tanzania. A study was carried out among selected eight villages of Kiteto district (Njoro, Ilkiushiobor, Katikati, Ndedo, Makame, Olkitkit, Lergu and Ngapapa villages) and four villages of Kongwa district (Mlali, Laikala, Moleti, and Manyusi) of semi-arid Tanzania based on specific objectives : (1) to analyze livestock grazing management systems, (2) determine available grazing land area, and (3) to determine forage biomass productivity and nutritive potential of conventional feed resources through chemical composition and *in vitro* feed digestibility. The information adds value on livestock management systems in the two districts. Key informant interviews, panel discussions and resource mapping of the grazing land resources were carried out among 293 participants.A point sampling technique was adopted to assess herbage biomass productivity by vegetative clipping at 5 cm above the ground in five sites. Feed nutritive potential was assessed through chemical composition and *in vitro* digestibility. Qualitative data on grazing land management systems of the agro-silvopastoral technologies were analysed for simple descriptive statistics using SPSS. Quantitative data on the herbage biomass productivity and feed nutritive potential were analysed into means and standard errors using SAS statistical software. Kongwa district was characterised by lack of firm livestock grazing management systems whereby during wet seasons, (from December to June), cattle are transferred to distant pastures on hilly areas where there is no cropping compared to dry seasons whereby cattle are normally grazed on crop residues such as maize and sorghum stovers. In Kiteto district in contrast, Maasai pastoralists set aside portions of pastures as differed feeds known as *Alalili* for livestock grazing while the latter system is not practiced among the predominant Kagulu and Gogo agro-pastoralists of Kongwa district. In both districts, during wet seasons, the livestock are transferred to distant pastures. In Kiteto district, two types of '*Alalili*' are recognised; "*Alalili longshu*", which refers to portions of pastures set aside for mature cattle herd, and '*Alalili lo roho*', which refers to portions of pastures set aside for a calf herd. Fodder productivity was variable between districts (*P<0.05*) and sites (*P<0.05*), ranging from 1.5-3.5 t DM/ ha, mainly due to both grazing management and site specific characteristics. Available grazing lands are highly variable across sites depending on specific land use systems. Utilisation of feed resources under *Alalili,*during dry seasons, is limited by their lower concentration of feed crude protein (CP) of 40 to 50 g/kg of dry matter (DM) than the recommended feed CP of 80 g/kg DM for optimal rumen functioning and enhanced animal

productivity. Enriched tree planting of rangelands with fodder trees and forage legume species that offer high resilience to the different agro-ecologies, drought tolerance, biomass productivity and nutritive value represent one of the viable options for enhanced rangelands productivity and thus improved ruminant livestock productivity.

Economic evaluation of improved grain storage technology in Tanzania

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Abstract
Postharvest grain losses are substantially high among smallholder farmers in Sub-Saharan Africa. The losses vary among countries, crops, and between seasons while the average figure ranges from 20-40%. This high loss suggests the need for greater attention to postharvest grain losses in order to address the problem of household food insecurity in these countries. As part of reducing the problem, Africa RISING has introduced the use of improved hermetic grain storage technologies to smallholder farmers in Tanzania and tested them for their effectiveness in reducing postharvest grain losses. This study was initiated to quantify the financial gains associated with the improved technologies and examine how they compare with the traditional technology. Specifically, we analyse the economic advantage of using Purdue Improved Crop Storage (PICS) bags over Polypropylene bags which are commonly used by the farmers. Results are based on participatory cost benefit analysis (PCBA) carried out with three male groups and three female groups of farmers in three village of Babati district. The PBCA data is complemented by survey data collected from 200 randomly selected households. The purpose of the survey was to collect data on farmers' storage facilities, capacities and allocation to maize and other crops, grain production and storage patterns, storage costs, use of improved hermetic bags in the study villages, and associated issues. Results show that about 22% of the households use PICS which constitutes only about 5% of the total storage requirements of the sample farmers. PICs are profitable and worth investing in. The discounted benefit-cost-ratio is 15.6 while the discounted net benefit is about TZS 655,000 (~USD325) implying that a typical maize producer in the study villages would gain about TSh36,399 per investment in one bag. The results suggest that promoting the improved storage technologies would substantially contribute to household food security and income by reducing storage losses.

Key words: Postharvest losses, cost benefit analysis, PICS bags.

Efficacy of in-situ rainwater harvesting techniques on soil water storage, run-off and maize (zea mays) performance in semi-arid areas of Central of Tanzania

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Abstract
In the semi-arid zones of Central Tanzania, crops are grown in a stressful environment with lack of predictable soil water supply and this can be singled out as most critical environmental factor affecting crop production apart from low inherited soil fertility status and continued use of low yielding crop varieties. Low soil moisture supply for crop production in this semi-arid zone is further aggravated by in-appropriate tillage practices which accelerate rain water loss through increase runoff. During 2013/2014 – 2015/2016 cropping seasons, on-farm experiment was set up in marginal areas of Mlali village, Kongwa District in Central Tanzania to investigate the effect of in situ rainwater harvesting techniques on maize crop performance, surface runoff and soil water storage to pave way for sustainable cropping intensification. The study consisted of three tillage methods namely: ox-plough (FC) i.e. local tillage practice, ox-ripping (RT) and conventional tied ridging (TR), arranged in Randomized Complete Block (RCBD) design with three replicates. Findings revealed that consistently across season, in-situ rainwater harvesting techniques significantly (P<0.05) affected soil water storage, runoff and maize productivity. Soil water content monitored at vegetative, flowering and grain filling stages varied between 6.5 % by volume (0.065 $m^3 m^{-3}$) for FC and 16 % by volume (0.16 $m^3 m^{-3)}$ for tied ridging. Higher volumetric water content under TR is attributed to the prolonged period of ponding water in the created micro-basins. The micro-basins also contributed to the significant (P<0.05) reduction in surface runoff by four folds when compared with FC, following the trend TR<RT<FC. Maize grain yield increments were at an average of 1222 kg/ha (77%) and 704 kg/ha (48.2 %) for TR and RT methods respectively. In view of ever increasing frequency and magnitude of agricultural droughts in this region, introduction of in-situ rainwater harvesting techniques notably tied ridging and ripping techniques were superior over ox-plough tillage and therefore is envisioned to bridge crop water deficit during dry spells, impart stability on household food security for majority of smallholder farmers, and minimise degradation of the natural resource base.

Key words: Semi-arid, Central Tanzania, In-situ rainwater harvesting, runoff, volumetric Water Content

Evaluation of Quality Protein Maize Using AMMI Model

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Abstract

Maize is the most important staple food in Zambia with human consumption averaging 91 kg capita^{-1} year^{-1} and is nutritionally deficient in two essential amino acids: tryptophan and lysine. Despite the development of quality protein maize (QPM) with high tryptophan and lysine, stunting and kwashiorkor remain high due lack of high yielding and adapted QPM varieties. The objective of this study was to evaluate a new generation of QPM varieties for yield and stability using site regression (SREG) model analysis. Before the QPM varieties were validated on-farm, they were simultaneously selected in four types of environments; (i) recommended agronomic management and high rainfall conditions (optimum), (ii) low-N stress, (iii) low-P stress and (iv) random stress. At each location an alpha lattice (0,1) design with three replicates was used and the number of entries ranged from 50 to 60. In 2014/15 seasons, 10 elite QPM varieties were selected from the on-station trials and compared with the best commercial check varieties on-farm. On-farm trials were conducted under farmer management practices and each farmer was considered as a block in a randomized complete block design. Analysis of variance for additive main effects and multiplicative interaction (AMMI) across the two seasons showed significant differences (P≤0.05) for genotype x environment interaction (G x E) thereby indicating opportunities to select for high yield and stability among genotypes. The new QPM varieties showed a yield advantage over the commercial check varieties by 6.6-18.2%. The results showed both narrow and broad adaptability, with hybrid CZH132044Q showing narrow adaptation while CZH142259Q broad adaptability.

Evaluation of Soil Health Indicators for Sustainable Intensification of Maize-based Cropping Systems in Semi-arid Tanzania

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Abstract
Improved management of land is critical to overcoming soil related constraints to sustainable food production in degraded soils. We characterized soils and land use patterns in Kongwa and Kiteto districts to assess fertility status and drivers of land degradation so as to develop integrated land management options for sustainable intensification. Two approaches that complimented each other were used. The first was the Land degradation Surveillance Framework (LDSF), which combines ground-sampling schemes and infrared spectroscopy to assess soil indicators needed to identify key land constraints for crops production and target interventions. Remote sensing and GIS techniques were used to generate clusters of plots within a 10x10m block (sentinel) in Njoro village. The second approach was the sampling scheme in experimental sites where fertilizer trials were established to confirm LSDF predictions. Standard mapping techniques were used to open, describe, and sample soils from profile pits in 5 villages and from random points in the plots. Soil data (nutrients, carbon levels, infiltration rates and types) and ecological data (land use types tree cover and density etc.) were collected for this study. Results showed that soils belonged to Lixosols (Laikala, Mlali and Molet Villages), Luvisols (Manyusi, Njoro and Laikala villages) and Vertisol (Mlali) orders. Generally soils in these villages had poor to moderate fertility, especially for CEC (7.3-8.7 Cmol$^{(+)}$/kg soil) and exchangeable bases. Soil total nitrogen (0.04-0.08%), extractable phosphorus (4.6-7.2 mg/kg) and organic carbon (0.5-0.72%) ranged from very low to low. The highest values noted for Luvisols in Manyusi while lowest values were found in highly degraded Luxisols in Laikala, Molet, and Mlali villages. Aridity indices revealed that Moleti has steppe characteristics while other villages are semi-arid with very short growing periods of 2-3 months. Only 9% of land in the Njoro sentinel is under cultivation and the rest is grazing land and forests (Acacia woodlands). Livestock carrying capacity exceeded the optimum and tree cover was low, being 84.3 stems ha^{-1} compared to 268.9 stems ha^{-1} for shrubs. These factors would be the major reasons for high land degradation noted in this study. To sustain crop production, soils will require inputs of fertilizers (especially nitrogen and phosphorus) and manure to replenish nutrients and build OC. Additionally integrating leguminous trees/shrubs in agricultural landscapes would enhance vegetation cover and carrying capacity of grazing lands in addition to improving soil health and land productivity.

