

# 27<sup>th</sup> Soil Science Society of East Africa and 6<sup>th</sup> Africa Soil Science Society International Conference

Theme: Transforming rural livelihoods in Africa: How can  
land and water management contribute to enhanced food  
security and address climate change adaptation and  
mitigation?

Nakuru, Kenya 20-25 October 2013

**Book of abstracts**

Conference papers are compiled in:



Adapting African Agriculture to Climate Change

Transforming Rural Livelihoods

Leal Filho, W.; Esilaba, A.O.; Rao, K.P.C.; Sridhar, G. (Eds.)

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# Preface

Africa is one of the continents mostly severely affected by climate change, for two main reasons. The first reason is because the geographical characteristics of the African continent make it highly vulnerable to the effects of climate change, especially from the projected changes in the rainy seasons and intensity of droughts, which in turn may affect agriculture and other human activities.

The second reason for high vulnerability of African countries is related to their limited capacity to adapt. By not having access to required technological and financial resources that are needed to implement substantial adaptation programmes, many African nations are finding it difficult to handle the many challenges that climate change poses to them.

Climate change is also one of the major challenges that the agricultural research community is facing in recent years. Compared to many other biophysical constraints that the smallholder farmer is facing, climate change is a difficult problem to address for various reasons. First, climate change is a future problem and there are problems in assessing the magnitude and direction of these changes accurately, especially at local level. Second, while temperature projections seem to be fairly certain, changes in rainfall both in quantity and in variability are difficult to predict and rainfall is the major factor influencing productivity and profitability of the agricultural systems. Third, our understanding of impacts of projected changes in climate on crop growth and performance, especially the role of changes in carbon dioxide concentration, is limited. Despite these limitations, significant progress has been made in understanding the impacts of climate change on smallholder agricultural systems and in identifying appropriate management options to adapt. Unfortunately, much of the fieldwork carried out in many African countries remained inaccessible to the global community.

The conference “Transforming Rural Livelihoods in Africa: How can land and water management contribute to enhanced food security and address climate change adaptation and mitigation?” organized by the Soil Science Society of East Africa (SSSEA) in collaboration with African Soil Science Society (ASSS) and held in Nakuru, Kenya during 20–25 October 2013 served as an important platform for scientists in the Eastern Africa region to share their findings and experiences.

The targeted are researchers, policy makers, farmers, extension agents, among others, involved in and/or having interest in soil science and land and water management. This book contains various papers presented at the 2013 Nakuru Conference, as well as other contributions written by teams of African experts and/ or by international researchers working in Africa.

Presentations at the conference covered a wide range of topics and presented a diverse set of viewpoints and perceptions on several of aspects of climate change and its impacts on agriculture. This book includes selected papers, based on their relevance and interest for the climate change research community, from the large number of presentations made during the conference. The papers are sequenced according to their focus in addressing a range of issues from methodological to technological and policy options for adapting agriculture to projected changes in climate.

Progressive changes in climate are hard to predict and assessing impacts of these changes on performance and productivity of crops is still harder. Since crop performance is an outcome of a number of interrelated factors it is difficult to predict how these factors independently and interactively affect the performance of crops under different climatic conditions. One of the promising approaches is the use of analogue sites, which are locations whose climate today appears as a likely analogue to the projected future climate of another location. The paper by Leal Filho and De Trincheria outlines this approach. The overall aim of climate change research is to find options that contribute to reduced vulnerability to climate variability and promotion of climate resilience in development investments, enhancing biodiversity, increasing yields and lowering greenhouse gas emissions. The second paper by Stephen Kimani highlights some of the measures that can be put in place to improve incomes and livelihoods of farmers in the semi-arid regions of Africa. The paper by Kwena Kizito dwells on the issue of how research generated information is availed and used. Through a review, this paper assessed the extent to which scientific information has been used to inform climate change adaptation policies, plans and strategies in Kenya as well as the effectiveness of existing platforms for sharing climate change information in the country. The paper by Sospeter Nyamwaro is based on information about the climate change-related projects undertaken in Kenya over the past five years. It analyses the areas covered by these projects and identified the high and low focus areas.