Key words: Carrying Capacity, Livestock, LDSF, Land management, Soil health

Ex-ante Welfare Impacts of Maize-Soybean Rotation Adoption in Eastern Zambia

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Abstract

In Zambia, maize is the most important food staple; as such smallholder production is characterized by high levels of soil depletion and land degradation. Lack se of use of grain legumes in maize based systems has been attributed as one of the causes of accelerated soil fertility depletion. This paper estimates the welfare impacts of introducing legumes in the system in the form of maize-soybean rotation in eastern Zambia using data from on-farm trials and household survey data of over 800 households. The rotation regimes are analyzed under four different soybean nutrient management scenarios: (1) soybean without any external input; (2) soybean with inorganic fertilizer (NPK fertilizer); (3) soybean with inoculants; and (4) soybean with inorganic fertilizer and inoculants. The study applies the economic surplus framework to predict ex-ante impacts of maize-soybean rotation research on aggregate poverty. In the first stage, we use the survey data to assess the propensity of adopting the maize-soybean technology and to generate a technology adoption profile. The results show that several factors determine adoption, including total land cultivated education and gender of the household head. In the second stage, on-farm trial data are used to generate the benefits resulting from the rotation technology and in the final stage, the benefits are then allocated to the individual household's based on the survey data. Results from the economic surplus procedure show that the rotation regime that included inoculation only was the most profitable as it reduced cost by about 28% compared to maize mono-cropping. Analysis of the ex-ante welfare impacts shows that if all the non-adopters were to adopt maize-legume rotation, the incidence of poverty would reduce by 15 percentage points when compared to continuous maize. These results underscore the importance of including grain legumes in maize based systems.

Key words: Maize-legume rotation, economic surplus, poverty, Zambia

Farm typologies and sustainable intensification: where the rubber meets the road

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Abstract
Farm typologies support the categorization of farms into homogeneous sub-sets, to elucidate entry points and appropriately target agricultural intensification technologies. This addresses a major challenge, the heterogeneous socio-economic and biophysical nature of small farms. The literature has largely focused on descriptions and formulation of these typologies, with almost nil reports on the application of farm typologies. We report on a simplified, practical typology approach, based on four years of participatory action research in Central Malawi with more than 1000 farmers. We designed and tested sustainable intensification interventions for two distinct farm types: highly resource-constrained farms that average 0.6 ha, and resource-endowed farms that average 2 ha. Resource-constrained farms are marginally interactive with input (seed, fertilizers, agrochemicals) or output markets. For these farms, low-input combinations of maize-bean intercrops (65 to 70% of farm) and doubled up legume technologies (e.g., groundnut-pigeonpea intercrops), with targeted use of modest fertilizer doses increased productivity of maize for this farm type by two fold. Results also confirmed that resource-endowed farms are market-integrated and have enterprises that generate positive farm income, when fertilized maize is allocated on 50% of the farm, with the other half cropped with groundnut, cowpea and soyabean. For both farm types, the cropping patterns harness biological N_2-fixation, ensure grain legume diversity for family nutrition and risk-buffered market opportunities, and concurrently add quality organic residues for soil fertility enhancement.

Key words: Crop rotations, doubled-up legume technology, intercropping, maize, pigeonpea

Farm Typologies in Tanzania and Malawi

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Abstract

Africa RISING (AR) Sustainable Intensification (SI) Interventions may not benefit all the farmers to the same extent. It is therefore crucial to distinguish different typologies of project participants in order to evaluate their specific needs and better plan scaling activities. Taking advantage of the detailed data collected in the AR Baseline Evaluation Surveys (ARBES), we define and identify statistical typologies across the five SI domains: productivity, economic, environment, social, and human. The methodology used is a combination of factor and cluster analysis, which allows to define groups based on a wide range of different dimensions consistent across all the AR countries.

In Tanzania we obtain four groups. The first is mostly composed of female-headed households with low educational attainment and endowments. The second defines relatively younger households with medium endowments. The third includes vegetables producers who frequently use intercropping and are medium endowed. Finally, the fourth contains livestock breeders and legumes growers who seem to be better-off. The four groups are not homogeneously distributed across space: the first is highly concentrated in the Kongwa district; while the third and fourth groups are more widespread in the Babati and Kiteto districts. In terms of SI performance, the third and fourth groups are by far the most productive, with the fourth dominating in terms of economic endowments. In the human domain, the first group lags behind while the others perform similarly. On the other hand, the first and the fourth group are the best performers in terms of social and environmental aspects while groups two and three are struggling in these areas.

In Malawi we again obtain four groups. The first is mostly composed of female-headed households with low educational attainment and endowments. The second defines relatively older households with medium-to-low endowments. The third includes highly productive households who are medium-to-high endowed. Finally, the fourth contains households that mostly breed small ruminants and are highly endowed. The four groups are not homogeneously distributed across space: the first group is highly concentrated in the Mtakataka Extension Planning Area (EPA) while the fourth group is more widespread in the Lobi and Nsipe EPAs. In terms of SI indicators, group three and four are by far the best performers in the economic, productivity and human domains, with the fourth group performing similarly in the social aspect. In terms of environmental conditions, group one is lagging behind, group two and three show the best soil conditions, while group four engages in soil conservation practices the most.

We use the group-specific strengths and weaknesses from this characterization to propose targeted intervention recommendations in each country. These typologies are now ready for field validation and testing, and can be used as a useful tool to plan the scaling phase.

Farmer Attitudes toward Improved Agricultural Technology: Willingness to Pay Analysis in Tanzania

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Abstract

With Tanzania's economy being heavily dependent on agricultural production, there is no alternative to increasing agricultural productivity than through yield-increasing technologies such as improved seed and fertilizer. Recent years have seen a surge in the promotion of system based agricultural technologies as part of sustainable intensification of agriculture in developing countries. These initiatives introduce improved technologies that are tailored to farmers' local conditions by demonstrating the technologies in trials with free provision of improved seeds and fertilizers. But it is not clear whether small holder farmers would be willing to pay for these technologies, and what factors determine their informed demand for technologies. The goal of this study is to elicit willingness to pay (WTP) and demand for improved agricultural technologies among farmers using the stated preference experiment. The specific objectives are to investigate the determinants of farmers' demand for improved seed and fertilizer including the role of farmer's attitude toward risk and credit rationing.

As part of a broader research initiative aimed at evaluating Africa RISING (AR) project we conducted a contingent valuation study for hybrid maize seed and local inorganic fertilizer called *Minjingu mazao* in three villages (Long, Sabilo and Seloto that belong to different agro ecologies) in Babati district in Tanzania. In this study area we initiated a field experiment where 400 participants were recruited randomly at the village and sub-village level to attend a field day in June 2013. About half farmers were randomly selected, via public lottery, to receive inputs (*Minjingu mazao* ferlitizer and improved maize seed) via coupon distribution. Also as part of AR program in Tanzania a household level baseline evaluation survey of 810 households was conducted in January-March 2014. This study is based on the combined data from contingent valuation experiment and baseline evaluation household survey in Babati.

WTP was estimated using a dichotomous contingent valuation with follow-up model, and the average WTP was found to be 61.2% higher for hybrid maize seed and 15.4% lower for *Minjingu mazao* fertilizer compared to their average market prices. Education of household head, maize productivity and household wealth were found to influence farmers' likelihood of buying hybrid maize seed positively, whereas farmers risk aversion preference (elicited through experiments with real monetary incentives) had a significant negative influence on WTP for both hybrid seed and *Minjingu mazao* ferlitizer. The study concludes that WTP analysis can not only shed lights on cost-benefit analysis but also on the sustainability of agricultural innovation.

Key words: Willingness to pay, agricultural technological innovation, desired demand, contingent valuation, sustainable innovation

Farmer learning and application for sustainable intensification in Tanzania: drivers and implications for scaling

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Abstract
Many Sub-Saharan Africa (SSA) countries struggle to ensure realization of increased agricultural production amidst challenges such as climate change and population pressure. The approach of sustainable intensification (SI) in agriculture, characterized by increasing agricultural production using existing farm land in ways that are environmentally sound, socially acceptable and economically feasible, is being fronted as promising. Technologies that can lead to the realization of SI are available but one of the key challenges is the low reach among smallholder farmers. Farmer training and co-learning among actors in the innovation system is a key pillar aimed at enhancing access to knowledge and skills, and subsequently, application. However, little is known about the drivers of learning transfer among beneficiary smallholder farmers in agricultural productivity enhancement interventions. We use the learning transfer inventory model to interview 150 farmers and five key informant interviews with extension staff to analyze the drivers of learning transfer in two districts in Tanzania, Kongwa and Mvomero, where the Africa RISING program is operational. A structural equation model that estimates the drivers and their strength was generated. Results indicate that access to markets, capital, timely information and influence are critical for effective learning transfer. Design of the learning interventions is also critical for learning transfer, with implications for a deliberate focus on choice of appropriate documentation, extension and training methods.