The next four papers deal with issues related to assessing and characterizing climate variability (Oscar Kisaka) and the potential impacts of climate variability and change on water resources (Sridhar Gummadi) and crop performance (Justice Nyamangara). One key aspect of climate change impact assessment studies is lack of information on how these impacts are felt differently by different gender, age and social class differentiated groups. The paper by Kumbiari Musiyiwa using the data collected through surveys conducted at analogue locations highlights this aspect of climate change and identifies gender sensitive adaptation options.

Among the key options for adapting agriculture to climate change, soil and water management measures including irrigation figure prominently. This is mainly because of the expected increase in the demand for water by crops due to increased

evaporation and transpiration under warmer temperatures. The papers by Musyimi, Ngugi, Evans Mutuma and Geoffrey Gathyungu provide some insights into the potential role of water conservation in mitigating the water stress on some important food crops. The study reported by P.N.M. Njeru tried to compare and contrast farmer and scientific evaluation of various climate change adaptation options that integrate soil water and soil fertility management practices aimed at improving productivity of sorghum.

The final set of four papers explores the use of drought tolerant crops and varieties as an alternative adaptation strategy. Finyange N. Pole evaluated a number of maize genotypes to identify varieties that are efficient in both nutrient and water use. While Fabian Bagarama explored the performance of tomato as an alternate crop under warmer climates, studies reported by Cyrus M. Githunguri assessed the potential of traditional food crops as alternatives. Interest in research on issues related to climate change in Africa has been high over the past decade. It is important that this remains high and these efforts will be successful in identifying robust management options that help smallholder farmers make best use of the variable climatic conditions while helping in adapting to future changes.

This book is also an output of the project Adapting agriculture to climate change: Developing promising strategies using analogue locations in Eastern and Southern Africa (CALESA), funded by the German International Agency for Cooperation (GIZ) and undertaken by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in collaboration with Kenya Agricultural Research Institute (KARI), Kenya Meteorological Department (KMD), Zimbabwe Meteorological Department (ZMD), Midlands State University (MSU) and the Hamburg University of Applied Sciences (HAW) in Germany.

Using a combination of model-based *ex ante* analyses and iterative field-based research on station and in farmers' fields, the project has tested potential agricultural adaptation strategies for rainfed agriculture in the semi-arid and dry sub-humid tropics. This has been achieved through choosing four currently important crop production zones (two in Kenya and two in Zimbabwe) and then identifying corresponding 'spatial analogue locations' for each production zone, providing eight study locations in all. This book contains a set of chapters which describe some of the results achieved as part of the project.

The editors wish to thank the GIZ, the CALESA project partners, the Soil Science Society of East Africa (SSSEA) and the Africa Soil Science Society (ASSS), for their support to the conference, to the CALESA project and to this book. The ASSS and the SSSEA acknowledge, with appreciation, the efforts and contributions of the Kenyan government, Kenya Agricultural Research Institute (KARI), ICRISAT, the Alliance for a Green Revolution in Africa (AGRA), the National Commission for Science Technology and Innovations (NACOSTI), MEA Ltd, The International Atomic Energy Agency (IAEA), The Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), Africa Soil Health Consortium (ASHC), the International Union of Soil Science (IUSS), SANREM Innovation Laboratory of Virginia Tech, Australian Agency for

International Development (AusAID), the University of Sydney and the Joint Research Commission (JRC) of the European Union (EU) for supporting the conference.

Due to its scope, the actuality of the topic and its importance in documenting and promoting experiences of climate change adaptation in Africa, this book will provide timely assistance to the current and future adaptation efforts in the African continent.

Walter Leal Filho  
Anthony O. Esilaba  
Karuturi P.C. Rao  
Gummadi Sridhar



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**Conference at a Glance (MCH = Main Conference Hall; CH1 = Conference Hall 1; CH2 = Conference Hall2)**

Time	Monday 21	Tuesday 21	Wednesday 23	Thursday 24	Friday 25
8.00-10.00	<b>Session 1: MCH</b> Welcoming Ceremony	<b>Session 6: MCH</b> Official Opening Ceremony	<b>Field Excursion</b> Whole day	<b>Session 13A: MCH</b> Climate change	<b>Session 24: MCH</b> Land use
	Introduction/ Welcome Remarks	Official Opening of Conference/exhibition: Principal Secretary (PS), Ministry of Agriculture		<b>Session 16: CH1</b> Soil Biology <b>Session 20: CH2</b> Enhancing Applications of Adaptation and Mitigation to Climate change Variability and Change	<b>Session 26A: CH1</b> Integrated Nutrient Management <b>Session 27: CH2</b> Agronomy and Crop management
10.00-10.30	<b>Health Break</b>				
10.30-13.00	<b>Session 2:</b> Keynote Presentations: Setting the Scene	<b>Session 7: MCH</b> Key note Presentations: Setting the Scene		<b>Session 13B: MCH</b> Climate Change <b>Session 21: CH2</b> Integrated Nutrient Management	<b>Session 26B: CH1</b> Integrated Nutrient Management
				<b>Session 17: CH1</b> Organic resources	<b>Session 28: CH2</b> Agronomy and Crop management
13.00-14.00	<b>Lunch</b>				
14.00-16.00	<b>Session 3A: MCH</b> Enhancing Applications of Adaptation and Mitigation to Climate Change Variability and Change	<b>Session 8: MCH</b> Land Use <b>Session 12: CH2</b> Socioeconomics		<b>Session 14: MCH</b> Climate Change <b>Session 15: MCH</b> Crop Management <b>Session 18: CH1</b> Land Use <b>Session 19: CH1</b> Integrated Nutrient Management (INM) <b>Session 22: CH2</b> Integrated Nutrient Management (INM)	<b>Session 29:</b> Poster Session  <b>ASSS Business Meeting</b> <b>SSSEA Business Meeting</b>
		<b>Session 4: CH1</b> Integrated Nutrient Management		<b>Session 10: CH1</b> Soil Biology	
16.00-17.30	<b>Session 3B: MCH</b> Outreach and Partnerships, Farmers Forum & Exhibitions	<b>Session 11: CH1</b> Soil and Water Management		Session 23: CH2 Agronomy and ecosystem restoration	<b>Session 30: MCH</b> Closing Ceremony
	<b>Session 5: CH2</b> Crop/Soil Livestock Interactions	<b>Session 12B: CH2</b> Socio economics <b>Session 9: MCH</b> Launching Soil Atlas for Africa			
17.30-18.00	<b>Health Break</b>				