Feeding the future: The role of sustainable intensification indicators in East and Southern Africa

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Abstract
One of the key challenges in working towards sustainable Intensification (SI) is developing technologies that can achieve the multiple goals of sustainability and have high potential for adoption by smallholder farmers. In this paper we use a framework of SI indicators with five domains (production, economic, environment, social and human condition) to analyze technological innovations developed as part of a Feed the Future program, Africa RISING in East and Southern Africa. Using data from Northern Tanzania and Central Malawi (including mother and baby on-farm trial sites representing three agro-ecologies and over three hundred farmers) we present radar charts to visualize performance of the technologies across the five domains. We demonstrate how the use of the SI indicator framework can be strengthened by a co-learning approach with systematic feedback from farmers about the interventions. The two most promising interventions in terms of SI performance and farmer preference were doubled up legume rotations with maize, and integrated nutrient management. Environmental performance of these technologies was high compared to maize-dominated farmer check systems. This was primarily due to large gains in biological nitrogen fixation, carbon fixation and soil rehabilitation. Maize production and economic assessment were mixed, although predominantly favorable. The domains of social and human capacity building were superior, notably in terms of diverse diet, food security and farmer preferences (including those of female household heads, who favored the doubled up legume crops for food production purposes). Overall, the SI indicators framework provided a systematic means to consider tradeoffs and opportunities associated with novel crop combinations and management practices. Combining analysis of these SI indicators with a participatory co-learning approach facilitates the development of technologies with higher potential for adoption by farmers.

Food insecurity and nutrient intake among rural households operating maize-based farming systems in Tanzania

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Abstract

The Millennium Development Goal (MDG) of defeating world hunger has not been met. A large portion of people in the world still suffers from hunger due to insufficient food intake. Understanding the intricacies of hunger and the most important underlying causes is required to design and implement solutions to world hunger. This study was designed to determine food security status by assessing nutrient intake and food insecurity levels among households in rural Babati District Tanzania. A cross-sectional study design which employed a 24 hour dietary recall method was conducted between May and June, 2014 before the maize harvesting season was used to collect data from 353 adult rural household. There were 44 (12.5%) female headed household. Results show that the prevalence of food insecurity (FI) among the households, defined as calorie intake below the Minimum Dietary Energy Requirement (MDER) of 2200kcal/day, was 86.4%. Food insecurity prevalence was higher among female headed households (90.9%) than male headed households (85.8%). Nutrient intake was negatively correlated with the age of the household head ($p < 0.0001$, $r = -2.07$), while energy intake was negatively correlated with household size ($p < 0.0001$, $r = -4.89$). Nutrient intake was positively correlated with the monetary value of the food eaten by each household ($p <0.0001$, $r = 0.837$). The monetary value of the food eaten by each household was also negatively associated with FI ($p = 0.000$, $B = -3.822$; odds ratio= 0.022). Gender, age, household size and income level all have impact on the propensity of adult family members to suffer from hunger. Knowledge of the complex, underlying causes of hunger could be used at the national level to inform policies and strategies related to hunger prevention and reduction in the country.

Key words: Food expenditure, food insecurity, hunger, nutrients, rural-households

From skepticism to realism: unlocking productivity potential under small holder farmers in Babati, Northern Tanzania

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Abstract
Low productivity of agriculture is hampered by lack of/poor knowledge on improved soil management. As part of Africa RISING of the Feed the Future initiative and a follow-up scaling project, multi-faceted approaches were undertaken to introduce, refine and train farmers on new technologies over 4 years including demonstration trials, field days and agronomic surveys to assess farmer's experiences in use of improved practices in crop production in Babati. Use of improved practice (use of fertilizer and improved seed at recommended plant densities) resulted in high and profitable yield increases consistently over the years. As a result, the practice was introduced to 125 farmers among whom an agronomic survey was undertaken; each farmer had the improved practice alongside a local practice. The agronomic survey showed that 46% of farmers in the 4 villages did not use manure mainly due to scarcity issues and fields being far from source of the manure. Overall, 72% and 16% of the farmers grow maize with pigeonpea and common beans (mostly in the drier Sabilo village), respectively, as intercrops, i.e., only <10% grow maize as a monocrop. 63% are using rope planting for the first time and of these, 10% have extended this practice beyond the fields supported by the project. In the improved practice promoted, improved varieties are the most preferred (50% of the farmers) while fertilizer and optimized spacing have equal preference (ranked first by 25% of farmers each). Compared with the local practice, increased cob size, strong and taller plants and greener leaves were observed under the improved practice by at least 80% of the farmers. Only 30% of the farmers in our study population have used fertilizers before, mostly in agronomic activities conducted by Africa RISING project in the last 4 years. Nevertheless, >95% of farmers intend to continue using fertilizers to increase productivity although this needs to be further verified. Trends in yield over time as observed by the farmers are related with the presence or absence of soil and water conservation, farmer knowledge and management.

Heterogeneous Impacts of Credit Constraints in the Presence of Risk Rationing: Evidence from Tanzania

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Abstract

Although theoretical and empirical literature widely suggest adverse effects of credit constraints on farm outputs, identification and estimation of the causal impacts still remain problematic. The difficulty is due to the fact that farmers' credit constraint status is not exogenous – the same observable and unobservable characteristics simultaneously determine both the output of the farm and its credit constraint status. For instance, richer farmers are less likely to be credit constrained but they may also have higher productivity due to newer technology adoption and scale effects. The recent attempt to redefine credit constraint status by including the risk rationed farmers – those who refrain from borrowing due to the risk of losing collateral – may further exacerbate the existing problem of endogeneity because selection based on individual preference (unobservable) is harder to control than observable characteristics such as wealth and farm size. The objective of this study is to assess the econometric implication of self-selection in credit rationing and to estimate the heterogeneous impacts of credit constraints on farm productivity.

Using direct elicitation of credit constraints through a specialized survey in Tanzania coupled with Africa RISING baseline evaluation survey data we identify and estimate the average cost of credit constraint on agricultural productivity for constrained, unconstrained, and the entire sample population. We directly elicit household's credit constraint status for borrowers and non-borrowers using survey-based technique akin to contingent valuation. We have found a modest 13% of households are quantity rationed whereas more than half of the sample (57%) are risk rationed. We employ a generalized version of Heckman's selection model to account for farmers' self-selection based on unobserved heterogeneity and find that the average cost of credit constraint for the entire population of farmers in our study area is about 19% loss in agricultural productivity. If the constraint is removed from a constrained farmer, on average his/her productivity is expected to increase by 11%, and if credit constraint is imposed on an unconstrained farmer, he/she is expected to suffer a very high 38% loss in productivity. We have found that average cost of constraint for the unconstrained set is much higher than that of the constrained set which indicates that the principle of comparative advantage is at work. By estimating heterogeneous response to credit constraint this study not only estimates the average cost of credit constraint for the entire population but also estimates the full distribution of cost of constraint including other important parameters of policy interest such as the average cost of constraint for the constrained and the unconstrained set of households.

Keywords: Credit constraints, Risk rationing, Heterogeneous selection, Tanzania Africa RISING, Average treatment effect

Improving productivity a soyabean-pigeonpea based system through phosphorus fertilization under different agro-ecologies of Central Malawi

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Abstract

Pigeonpea and soybean are grain legumes with increased local level consumption by rural households in Malawi. Also, intensified production of these legumes in the maize-dominated cropping system will improve nitrogen (N) economy. A study was conducted during the 2013/2014 growing season at three sites in central Malawi. The study objectives were to determine the grain yields and biological N2-fixation sole and intercropped pigeonpea and soybean under without P application or 14 kg P ha-1. The N difference and 15N natural abundance methods were used for biological N2-fixation (BNF) estimations.

Soybean grain yields and N fixed in sole stand were 1280 kg ha-1 and 54 kg N ha-1, respectively, while pigeonpea grain yields and N fixed in sole stand were 840 kg ha-1 and 65 kg N ha-1, respectively. Intercropping reduced pigeonpea grain yields and BNF by 47% and 38.5% respectively, but had no negative effect on soybean productivity. The intercrop system had better utilization of resources with a land equivalent ratio of 1.44. The soybean + pigeonpea intercrop fixed 90 kg N ha-1, which was 67% and 38% higher than that fixed by the sole crop systems of soybean and pigeonpea. The effect of P on soyabean BNF was a function of agro-ecology; ranging from no effect in the driest site, to between 60-71% increase in BNF wet environments.

It can be concluded that intercropping of soybean and pigeonpea and application of P in high potential agro-ecologies offers an opportunity to increase productivity, and reinforce soil fertility through net N-input.