## PROGRAMME

<b>MONDAY 21 OCTOBER 2013</b>	
<b>Time</b>	<b>Event</b>
8.30 -9.00	Registration of Participants
<b>Session 1: WELCOMING CEREMONY</b>	
<b>Venue: Main Conference Hall</b>	
<b>Chairperson: Representative African Soil Science Society (ASSS)</b>	
<b>Rapporteur: Dr. Anthony Esilaba Chair, Soil Science Society of East Africa (SSSEA)</b>	
9.00 - 10.00	Introduction/Welcome: Chair, Soil Science Society of East Africa
	Remarks: Chair, African Soil Science Society
	Opening Remarks: Director, Kenya Agricultural Research Institute (KARI)
10.00-10.30	<b>HEALTH BREAK</b>
10:30-11:00	Media Briefing
<b>SESSION 2: KEY NOTE PRESENTATIONS: SETTING THE SCENE</b>	
<b>Venue: Main Conference Hall</b>	
<b>Chairperson: Dr. J. Wamuongo</b>	
<b>Rapporteur: A.O. Adaikwu</b>	
10.30-10:50	Enhancing Applications of Adaptation and Mitigation to Climate Change Variability and Change. <b>KPC Rao</b>
10.50-11.10	Exploring options for sustainable intensification and diversification of crop-soil-livestock systems in response to climate change. <b>Mureithi, J.G</b>
11.10-11.30	Tapping into agriculture to enhance agricultural intensification and diversification in Africa: the role of legacy of soils and farming systems research. <b>Prof. I. Odeh</b>
11:30-11:50	Developing Capacity to address Soil Health. <b>B. Jama</b>
11:50-12:10	Outreach and partnerships in Kenya. <b>Dr. Felister Makini</b>
12:10-1.00	<b>ROUND TABLE DISCUSSIONS</b>
<b>1.00 -2.00</b>	<b>LUNCH BREAK</b>
<b>SESSION3A. ENHANCING APPLICATIONS OF ADAPTATION AND MITIGATION TO CLIMATE CHANGE VARIABILITY AND CHANGE</b>	
<b>Chair: Dr. A. Esilaba</b>	
<b>Rapporteur: Dr. Kaizzi Kayuki</b>	
<b>Venue: Main Conference Hall</b>	
2.00 - 2.30	Keynote Presentation: Mitigation and adaptation of climate change: land and water management challenges. <b>Prof. J Gathenya</b>
2.30-2:42	Evaluation of rainfall data reconstruction techniques and variability indices in the drier zones of the central highlands of Kenya- <b>Kisaka O., Shisanya, C. and Makhoka, G. L.</b>
2:42-54	Influence of agro-climatic conditions and fertilizer use on different pest mite management options in cassava production. <b>Mutisya D.L., Khamala P.M., Kariuki C.W. and Banhawye E.M.</b>
2:54-3:06	Determinants of farmers' choice of technological options for adapting to climate variability: a case of eastern Uganda. <b>Kansiime K.M., Wambugu K.S. and Shisanya A.C.</b>
3:06-3:18	Drought mitigating technologies: an overview of cassava and sweet potato production in Mukuyuni division Makueni County in semi-arid Eastern Kenya. <b>Githunguri, C.M</b> and Amata R.
3:18-3:30	Situation analysis of climate change aspects in Kenya. <b>Nyamworo, S.O., Wamae, D.K., Kwena, K., Esilaba, A.O., Ndegwa, W., Matere, S.J., Wasswa, J.K., Ruttoh, R., Kibue, A.M</b>
3:30-3:12	Characterization of seasonal rainfall variability and drought probability of the semi arid areas of Mbeere region in Embu County, Kenya. <b>Kisaka O., Mucheru-Muna M., Ngetich, F.K., Mugwe J., Mugendi, D., and Mairura, F</b>
3:12-3:24	Effect of temperature and rainfall on maize growth and yield under different fertilizer (Urea, NPK, compost) application. a case study of Rubengera and Busogo sectors in respective western and northern provinces of Rwanda. <b>Disi D, Nahayoa and Ingabire N</b>



3:24-3:36	Green infrastructure for enhancing soil-water-plant nutrient balance and climate change adaptation on smallholder field. <b>Oku E. E.</b> and Aiyelari E. A.
3:30-3:45	<b>GENERAL DISCUSSION</b>
3:45-4.00	<b>HEALTH BREAK</b>
<b>Session 3B OUTREACH AND PARTNERSHIPS, FARMERS FORUM &amp; EXHIBITIONS</b>	
<b>Chair: County Director of Agriculture, Nakuru County</b>	
<b>Rapporteur: Purity Kaburu</b>	
<b>Venue: Main Conference Hall</b>	
4:00-5.00	Farmer Discussion Forum
5:00-6:00	Exhibitions

<b>DAY 1 MONDAY 21<sup>ST</sup> OCTOBER 2013</b>	
<b>SESSION 4. INTEGRATED NUTRIENT MANAGEMENT</b>	
<b>Chair: Dr. S. Koala</b>	
<b>Rapporteur: Dr. J. Lekasi</b>	
<b>Venue Conference Hall 1</b>	
Time	Presentation
2.00 - 2.30	Keynote Presentation: Integrated Soil Fertility management, current challenges and opportunities. <b>B. Vanlauwe</b>
2.30-2:42	Effects of urea and plant residue combinations on yield and yield components of maize under <i>Striga</i> infestation. <b>Nyambati R. O., Odhiambo G. D., Othieno C.O., Serem C.K.</b>
2:42-54	Yield and N use efficiency of five NERICA genotypes under different N levels in the moist savanna of South West Nigeria. <b>Aduramigba-Modupe, V.O.</b> Denton, O. A. Olanipekun S.and.Ojo A.O
2:54-3:06	Upland Rice Productivity and Nutrient Use Efficiencies under Varying Nitrogen (N), Phosphorus (P) and Moisture Regimes. <b>Bwire, P.S., Mulumba, L.M., and Tenywa, J.S.</b>
3:06-3:18	Response of Maize Crop to Sulphur in Ruvuma Region, Tanzania. <b>Malley, Z.J.U;</b> Mmari, W.N.; Marandu, A.; Ngailo, J. and Mzimhiri, M.
3:18-3:30	Impact of soil fertility management strategies in Kakamega County – the case of SO7 project in Western Kenya. <b>Onyango E.,</b> Mbakaya D., Mudeheri M , Odendo M and Ambitsi N.
3:30-3:12	Effect of different sources of phosphate rocks on wheat growth in Chepkoilel University College, Uasin Gishu County. <b>Serrem C.K.;</b> Ngunjiri M.W. and Okalebo J.R.
3:12-3:24	Farm stratification for targeting soil fertility management options in small holder farms in Central Kenya. <b>Kathuku A.N.,</b> Kimani, S.K., Esilaba, A.O., Okalebo, J.R.O. and Othieno, C.O.
3:24-3:36	Evaluation of soybean [Glycine max (L.)merr.] genotypes in central and North Rift Valley of Kenya. <b>Njoroge J.N.,</b> Owouche J.O. and Oyoo M.E.
3:30-3:45	The effect of soil nutrient intensification and omission regimes on maize yield in the southern rangelands of Makueni County in semi-arid eastern Kenya during the long rains. <b>Githunguri, C.M.</b> Esilaba A.O. Zingore, S., Kibunja, C, Thurairira, E.G., Gatheru, M., Omakwe, J.A. Ndwiga, E.N. and Anyanzwa, H.
3:45-3:57	<b>HEALTH BREAK</b>



<b>DAY 1 MONDAY 21ST OCTOBER 2013</b>	
<b>SESSION 5: CROP/SOIL LIVESTOCK INTERACTIONS</b>	
<b>Chairperson: Isabirye Moses</b>	
<b>Rapporteur: Ssesanga S.</b>	
<b>Venue: Conference Hall 2</b>	
<b>Time</b>	<b>Presentation</b>
2.00 - 2.30	Lead Paper: Sustainable intensification in mixed crop-livestock agro-ecosystems: the case for the guinea savannah zone of Ghana in the Volta Basin. <b>Kizito F.</b> , Bossio D., Sommer R., Ayantunde A., Akoto E., Danso A., Agyare W., Naminong K., Panyan E. and Quansah C.
2.30-2:42	Nutrient management practices for vegetable production in (47)smallholder crop-livestock farming systems in the peri-urban areas of semi-arid eastern Kenya. <b>Itabari J. K.</b> , Njarui D. M. G., Gatheru M. and Mutuoki T. K.
2:42-2:54	Increasing land productivity through optimum cattle stocking rates. <b>Irungu R.</b> , Kitilit J.K, Kariuki J.N. and Guliye A.Y.
2:54-3:06	Agropastoral mutation and poverty reduction in the north and south eastern slopes of Nkambe highlands, Cameroon. <b>Tsalefac Maurice</b> , Julius Tata Nfor, Umaru Buba, Achankeng Eric
3:06-3:18	Livestock, Banana and livelihoods: A case of banana and sedentary pastoralism in the western shoreline of L. Victoria, Uganda. <b>Isabirye Moses</b> , Mathias Magunda, Jean Poesen, Miet Maertens, Jozef Deckers
3:18-3:30	Characterizing access to climate information and services by the vulnerable groups in semi-arid Kenya. <b>Kirui V.C.</b> , Oseni S and Bebe B.O.
3:30-3:12	Potential of manure, lime and mineral p fertilizer for improve soil fertility and soybean yields on smallholder farmers in central highlands of Kenya. <b>Verde, B.S.</b> , Danga. B.O., Mugwe, J.N.
3:12-3:24	Effect of Mavuno and farm yard manure fertilizer application on soil properties in western Kenya. <b>Kamanga C S.</b> , Onwonga R. and Vanlauwe B.
3:24-3:45	<b>GENERAL DISCUSSION</b>
<b>3:45-4:00</b>	<b>HEALTH BREAK</b>