Integration of Maize Lethal Necrosis Disease Management in Crop/Livestock Intensification to Enhance Productivity of Smallholder Agricultural Production Systems in East Africa

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Abstract
Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) is implementing research activities in East Africa (EA) using a Crop/livestock intensification approach to improve the productivity of smallholder agricultural systems in the region. Preliminary results on variety selection during the 2012 cropping season revealed that varieties are not a significant factor in bridging the current maize yield gap, while good agronomic and natural resource management are critical factors. But the outbreak and rapid spread of Maize Lethal Necrosis (MLN) in EA has emerged as a big challenge to maize production and has significantly affected the productivity of smallholder maize based agricultural systems as well as the commercial maize production sector, and justifies the use of improved varieties. Results from survey to determine the incidence and prevalence of MLN based on samples from 160 farms in Manyara, Dodoma and Arusha regions of Tanzania have shown 66.5% of MLN prevalence in the three regions with higher prevalence in Arusha and Manyara regions. There was also a 17% incidence of MLN in the three regions with higher incidence in Manyara and Arusha. We evaluated 5,600 maize hybrids in 2015 for resistance/tolerance to MLN and for their agronomic adaptability in Babati under natural MLN pressure and established that CKH140117, CKH140098, CKH140107, CKH140031, CKH140105, CKH140035, CKH140017, CKH140106, and CKH140124 were the top performing hybrids with a mean of 2.4 tons per hectare compared to popular or farmer preferred hybrids H513 and H520 with a mean yield of 0.01 tons per hectare. We recommend that these are the hybrids that should be targeted in studies and practices that address sustainable intensification in maize-based systems in areas with potential for MLND prevalence.

Is there a local demand for sustainable intensification? The role of multi-stakeholder platforms to target smallholders' needs in Babati, Tanzania

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Abstract
This paper focuses on an evaluation of the organization, functioning and long-term sustainability of Research-for-Development (R4D) platforms established by the USAID Feed the Future programme Africa RISING (Research in Sustainable Intensification for the Next Generation). The case presented here is from Babati District in north-central Tanzania.

Strategies for sustainable management of agricultural resources by rural communities and farmers must be tailored to local conditions and should foster communication, collaboration and trust between stakeholders on the ground. This is particularly important for the benefits of groups with limited access to resources, including women and youth. Furthermore, R4D programs need to incorporate local knowledge and consider the particular challenges in specific contexts in order to design effective interventions and build the trust required for collaboration with local communities. This process of co-learning between local stakeholders and research programs needs to be initiated at an early stage.

Research-for-development (R4D) platforms were initiated as a model for institutional collaboration and co-learning for Africa RISING in 2014, and in Babati it was formally launched as the district level platform JUMBA (*Jukwaa la Utafiti kwa Maendeleo wilaya ya Babati*) in April 2014. This initiative summons all major stakeholders in agricultural development in Babati District and functions as a strategic body for coordination of research and development activities on crop and livestock farming and natural resource management in the district.

One of the challenges has been to follow up and measure the progress and impact of multi-stakeholder arrangements. Long-term benefits require strong commitment in the form of local ownership and leadership that fosters mutual trust between stakeholders as well as a commitment to the sustainability of farming into the future. What are the success criteria for demand-driven approaches? For what kind of interventions are R4D platforms suitable or necessary?

We assess these aspects in an evaluation of the JUMBA platform based on interviews with key stakeholders in the process. The analysis is framed around three dimensions of platform performance, namely 1) platform establishment, 2) platform functioning, and 3) platform

outcome (cf. Damtew and Duncan 2015). In addition to these dimensions, and the related performance indicators, we have added a relational dimension to explore how platform members build networks and relations within and outside the platform itself. The relational dimension is essential to understand the platform's potential for long-term impact.

Modeling agricultural interventions from farm-scale to landscape: The case for the Agricultural Policy/Environmental eXtender (APEX) tool in Northern Tanzania

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Abstract

Evaluation of agricultural interventions at the farm level is important in order to scale viable interventions that benefit smallholder farmers within the landscape. It also allows for more effective agricultural policies that can be applied at scale. The Agricultural Policy/Environmental eXtender (APEX) model was applied to two farms in Seloto Village of Tanzania and subsequently to the watershed level. Using a calibrated and validated APEX model, the simulation of two conservation practices, specifically contours on sloping farm fields and forages grasses in farming systems (single and combined), was conducted at the field scale on two farms. Four variables [runoff, sediment, soil moisture storage and crop yield], were compared between field data collected over three years and the simulated practices. The field-scale outputs were then extrapolated to the areas encompassed by the different conservation practices at the watershed scale. In addition, we simulated how the field interventions would perform if they were hypothetically scaled within the landscape. The speculative estimations are presented as percentage reductions compared to the baseline scenario. When single conservation practices were implemented, reductions were 25% for runoff, 35% for sediment and 20% increment for soil moisture storage. In contrast, runoff losses increased by 20% at the watershed level while crop yields registered a 15% increment. The increase in runoff appears to be associated with patches in the watershed with no vegetation cover and interventions that increase the runoff loads at the watershed scale. When the conservation practices were combined, percentage reductions increased for all variables. The total reductions for the combined two practices were 55% for runoff, 60% for sediment, with 58% increase for soil moisture storage and 30% increases in crop yields. Model performances in simulating runoff, sediment load, soil moisture storage and crop biomass were generally satisfactory. APEX was an efficient tool for simulating the variables examined. Overall, the cumulative and combined effects of field conservation practices are scalable and can help address excess nutrient and sediment concerns and improve water quality at the landscape level while allowing smallholder farmers to reap the benefits associated with sustainable intensification through improved yields with a lower environmental footprint.

Keywords: Farm-scale, interventions, landscape, APEX, smallholder farmers, sustainable intensification

Motivations for adoption and adaptation of sustainable intensification innovations for smallholder farms in East and Southern Africa

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Abstract
Diversity among farms and within farming systems needs to be addressed when developing technology innovations to ensure wide adoption and sustainability of smallholder farming systems. There is also need to analyze and understand motivation drivers for adopting particular innovations, suitability of innovations promoted and the associated trade-offs faced by smallholder farmers. This can help to shape the existing systems in a more sustainable way and bring out scalable innovations that strengthen systems' resilience. We assessed the factors that explain choices of innovations and the adoption of local and externally proposed innovations by smallholder farmers in maize and legume cropping systems in Eastern and Southern Africa and the trade-offs associated with such choices. We used Likert scale data obtained from household surveys using a motivation questionnaire. The collected data was subjected to descriptive analytical procedure to produce data summaries and motivations for adopting sustainable intensification innovations in Babati district based on self-determination theory. According to the descriptive analytical results and findings, farmers in Babati District perceived SI innovations to be beneficial to them with an average score of 4.24 on a scale from 1-5 (where 1 means strongly disagree and 5 means strongly agree). The technologies of priority implemented in the district are intercropping (87%), improved maize and legume seeds (94%), improved spacing between plants and within rows (81%) , and manure application (87%). Three farmer endowment levels were developed based on their land sizes, thus Low Resource Endowments (LRE <5acres), Medium Resource Endowments (MRE >5 acres - <=10 acres) and High Resource Endowments (HRE >10 acres). Land was chosen because it is a very important component of rural household wealth. These were used in the subsequent analysis to compare different levels of motivations across different farm types (subsistence and semi commercial farms). Farmers of these three endowment levels expressed increasing scores for increasing levels of self-determination from extrinsic (3.58 out of 5), to introjected (3.99 out of 5), identified (4.32 out of 5) and intrinsic (4.28 out of 5) motivation. The level of experienced autonomy was considerably lower for LRE farmers than for MRE and HRE farmers. Despite the low stated attachment to external incentives for motivation, the most indicated constraints to adoption were related to financial resources (average score of 3.69 out of 5) and time requirements (3.09 out of 5). Lack of knowledge was not identified as an important barrier to adoption of SI technologies (<2.50). Promotion of SI innovations in Babati district was found to be influenced by extrinsic rewards such as money, inputs, seeds and machinery among other incentives to induce intrinsic motivation for adopting SI innovations.

New cereal and legume technologies to underpin sustainable intensification in semi-arid agro-ecologies of central Tanzania

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Abstract

Africa RISING is undertaking research to support sustainable intensification of crop and livestock production systems. In semiarid agroecologies of Tanzania, the work is based in Kongwa and Kiteto districts. These agro-ecologies annually receive 400-700 mm of rainfall in one growing season; have limited access to improved technologies, with up to 51% of the population living below the poverty line. An integrated R&D approach that: (i) Tests individual technologies, (ii) validates integrated technology packages, and (iii) tests models for scaling, is being used to study resilience and productivity enhancement options for maize-legume based farming systems in the two districts. New technologies being evaluated include legumes: Groundnut (5 genotypes); Pigeonpea (6 genotypes) and cereals: Maize (55 QPM and 10 drought tolerant genotypes); Sorghum (20 genotypes); and Pearl millet, (20 genotypes). Both complete and incomplete block experimental designs are used as appropriate on-station and on-farm along with participatory variety selection done in five sites/villages. In general, all new groundnut genotypes out performed the local check with a 3-4 fold yield advantage. ICGV-SM 02724, the best groundnut line, produced >800 kg/ha presenting a 120% yield advantage. ICEAP 00932 a new pigeonpea variety, produced 1422 kg/ha compared to 1243 kg/ha and 1138 kg/ha for the older varieties ICEAPs 0040 and 00557 respectively), and a yield advantage of 156% over the local variety. The maize line T283-34 out-performed released QPM varieties LISHEH2 and KILIMAQH06, with a 2 fold yield advantage; Sorghum and pearl millet test lines produced up to 4 tons/ha and 3 tons/ha respectively, presenting a 3-4 fold yield advantage. In order to test models for scaling-up, an R&D framework involving a network of farmers and key value chain actors (Farmer Research Networks -FRN), is being used for learning and discovery. The FRN will elucidate the roles of cropping systems and socio-economic dynamics on adoption of improved dryland cereal and legume innovations. Sixty-five households from both districts in the first study and 40 households in the follow up study, from two villages in Kongwa- Moleti (moderately ecologically constrained) and Laikala (highly ecologically constrained) are involved. Preliminary results show that >33% of households manage farming risk through intercropping and livestock production. Access to markets (for inputs- seed and outputs- grain) and knowledge (agronomy) are most limiting drivers of adoption, whilst land is only limiting to one third of the population but its quality is an issue. Thus optimization of intercropping systems contextualized for farm typologies is needed to guide deployment of innovations at scale.