<b>PROGRAMME DAY 2: Tuesday 22 OCTOBER 2013</b>	
<b>Time</b>	<b>Event</b>
9:00-10:00	
<b>SESSION 6: OFFICIAL OPENING</b>	
<b>Venue: Main Conference Hall</b>	
<b>Chairperson: Representative, African Soil Science Society (ASSS)</b>	
<b>Rapporteur: Representative, Soil Science Society of East Africa (SSSEA)</b>	
9.00 - 10.00	Introduction/Welcome: Chair, Soil Science Society of East Africa
	Opening Remarks: Chair, African Soil Science Society
	Opening Remarks: Director, Kenya Agricultural Research Institute (KARI)
	Opening Remarks: Governor, Nakuru County
	Official Opening of Conference/exhibition: Principal Secretary (PS), Ministry of Agriculture
10.00-10.30	<b>HEALTH BREAK</b>
10:30-11:00	Media Briefing
<b>SESSION 7: KEY NOTE PRESENTATIONS: SETTING THE SCENE</b>	
<b>Venue: Main Conference Hall</b>	
<b>Chairperson: Dr Anne Muriuki</b>	
<b>Rapporteur: A.O. Adaikwu</b>	
10.30-10.50	The Role of Science, Technology and Innovations in the Promotion of Agricultural Productivity and Global Competitiveness. <b>Prof. Shaukat Abudulrazak</b> – CEO National Council of Science and Technology
10.50-11.10	Multistakeholder Platforms: Farmer Organizations and Value Chains <b>Dr. Mutunga</b> , KENFAP



11.10-11.30	Public-Private technology transfer partnerships in agriculture. <b>Eustace Muriuki</b> , MEA Ltd
11.30-11.50	Challenges of water management for agricultural production under threats of climate change. <b>Bancy Mati</b> , JKUAT
11.50-12.10	The 4R Stewardship: <b>Shamie Zingore</b> , International Plant Nutrition Institute (IPNI)
12:10-1.00	<b>ROUND TABLE DISCUSSIONS</b>
<b>1.00 -2.00</b>	<b>LUNCH BREAK</b>
<b>DAY 2 22 OCTOBER 2013</b>	
<b>SESSION 8: LAND USE</b>	
<b>Chair: Joy Tumuhairwe</b>	
<b>Rapporteur: P. Kamoni</b>	
<b>Venue: Main Conference Hall</b>	
2.00 - 2.18	Variation of nutrient content in soils of South Kivu, DR Congo. <b>Mulumuna-wa-Lola J.</b> , Walangululu J., Bashagaluke J., Pypers P., Vanlauwe B., and Boeckx P.
2:18-2:30	Capacity building on spectral diagnostic techniques for land health surveillance. <b>Weullow E.</b> , Sila A., Aynekulu E. and K Shepherd
2.30-2:42	Andosolization of soils on a Strombolian cone at mount Bambouto, Cameroon. <b>Jiomeneck P.S.T.</b> , Tematio P., Wilson A. and Yemefack M.
2:42-2:54	Multi-scale organization of the doumbouo-fokoué bauxites ore deposits (west Cameroon): implication to the landscape lowering. Momo M.N., <b>Tematio P.</b> and Yemefack M.
2:54-3:06	Effects of tillage, fallow and burning on selected properties and fertility status of andosols in the mounts Bambouto, west Cameroon. <b>Tematio P.</b> , Tsafack E.I. and Kengni L.
3:06-3:18	Evaluation of the most appropriate method in orographic rainfall data reconstruction of mbeere district using geographical information system tools for agricultural development. <b>Kisaka O.</b> , Ngetich K. F., Shisanya C. and Makhoka, S.
3:18-3:30	Pollution des eaux superficielles et des nappes en milieu urbain : cas de la zone industrielle de Douala-Bassa (Cameroun). <b>Kengni L.</b> , Tematio P., Rharrassi K. F, Tepoule Ngueke J., Tsafack E. I., Mboumi T. L. and Mounier E.S.
3:30-3:12	Soil and rainstorm sequence interactive effects on crust strength, steady state infiltration rate and erosion in quartz dominated soils in South Africa. <b>Wakindiki I.I.C.</b> and Nciizah A.D.
3:12-3:24	Status and variability of soil micronutrients with landforms in western Usambara mountains, Tanzania. <b>Meliyo J.L.</b> , Massawe B.H.J., Kimaro D.N., Msanya B.M., Hieronimo P., Deckers J.A Mulungu L.S., Kihupi N.I., and Gulinck, H.
3:24-3:36	Subsoiling and soil surface management effects on maize productivity in the central highlands of Kenya. <b>Mugendi D.N.</b> , Ngetich K.F., Mugwe J.N., Mucheru-Muna M., Shisanya C.A. and Diels J
3:30-3:45	<b>GENERAL DISCUSSIONS</b>
<b>3:45-3:57</b>	<b>HEALTH BREAK</b>
3:57-4:09	Effects of agricultural land uses on phosphorus fractions and aggregation of wetland soils in East Africa. <b>Kamiri H.</b> , Richarts H., Kreye C. and Becker M.
4:09-4:21	Soil organic carbon stocks at different elevations in the miombo woodlands of Kitonga forest reserve, Tanzania. <b>Shelukindo H. B.</b> , Semu E., Msanya B. M., Munishi P. K. T. and Singh B. R.
4:21-4:33	Characterization of some soils of the miombo woodlands ecosystem of Kitonga forest reserve, Iringa, Tanzania: physicochemical properties and classification. <b>Shelukindo H.B.</b> , Msanya B.M., Semu, E., Mwango S.B., Munishi P.K.T. and Singh B.R.
4:33-4:45	Diagnosis of sources of soil salinization in selected irrigation schemes in semi-arid lands of Taita Taveta County-Kenya. <b>Kathuli. P.</b> , J.K. Itabari, I.V Sijali, J. Gatuthu and S. Kiaura.
4:45-4:57	Soil information to support sustainable food security in Africa. <b>Leenaars J.G. B.</b> and Batjes N.H.
<b>4:57-5:15</b>	<b>GENERAL DISCUSSION</b>



<p><b>Day 2 22 October 2013 Launching Soil Atlas for Africa</b>  <b>Session 9: Land Use</b>  <b>Chair: Yamefack M</b>  <b>Rapporteur: Lenaars J.</b>  <b>Venue: Main Conference Hall</b></p>
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<b>5:15-6:00</b>	Launch and presentation on: Approach to translate the expected Global Soil Map product to soil classes on examples of major soils of Africa. Michéli, E., Láng, V., Márta, F.
<b>6:00</b>	<b>End of day</b>

<p><b>DAY 2 22 OCTOBER 2013. SESSION 10: SOIL BIOLOGY</b>  <b>Chairperson: Prof. Nancy Mungai</b>  <b>Rapporteur: Dr. Bagarama</b>  <b>Venue: Conference Hall 1</b></p>
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Time	Presentation
2.00- 2.30	Keynote Presentation: Soil Biology: Current challenges and opportunities. <b>Prof. Kimenju</b>
2.30-2:42	Improving shelf life of legume inoculants in East Africa. <b>Balume I.K.</b> , Keya S.O., Karanja N.K. and Woomer P.L.
2:42-2:54	Soil effective microorganisms as foul odor eliminator in pig production in Uganda. <b>Nkwiine C.</b> and Mbowa, A
2:54-3:06	Effect of land use intensification on earthworm abundance, biomass and soil impact index in Mabira tropical forest and adjacent farmlands, Uganda. <b>Nkwiine C.</b> , Tenywa J. S., Silver M. R, Okwakol M.N. and Kadu J. B.
3:06-3:18	Enhancing nitrogen fixation and productivity of dry bean genotypes in Phosphorus & Nitrogen limited areas of central Kenya highlands through <i>Rhizobium</i> , <i>azospirillum</i> rhizobacteria- <i>rhizobium</i> co-inoculation. <b>Muthamia J G. N.</b> , Kimani P.K., Cheminingw'a G., and Esilaba A.O.
3:18-3:30	Conservation agriculture effects on earthworm populations in western Kenya and eastern Uganda soils. <b>Oluko, P.S.</b> , Norton, B J., Okalebo J.R., Omondi, B. E., Shikuku D.S., Kisinyoa P.O.
3:30-3:12	Enhancing biological nitrogen fixation in climbing beans growing on acidic soils of Rwanda. <b>Damascene N. J.</b> , Tumuhairwe J.B. and Vicky R.
3:12-3:24	Evaluation of four inoculants to assess biological nitrogen fixation on soybean varieties in acid soil of Rwanda. <b>Nzeyimana F.</b> , Tumuhairwe J. B. and Ntabahungu I.
3:24-3:36	Performance of potato ( <i>Solanum tuberosum</i> ) inoculated with rhizobacteria and arbuscular mycorrhiza fungi (amf) dual inoculants in control of bacterial wilt ( <i>Ralstonia solanacearum</i> ). <b>Aguk, J.A.</b> , Karanja, N.K., Schulte-Geldermann, E., Kinyua, Z. and Jefwa, J.
<b>3:30-3:45</b>	<b>GENERAL DISCUSSION</b>
<b>3:45-3:57</b>	<b>HEALTH BREAK</b>