Nutritional Status and Dietary Diversity of Rural Children in a Maize-based Farming System of Tanzania

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Abstract
The hunger target of the Millennium Development Goal 1c (MDG 1c) to halve the proportion of undernourished people in developing countries by 2015 has not been met. Understanding the intricacies of inadequate dietary intake is the most important step required to design and implement the solutions towards the eradication of malnutrition. We determined dietary diversity and nutrition status of children below five years of age in Babati District, Tanzania, by conducting a cross sectional survey of the dietary intake among 356 households (HHs). Food consumption data were collected using 24-h dietary recall. Anthropometric measurements were performed using the WHO standard procedures. The anthropometric indices were derived using the WHO Anthro software version 3.2.2. The overall prevalence of stunting, underweight and wasting was 54.7%, 20.8%, and 2.6%, respectively. The prevalence of both stunting (58.1%) and underweight (20.9%) among boys was higher compared to girls (50.5% and 20.6%, respectively). Stunting levels were highest (69%) among children of 24 - 35 months. Seventy one percent of children were fed with less than five food groups per day. Consumption of legumes and nuts correlated more with low levels of stunting ($p = 0.009$, $r = -0.174$). The dietary diversity score of the children was positively correlated with household dietary diversity score ($p < 0.001$, $r = 0.287$). Within first 1000 days, a statistically significant negative correlation between the stunting level and child's dietary diversity score ($p = 0.049$, $r = -0.0224$) and consumption of dairy products ($p < 0.001$, $r = -0.449$) existed. There was a statistically significant negative correlation between wasting and consumption of flesh foods ($p = 0.001$, $r = -0.208$). The prevalence of stunting and underweight was highest with strong association between dietary score and nutritional status of children.

Key words: Children, dietary diversity, nutritional status, household.

Optimizing Growth and Yield of intercropped Maize, Pigeonpea and *Gliricidia* in Kongwa and Kiteto Districts, Tanzania

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Abstract

Low crop yields and limited supply of high quality livestock feeds are among the main development challenges facing farmers in semi-arid Tanzania. To address these problems, farmers under the Africa RISING project in Kongwa and Kiteto Districts are integrating maize, pigeonpea and G*liricidia sepium*. Pigeonpea is a fairly new legume crop in these Districts, requiring both adaptability and agronomic studies to guide farmers on the best technology options, which can optimize farm productivity. We employed the participatory variety selection approach to identify adaptable pigeonpea varieties. These were then tested on farms in Mlali and Chitego (Manyusi) villages under various intercropping arrangements with maize (Pure stands, 1:1, 1:2 and 2:1) and/or *G. sepium* (Pure stands, Maize+Pigeopea, Maize+Pigeopea+Gliricidia) to assess options for optimizing growth and yields of crops and fodder. Two pigeonpea varieties (ICEAP0057 and ICEAP 0054) were selected by farmers based on superior growth and grain yield. Maize grain yield ranged from 1.20-2.04t/ha in Mlali and from 1.24-3.25t/ha in Chitego, reflecting higher potential in the latter site. Relative to monoculture, yield of maize was reduced (28-40% in Mlali and 2-62% in Chitego) with the highest reduction noted for with increasing pigeonpea proportions. At 1:1 ratio, reduction was modest and ranged from 30-40% in both sites. Similar trends were noted for pigieonpea grain yield. Land Equivalent Ratio (LER) was above 1 in all cropping combinations (ratios), suggesting that intercropping was more efficient in utilizing land resources for sustained productivity. Increasing the proportions of pigeonpea in maize based systems was more beneficial to farmers in less potential sites (LER = 1.53) than in high potential sites (1.15) at 1: 2 ratio of Maize and pigeonpea intercropping. At higher potential sites, farmer can benefit more by having larger proportion of maize than pigeonpea (1.06 versus 1.71). Thus, pigeonpea intercropping at the appropriate proportions based on local site conditions is necessary and a promising strategy to optimize yields in mixture and increasing resilience of farming systems. Economic assessment is going on to come up with the attractive and profitable intercropping systems for out scaling purposes.

Participatory on Farm Evaluation of Improved Napier grass (*Pennisetum purpureum)* accessions in northern Tanzania

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Abstract
In Tanzania livestock feed availability is one of the major problems hindering livestock productivity. Integrating improved forages such as Napier grass into existing livestock farming systems has potential to improve the overall supply of feed resources for livestock. Participatory variety selection involving farmers was conducted at on-farm field trials managed by farmers using a rating and voting exercise in 2014 and 2015. This was done to evaluate the performance of Napier grass accessions and establish farmers' criteria for Napier grass accession selection. Six Napier grass accessions (KK2, KK1, ILRI 16837, ILRI 16835, ILRI 16803 and ILRI 14984) were harvested at six and eight weeks from 3 field trials replicated 3 times in a randomized complete block design. Two cuts per season of growth, nutrition and yield data was collected for two seasons. Farmers identified and ranked their preferred napier grass characteristics. The number of leaves and shoots, tolerance to drought, rapid regeneration after harvest and length of stem were the main characteristics identified. Farmer's ranked (pairwise ranking) Kakamega (KK) 2, ILRI 16835, ILRI 16837 and KK1 as first, second, third and fourth best accessions, respectively. The six weeks DM yields of the accessions were 1.94, 1.50, 1.33, 1.31, 1.24 and 0.75 for accessions ILRI16835, KK2, ILRI16837, KK1, ILRI14984 and ILRI16803 respectively. The mean yield was 1.40 t ha^{-1} (DM); sd = 0.97 and results further showed a significant (P<0.05) difference between accessions ILRI16803 with the rest of the accessions. The number of tiller showed a significant relationship with DM yield. Farmers ranking and the research results show ILRI 16803 as the worst performing accessions. This shows the importance of involving farmer's variety selection process because yield alone is the most important characteristics in forage choice. Based on the results, KK2 and ILRI 16835 are the best bet accessions to integrated in the in the study area. Farmers' criteria of selecting Napier grass accessions will inform future Napier grass improvement.

Key words: Napier grass; forage; livestock; sustainable intensification

Phenotypic Characterisation of Local Chicken Ecotypes Indigenous to Semi-arid Areas of Central Tanzania

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Abstract
Optimal productivity of local chicken population is limited by poor genetic material and lack of appropriate breeding strategy, poor housing management, poor feeding and nutrition, and incidences of diseases. A study was carried out in Kongwa and Kiteto districts of central Tanzania to characterize local chicken ecotypes with high meat production potential based on objectives: (1) to assess qualitative traits, and (2) to quantify phenotypic characteristics of selected local chicken ecotypes. Chickens indigenous to selected sites of the two districts were screened for qualitative traits mainly plumage colour, comb type, shank colour, and physical parameters, namely, body weight, chest circumference and shank length. Data on chicken qualitative traits were analysed for simple descriptive statistics using SPSS. Data on quantitative traits were analysed into means and standard errors using analysis of variance (ANOVA) of SAS. Results revealed variable plumage colour ranging from white, brown, white as well as comb type. The chickens exhibited highly variable body weight (BWT), body length (BL), chest circumference (CC) and shank length (SL) attributes suggesting high variability in economic traits both between and within ecotypes. Phenotypic measurements show notable variations in live BWT, BL, CC and SL between ecotypes ($P<0.001$), study villages ($P<0.001$) and due to the interaction effects of ecotypes and study villages ($P<0.001$). Mean BWT ranged from 1.1 to 2.8 kg (mean; 1.8 kg). The BL, CC and SL varied from 32.2 to 44.5 cm, 26.3 to 35.5 cm and 7.5 to 9.8 cm, respectively. Body measurements were positively correlated with body weight. There were clear variation in terms of phenotypic performance between sexes with cocks having higher measurements than hens and pullets. Local strains with promising characters include chickens with less feathered bodies locally known as '*Kuchi*' strain. Kuchi strain is characterised by higher body weight than other local strains. Chickens with naked neck- gene suggest both high meat and egg production potential. Chickens with frizzled feathers locally known as '*Sasamala*' were appearing at low frequency in the village rural chicken population probably suggesting being of less stable gene. The SL was positively correlated with BWT (r= 0.55). The SL was positively correlated with BWT (r=0.43). Similarly, SL was positively correlated with BWT (r=0.31). Cross-bred chickens represent a strain with promising high production potential in terms of carcass weight. This potential could be further improved through controlled cross breeding. It is further recommended to carry out a genetic analysis to isolate the concerned quantitative traits.

Keywords: Plumage color, body weight, domesticated chickens, Central Tanzania, local chicken ecotypes

Plant different, eat different? Insights from participatory agricultural research

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Abstract

We examine the link between agricultural production diversity and dietary diversity using data from a participatory agricultural research program in Malawi. Given the non-random selection into the program and possible simultaneity between production and consumption decisions, we use instrumental variables to examine the link. We also estimate average treatment effect on agricultural income and, considering the program's focus on maize and pulses, on household total and disaggregated food expenditure. Program participants have a more diverse (into pulses) and valuable production, relative to nonparticipants. Specifically, participants harvested about 2 more crops during the reference season and had an annualized food expenditure of about 37, 000 Malawian kwacha higher, both relative to non-participants. The increase in household food consumption came from carbohydrate (starchy) foods versus the diversified pulses that are rich in crucial micronutrients and have better (and higher) quality protein than other grains. While we observe an overall positive association between production diversity and dietary diversity, the effect of production diversity on dietary diversity does not vary by program participation status. These findings highlight that planting different and better quality (and high value) crops may not translate into better quality diets, at least in the immediate term. As such, production-oriented interventions may need to be accompanied by other efforts, such as nutritional education, to maximize their health benefits.

Keywords: production diversity, dietary diversity, propensity score matching, instrumental variables, Malawi

Productivity and profitability of manual and mechanized smallholder conservation agriculture (CA) systems in Eastern Zambia

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Abstract
Climate variability and declining soil fertility pose a major threat to sustainable agronomic and economic growth in Zambia. In general, southern Africa has increasingly experienced poor rainfall distributions, in-season dry spells, lasting 18-33 days and low rainfall amounts (<400 to 650 per annum) in the current decade, resulting in low production or complete crop failure. The objective of this study was to identify land- and labour productivity enhancing technologies that are more resilient to climate variability through adaptive research in Eastern Zambia. The economic analysis was based on on-farm trials which lasted from 2012-2015. Farmers in target areas were replicates of a randomized complete block design. Net return ha^{-1} was estimated for each maize and legume yield observation (kg ha^{-1}) produced by each seeding technology (i.e. conventional ridge tillage, CA dibble stick planting, CA animal traction ripping and direct seeding), based on the domestic maize price and the variable costs of each technology. The dibble stick, ripline and direct seeding CA systems had 6-18%, 12-28% and 8-9% greater maize yield response relative to the conventional tillage system, respectively. Rotation of maize with cowpea and soybean significantly increased maize yields in all CA systems. Intercropping maize with cowpea increased land productivity (e.g. the land equivalent ratio for 4 seasons was 2.01) compared with full rotation of two crops under CA. Gross margin analysis from 2012-2015 of manual cropping system showed that intercropping of maize with cowpea using dibble stick produced the highest net returns ha^{-1} of between US$312.64 - US$767.76 as compared to US$204.95 – US$657.94 for dibble stick maize-cowpea rotation; US$108.53 – US$584.70 for dibble stick maize monoculture; and US$64.22–US$ 516.06 for the conventional ridge and furrow maize monoculture. The net-return for the mechanized animal traction system showed that maize-soybean rotations using the ripper for planting was more profitable than the cultivation with an animal-drawn direct seeder or conventional ridge and furrow. The study clearly shows that cropping systems based on the principles of CA were more profitable and resilient to climate variability. Their economic benefits as well as good agronomic practices therefore have the potential to improve food security and agricultural productivity for smallholder farmers in eastern Zambia.

Reducing yield gaps under small holder farmers conditions in Babati Tanzania: potentials and opportunities

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Abstract
Maize and pigeonpeas yields in Babati are poor due to low rains availability (average precipitation for the district is 790 mm/year). and distribution, use of unimproved seeds and low or non-use of fertilizers. This study assessed the potential of sustainable intensification options through maize-pigeon peas intercropping using improved seed, phosphorus fertilizers, and farm yard manure for reducing the yield gap as well as increase income of the farmers. The trials initiated in 2013 included 3 villages namely Sabilo, Selotho and Long, which are located at 1635 to 2200 m.a.s.l.; and evaluated 3 sources of P fertilizer (Minjingu Phosphate Rock [N 0%, P 13%, K 0%]), Minjingu Mazao [N 10%, P 9%, K 0%] and DAP [N 18%, P 20%, K 0%]) applied at a rate of P= 20 kg/ha at planting, compared with farmers' practice of improved maize/pigeonpeas intercropping without fertilizer.

Different improved maize varieties were used based upon the villages' altitude/elevation, amount of rainfall received and the rainfall duration. An early maturing maize variety called PAN 4M-19, and a medium maturing variety called SC 627 and a long maturing one called PAN 691 were planted at Sabilo, Seloto and Long villages respectively. An improved long maturing pigeonpea variety called Mali (ICEAP 00040) was intercropped with the maize in all villages. In 2014, different P sources (as in 2013) and farm yard manure were applied to 4 improved maize varieties, that had been selected by farmers based upon their priorities and performance in their respective areas, and tested in 6 villages. Farmers in Long village selected PAN 691, Long 6H, Pioneer 2859 and SC 627 maize varieties; whereas farmers in Seloto, Sabilo, Hallu, Matufa and Shaurimoyo villages selected DK 8031, PAN 4M-19, Pioneer 3253 and SC 627 varieties. Each maize variety was intercropped with the Mali pigeonpea variety, or Lyamungu 90 common beans variety in the case of Long village. The fertilizer treatments for 2015 were similar to 2014 but, the number of maize varieties were reduced to two based again on farmers' preferences, and the number of villages to 4. Long village farmers selected SC 627 and PAN 691, whereas those in Seloto, Hallu and Sabilo villages chose SC 627 and Pioneer 3253 maize varieties. Trial plot size was 10 x 10 m for each of the treatments. Both maize and pigeonpeas were planted at 100 cm between rows and 50 cm between hills with 2 plants per hill, while beans were planted at 80cm x 40cm with 20 cm in between beans holes.

The data collected included characteristics of soil samples at 20 cm depth during planting, plant stand, biomass, grain yield and socio-economic data for calculating economic benefits of the treatments. Soils in the villages were highly deficient of N, and the P levels in Seloto and Sabilo villages were average/medium, with high variability between individual fields. DAP and

Minjingu Mazao fertilizers were the best sources of P nutrient in all the 3 years. The high yielding maize varieties were PAN 691, SC 627, Pioneer 2859 and Pioneer 3253. On average, maize yields obtained from the two fertilizer sources in 2014 and 2015 seasons across the different sites increased from about 1.5 t/ha to 6 t/ha for the high yielding varieties with adequate rainfall like in Long village . Pigeonpea increased by more than 5 times from 0.2 t/ha to 1.3 t/ha in the same period when the two fertilizers were applied; whereas common beans increased from 0.35 t/ha to 0.5t/ha in 2014, and from 0.1 t/ha to 1.9t/ha in 2015. Applying farm yard manure alone in both intercrops did not increase yield as compared to the combination of Farm Yard Manure with Minjingu Mazao.

The benefit cost ratios for the maize pigeonpeas using DAP or Minjingu Mazao fertilizers in 2013 were 2 times more compared to the non-fertilized treatment, whereas the DAP/Minjingu Mazao fertilized maize-common beans intercropping gave a benefit:cost ratio of about 3 times more in 2015 compared to the unfertilized treatment. In moisture stressed conditions, DAP performs better than Minjingu-based sources. However, in seasons with adequate moisture, the performances of both DAP and Minjingu fertilizers is more or less the same. The pigeon pea or common beans -maize intercrop with phosphorus fertilization did not only increase yield and income but, could change Babati to a food secure and richer district.

Simulating adoption of sustainable intensification technologies in semi-arid areas of central Tanzania

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Abstract
Despite sustainable intensification technologies being the best options for enhancing crop and livestock productivity in many fragile ecosystems, there is limited uptake of these technologies to address challenges to crop and livestock productivity in Tanzania. The study was conducted to simulate adoption of sustainable intensification technologies in semi-arid areas of central Tanzania. ADOPT (Adoption and Diffusion Outcome Prediction Tool) was used to simulate adoption of the farm level technologies tested including improved poultry feeds, improved seeds and agroforestry technologies. Presentations of the technology diffusion results from ADOPT simulation model used the S-shaped function of time. Other useful adoption indicators that were considered were degree of adoption and intensity of adoption. The adoption rate was used since it is largely involved with other farm decisions making tools such as cost-benefit analysis. Results projected adoption peak of improved poultry feeds being 58% and 93% in Mlali and Njoro villages respectively. Further projections show that it would take 10 and 12 years to reach adoption peak in Mlali and Njoro, respectively. The differences on improved poultry feeds adoption level have been associated with closeness of these villages to agro-dealers. A village which is located at approximately 2-5 km from the town centre is favored in terms of being close to agro-dealers hence can easily adopt improved poultry feeds and other agro-inputs related ones. Improved seed has been projected to be easily adopted in Mlali compared to Laikala village of Kongwa district. Adoption peak of 82% would be reached after 8 years in Mlali, whereby, the peak of 68% would be reached in Laikala after 12 years. Proximity of these villages to agro-dealers would facilitate easily adoption of improved seeds. In this regard, farmers would be encouraged to use and test these farm level technologies in combination as package. The adoption rate peaks have been projected to be very high for agroforestry in both villages. However, it would take 9 years to reach adoption peak of 94% and 12 years to reach adoption peak of 90% in Moleti village of Kongwa district. The study recommends integration of promising technologies to enhance adoption and diffusion of technologies through promoting proper use of fertilizers, improved seeds and enhancing rain-water harvesting for drought risk minimization

Keywords: production technologies, socio-economic factors, adoption level, simulation

Smallholder farmers' comparative assessment of traditional and improved storage options for maize in Tanzania

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Abstract

In recent times, the awareness of smallholder maize farmers about food loss prevention options has increased the potential adoption of new improved storage technologies. However, farmers need some decision criteria to adopt a feasible and economically viable option without undergoing many years of expensive experimentation or try-and-error.   We present the results of farmers' own assessments of their postharvest practices, comparative assessment of some storage technologies and financial decision options inform adoption decisions. Food losses were measured after 8 months storage and price data for maize were collected from the markets using price data sheets. The Gross Margin (GM) analysis and Benefit-Cost ratio (B/C ratio) were used to determine the financial benefits of the use of the storage options. The price of major crops differed significantly during the period of harvest and off-season (P<0.005). Pests and diseases were reported by 52% of the farmers as the major factors responsible for storage loss. Storage of maize using modern methods is beneficial in preventing storage losses thereby increasing food availability but there may be a negative financial benefit especially when market prices are low. The lesson learned was that development practitioners should carefully evaluate the potential financial, food security and other benefits of a new storage technology prior introduction to farmers.

Key words: adoption option, benefit, food loss, pests, prices, storage

Social Exchange Networks and Historical Experiences: Following a Maize-Fertilizer Intervention in Babati (Tanzania)

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Abstract

In Tanzania, the promotion of seed-fertilizer technologies has been a central concern of development programs and interventions for almost five decades. Past initiatives typically relied on cost relieving and knowledge building means in order to raise farmers' interest and capacity for adoption. However, current estimations suggest that only about 10% of farmers in the country use improved seeds, whilst about 12% apply inorganic fertilizers with the majority located in the Southern Highlands. In 2014 researchers of the R4D project Africa RISING conducted an experiment in three villages in the Babati District, northern Tanzania. They investigated farmers' "willingness to pay" for both improved maize seeds and inorganic fertilizers. The experiment's design corresponds to the principal rationales of past development interventions. It reflects the general lack of inclusion of non-economic social-science perspectives in research on agro-inputs and their adoption in Tanzania. Our study recapitulates the "willingness to pay" experiment considering the wider social, cultural, and historical context. It describes and analyzes the course and outcomes of the experiment as well as the underlying processes leading to them. It is based on an extensive literature review and over 50 semi-structured interviews with participating male and female farmers, implementers, district officers, and representatives of previous development interventions in the district. The results demonstrate the important role of historical experiences and social exchange networks as factors that shape farmers' decisions to adopt or reject improved seeds, inorganic fertilizers and the agricultural practices associated with them. Farmer-to-farmer exchange revolves around ox-ploughing, land, manure and labor with differential positions along stratifying lines (e.g. gender and class). Such an approach enables us to explore who could potentially benefit from maize-fertilizer technologies.

Key Words: Fertilizer, Improved Seeds, Social Exchange Networks, Adoption, Tanzania

Sustainable Intensification of Maize-based Cropping Systems in Semiarid Tanzania through Improved Nutrient Management

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Abstract

Estimating crop response to fertilization and identification of affective fertilizer materials is important to meet nutrient requirements of maize and sustain soil fertility. Unlike other agro-ecological zones, no fertilizer recommendations have been developed for semi-arid zone in Tanzania. To fill this gap field experiments were carried out to develop phosphorous (P) fertilizer rates and identify the effective P source for this zone. Randomized complete block design (RCBD) with three replications was adopted in this study that was conducted in Moleti and Njoro villages during the 2013 and 2014 growing seasons. Triple Super Phosphate (TSP) fertilizer was used to test the various application rates: 0, 7.5, 15, 30 and 45 and 60 kg P ha^{-1}. For P-source trials, Minjingu Mazao, Minjingu hyperphosphate and TSP were compared at 30 kg P ha^{-1} for each fertilizer material.   Maize, monoculture or intercropped with pigeonpea was used as the test crop in the two fertilizer trials. Soils in the study sites were deficient of P (5.53 mg/kg), N (0.045%) and Ca (3.03 Cmol $^{(+)}$/kg) and had very low organic matter content. Maize yield in across the two sites increased with fertilizer application rates and peaked at 30 kg P/ha in both maize monoculture (4.2 t/ha) and pigeonpea intercropping (3.9 t/ha). Maize yield after this rate declined slightly, possibly reflecting nutrient toxicity, representing 110 and 140 % yield increases relative to the control. Average maize yield at 15 kg P/ha in monoculture (3.6 t/ha) and intercropping systems (3.3 t/ha) was not significantly different from yield obtained with the application of 30 kg P/ha, suggesting that farmers may reduce the application rate by 50% without losing yield significantly. Maize grain yield after Minjingu Mazao was similar to the yield obtained with TSP application in Moleti village (3.6 vs 3.7 t ha^{-1}) and Njoro village (3.9 vs 4.2 t ha^{-1}). High response of maize to Minjingu mazao is attributed to slightly acidic soil condition, fortified N, Calcium and micronutrients in this fertilizer material. Economic assessment is going on to come up with the cost effective fertilizer recommendations for this semiarid zone, but agronomic results suggests that farmers may use Minjingu Mazao as an alternative to TSP at 15 kg P/ha.

The effect of different soil health management and cropping system options on yield of drought tolerant bush bean varieties in two agro-ecologies in central Malawi

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Abstract

In Malawi the common bean (*Phaseolus vulgaris* L.) is mostly produced under smallholder farming systems, where little or no manure or fertilizer are applied, leading to a low national average yield of 600 kg ha^{-1}. A participatory evaluation study, was conducted to assess the influence of various soil fertility management options (organic and inorganic fertilizer application), and cropping systems (maize-bean intercrop and bean sole crop) on the yield of 2 drought tolerant bush bean varieties (SER45 and SER83) in Dedza and Ntcheu districts, in central Malawi during 2013/14 and 2014/15 crop seasons. The trials were laid out in split-plot design with the bean varieties as main plots and the soil fertility management options and cropping systems as sub-plots, replicated three times. Under both cropping systems the soil fertility management options included: i) control (no soil fertility amendment) ii) 7.0 ton ha^{-1} of chicken manure (98 kg N, 112 kg P_2O_5 and 70 kg KO_2 ha^{-1}) on bean and maize bean intercrop, iii) 23 kg N and 21 kg P_2O_5 ha^{-1} fertilizer on bean sole crop, iv) 115 kg N and 21 kg P_2O_5 ha^{-1} fertilizer on maize and maize-bean intercrop and v) a combination of 7.0 ton ha^{-1} of chicken manure and 23 kg N and 21 kg P_2O_5 ha^{-1} fertilizer on bean sole crop or 115 kg N and 21 kg P_2O_5 ha^{-1} fertilizer on maize and maize-bean intercrop. Both bean genotypes performed significantly better (P< 0.01) in sole crop than intercrop, with yield differences of 620 kg ha^{-1} (SER45) and 340 kg ha^{-1} (SER83), maintain the same bean plant density under both cropping systems. The land equivalent ratios were 1.49 (SER45) and 1.29 (SER83). The application of inorganic fertiliser to bean in both sole intercrop systems had insignificant (p > 0.05) effects on the bean yield increase for both varieties. The bean varieties however responded differently to application of manure and a combination of manure and fertilizer. SER45 was responsive to manure application in a sole crop which led to a 79% yield increase, while SER83 was responsive to a combination of manure and fertilizer leading to 76% yield increase. Both bean genotypes showed superior performance across the two seasons, despite the 2014-15 crop season being exceptionally dry, posing terminal drought conditions for other crops. The study demonstrated the potential of increasing bean productivity through promotion of improved drought tolerant bean genotypes and appropriate soil fertility management options, which are variable depending on the bean variety.

Key words: *Cereal-legume cropping systems, drought tolerant bush bean, soil fertility management options*

The effect of nutrition management on the performance of local chickens in Tanzania

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Abstract
Local chickens are kept by most households in Tanzania, whereby they provide income and contribute to food security. However the productivity of the chickens is not as high as expected due to high mortality prior maturity and slow growth rate. A study was conducted under farm conditions in Babati District of Tanzania to evaluate the effect of nutrition management on growth and mortality in local and crossbred chickens. A total of 159 local and 193 crossbred chickens were used in the study. Chicks of both strains were reared at one place under full confinement with balanced rations for eight weeks and then randomly allocated to three feeding systems:(i)full scavenging, (ii) semi-scavenging (with feed supplementation) and (iii) full confinement (with intensive feeding). Growth performance was measured in terms of body weight gain and mortality rate was as well recorded. The data were taken at 8, 10, 12, 14, 16, 20 and 30th weeks of age. The mean gain for full scavenging, semi-scavenging and full confinement were 929.41, 674.97and 834.47g/bird respectively for the first 20 weeks of age, and were not significantly different (P< 0.05.The mean mature body weights for the local and crossbred chickens were 1491g and 1765g, respectively. The confined and semi-scavenging chickens experienced significantly (P< 0.05) lower mortality rates (39.83 and 58.58% respectively) than the full scavenging chickens (66.14%) by the end of the study. Means mortality rates for local and crossbred chickens were 59% and 75% respectively, and they differ significantly (P<0.05). The study revealed unbalanced feed rastioning practiced by farmers with either energy feeds (maize and or maize bran), protein feeds (sunflower seed cake and or fish meal) or vitamins source (vegetable wastes). Farmers preferred cheap locally available materials in feeding their birds regardless of nutrient requirement of the chickens and this influenced high mortality rate for the chickens. Most of farmers (90%) participated in the trials were feeding unbalanced rations to their chickens because of the high input costs for confined management. Semi-scavenging then offers the next best alternative as it reduces mortality rates. It is recommended that those locally available materials with enhanced feed value should be the ones targeted if the chicken performance has to be enhanced sustainably.

Key words: Local chickens, nutritional management, production performance, feed resources.

The impact of legume cereal based complementary food, reduced aflatoxin exposure and improved hygiene practices on malnutrition status of children in rural Tanzania

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Abstract
According to the Tanzania National Nutrition Survey 2014, the chronic malnutrition and stunting among children of age between 0-59 months are estimated at more than 40 % and 11 %, respectively. Apart from the rate of food insecurity and inadequate feeding practice, the underlying causes which play an important role are aflatoxin exposure and hygiene. A baseline survey was conducted on 100 mothers with the children of less than 24 months old from 5 villages (Moleti, Mlali, Chetigo, Njoro and Laikala) in Kongwa and Kiteto districts of Tanzania, as a basis for assessing the impact of diversification in food utilization, better hygienic practice and reduced aflatoxin exposure on underweight, wasting and stunting. It was found that more than 70% of the mothers had started feeding their children with complementary food prepared with maize and groundnut at the age of 6 months. The aflatoxin contamination in these grains were found to be >20ppb in >70% of the stored grains especially in the subterranean groundnut. The urinary aflatoxin biomarker study using enzyme linked immune sorbent assay (ELISA) method showed that about 47 % of the children had aflatoxin (AFM1) exposure ranging from 20 to 147 ng ml^{-1}. Infant and young child feeding practice (IYCF) showed that only 18% of the children from these villages were receiving minimum acceptable diet and the mean dietary diversity score (DDS) was 3 out of 7 food types. The weight-for-age Z-score (WAZ), height-for-age Z-score (HAZ) and weight-for-height Z-score (WHZ) showed that 19.4 % of the children were underweight, 37% were stunted and 2.8 % were wasted. Following the baseline, 21-day intensive training was provided to the mothers in the treatment group in all the five villages, where they were trained through a learning-by-doing process on aflatoxin free legume-cereal based food formulation and a list of better hygiene practices with periodic anthropometric measurement on the 0th, 7th, 14th and 21st days of the program. As the children were fed with the recommended complementary food that contained pigeonpea, finger millet, soya bean, maize, and vegetables rich in vitamin A, coupled with better hygienic practices and aflatoxin control, there was a 40% reduction in underweight (with 0.4 kg of average weight gain), and a 50% reduction in wasting within the period of 21 days. The study serves as a model for educating mothers in resource poor settings towards better health outcomes of their children through behavioral changes based on a short term attestation. Moreover, this is the first quantitative estimation from Tanzania of how the better practices immediately contribute to the reduction in malnutrition among young children.

Understanding smallholder farmer grain legume technology adaptation, integration and preference in maize-based cropping systems using participatory action research in Malawi

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Abstract
Integration of grain legume technologies into maize based cropping systems is an applicable pathway to achieving sustainable intensification for Malawian smallholder farmers. To ensure system sustainability, targeted technologies must be developed with an understanding of how farmers adapt, integrate and prefer such technologies in their current systems. Diverse edaphic qualities, varying livelihood and management strategies as well as low resource endowment, in increasingly unpredictable climatic conditions, inherently render such an understanding challenging without active farmer experimentation. In this study, using the mother-baby farmer participatory action research approach, we aimed to understand farmer adaptation, integration and preference of annual (common bean, cowpea, groundnut and soyabean) and semi-perennial (pigeon pea) grain legume technologies in current maize based systems. During two growing seasons (2012-2014), a total of 317 farmers over four agroecologies experimented with, adapted and integrated on-farm demonstrated sole legume, mixed legume and mixed maize-legume intercropped systems, which included novel semi-perennial pigeon pea and mixed legume intercropped technologies, into their own individual on-farm plots (*n=1344*). Over the two growing seasons, sole legume, mixed maize-legume intercropped and mixed legume intercropped systems were cultivated by 87, 50 and 35 percent of farmers, respectively. Thirteen percent of total plots included pigeon pea with mixed legume plots having the highest percentage of pigeon pea (34%). Farmers compared all technologies grown within the two years to sole maize and preferred maize intercropped with one or more legume specie(s), mixed legume and sole legume systems 62, 19 and 10 percent of the time, respectively. The novel pigeon pea and mixed legume technologies stood out among comparisons. Farmers who intercropped mixed legume technologies with maize and especially those who included pigeon pea in a mixed legume technology, with or without maize, had a higher preference of such systems over sole maize in comparison to all other systems. Notably, mixed legume technologies were not intercropped with maize on demonstration trials, yet 7% of farmer plots were cultivated in these systems and were preferred 66% of the time; the addition of pigeon pea to these systems increased farmer preference over sole maize from 63 to 74 percent. These results indicate that farmers, through adaptation and experimentation, can further sustainably intensify their systems beyond that of demonstrated technologies. Development of future technologies should be targeted towards more intense maize-grain legume intercropped systems, which include both annual and semi-perennial grain legume species.

Yield response and economic performance of elite vegetable cultivars to good agricultural practices within intensified farming systems in selected locale of Tanzania

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Abstract

Agronomic and economic performance of farmer selected and preferred elite Tomato (*Solanum lycopersicum*); African eggplant (*Solanum aethiopicum*) and Amaranths *(Amaranthus cruentus*) cultivars were undertaken in 4 communities located in the Babati district, Manyara region of Tanzania using the mother/baby field trial approach. The trials were carried out over 2 annual production seasons to study the performance of introduced technological packages viz: use of elite vegetable varieties complemented with selected good agricultural practices such as healthy seedlings, good agronomic practices and integrated pest and disease management in comparison with standard farmer practices, in terms of yield and profitability. The randomized complete block design involving one mother plot and three baby plots as replicates of improved practices per village were set up. Input-output data from the 16 plots were analyzed using One-way ANOVA. Using healthy seedlings, right spacing, weed control, joint application of farmyard manure and inorganic fertilizer along with judicious pesticide use, leads to significant yield increases (p<0.001) of up to 64.75t/ha compared to 28.28t/ha (BCR=8.5) and 53.97t/ha compared to 23.04t/ha (BCR=4.50) for Tomato and African eggplant respectively. For Amaranths, the yield increase under improved technologies was 59.67% higher from 8.46t/ha to 14.91t/ha. The application of a single technology such as healthy seedlings alone contributes to slight to yield increase compared to application of multiple good agricultural practices; 18.12%, 24.68% and 14.20% for tomato, African eggplant and Amaranths respectively compared to the business-as-usual scenario. Thus, simultaneous adoption of multiple good agricultural practices generates much higher yields and returns compared to a single technology.

Keywords: Mother-baby demonstration trials, African eggplant, Amaranth, Tomato, Good agricultural practices, Benefit-cost ratio (BCR), Agricultural technology adoption, Randomized complete block design

Yield response of climbing bean genotypes to different crop management options in two agroecological zones in central Malawi

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Abstract

Farmers in Linthipe (Dedza district) and Kandeu (Ntcheu district) evaluated several crop management options for intensifying maize-climbing bean production under smallholder farming systems in 2013/14 and 2014/15 crop seasons. Two climbing bean varieties, DC86-263 and MBC33, were evaluated for yield under sole and maize-bean cropping systems, as well as combinations of inorganic and organic soil fertility management options as follows: i) no soil fertility amendment, ii) chicken manure application (7 ton ha^{-1}), iii) fertilizer application (23 kg N ha^{-1} and 21 kg P_2O_5 ha^{-1} in sole bean; and 115 kg N ha^{-1} and 21 kg P_2O_5 ha^{-1} in intercrop with maize , and iv) application of a combination of manure and fertilizer. Results showed significant differences in bean yield due to effects of cropping seasons (p< 0.05). Both genotypes performed better in 2013/14 than in 2014/15 season (1.2 ton ha^{-1} - 0.7 ton ha^{-1} for MBC33 and 1.4 ton ha^{-1} - 0.3 ton ha^{-1} for DC86-263 respectively). Cropping systems significantly affected yield of MBC33 (P < 0.05), where values were lower in intercrops (0.34 ton/ha^{-1}) than under sole crop (0.9 ton ha^{-1}). Treatments with manure had significantly (p<0.005) high values (0.7 ton ha^{-1}) than without manure (0.4 ton ha^{-1}). On the other hand, application of both fertilizer and manure significantly increased yields of DC86-263 from 0.4 to 0.7 ton ha^{-1}. The interaction between seasons and a combination of inorganic fertilizers, significantly influenced the yield of DC86-263, where the yield tended to be consistently high under crop management options with inorganic fertilizer application. The combined maize and bean yield under maize intercrop with DC86-263, where a fertilizer and manure were applied, performed better, with a land equivalent ratio of 2.57, implying that the genotype is suited for maize-bean cropping system. On the contrary, the yield of MBC33 was drastically suppressed by the interaction between maize and manure application, as the same bean genotype performed 222% better when it was grown as a sole crop with stakes under manure application. The results from these studies indicate that the climbing bean genotypes respond differently under sole and intercrop systems, but also with organic or inorganic fertilizer application or a combination of the two. As such farmers will have to select specific bean varieties for different cropping systems and soil fertility amendment options that will provide the best economic returns under specific conditions.

Key words: Maize-bean cropping system, management options, climbing bean genotypes, soil fertility

END.