<p><b>SESSION 11: SOIL AND WATER MANAGEMENT</b>  <b>Chair: Cyrus Githunguri</b>  <b>Rapporteur: Peterson Njeru</b>  <b>Venue: Conference Hall 1</b></p>
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3:57-4:09	Underground water management and pollution threats in dry season vegetable growing in Tabora, Tanzania. <b>Fabian M. Bagarama</b> ; Revelina R. and Victor Kongo
4:09-4:21	Status review of the adopted soil and water management technologies in Kenya as a critical component of the environment. <b>Ouma E N.</b> , Rop S. and Okoba B.
4:21-4:33	Soil physical and hydrological properties modifications under <i>Arachis</i> species in Ibadan southwestern Nigeria. <b>Oluwasemire K. O.</b> and Fademi I. O.
4:33-4:45	Screening of <i>Dioscorea alata</i> genotypes for drought tolerance. <b>Odoh, N.</b> , Lopez-Montes, A., Oluwasemire K., Abaidoo, R. and Asiedu, R.
4:45-4:57	(Effect of tillage practices on soil moisture and selected soil physical properties in maize-bean intercropping systems in Mwala district, Kenya. <b>Karuma A.N.</b> , Mtakwa P.W., Amuri N. and Gachene C.K.K.



4:57-5:15	<b>GENERAL DISCUSSIONS</b>
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<b>DAY 2 22 OCTOBER 2013</b>	
<b>SESSION 12A: SOCIO-ECONOMICS</b>	
<b>Chairperson: Nyamwaro, S.O.</b>	
<b>Rapporteur: Ngailo, J.A.</b>	
<b>Venue: Conference Hall 2</b>	
<b>Time</b>	<b>Keynote Presentation</b>
2.00 - 2.18	The eastern and southern Africa country level soil health consortia. <b>Mutegi J.</b> , Zingore S., Harawa R. and Jama B.
2:18-2:30	Policy Brief: Ensuring food security by promoting uptake and scaling up the application of agricultural lime to combat soil acidity in Kenya. <b>Kimani S. K.</b> , Kihanda F.M., Mbakaya D.S., Miriti J.M., Lekasi J.K and Njeru P.N. M .
2.30-2:42	Critical analysis of policy related documents in the context of integrated land and water management in Kenya. <b>Matiri FM.</b> , Kagunyu A.W. and Kizito K.
2:42-2:54	Characterizing access to climate information and services by the vulnerable groups in semi-arid Kenya. <b>Viola Cherotich Kirui</b> , Saidu Oseni, Bockline Omedo Bebe
2:54-3:06	An assessment of gender sensitive adaptations options to climate change in smallholder areas of Zimbabwe, using climate analogue analysis and considering farmer perceptions. <b>Musiyiwa K.</b> , Filho W.L., Nyamangara J. and Harris D.
3:06-3:18	Analysis of analytical tools for climate change impacts on agriculture in Kenya. <b>Matere S. J.</b> , Kwena K., Nyamwaro S.O., Esilaba A.O., Ndegwa W., Wamae D.K., Kuyiah J.W., Ruttoh R., and Kibue A.M.
3:18-3:30	Analysis of technical efficiency of sorghum production in lower Eastern Kenya. <b>Chepng'etich E.</b> , Nyamwaro S. O., Bett E K. and Kizito K.
3:30-3:12	Climate change adaptation and agricultural development planning in Kenya. <b>Kuyiah J. W.</b> , Kwena K., Esilaba A.O., Nyamwaro S.O., Matere S.J., Ndegwa W., Wamae D.K., Ruttoh R. and Kibue A.M
3:12-3:24	Determinants d'utilisation de la fumure organique face a la baisse de la fertilité des sols dans la region semi-aride de Kibwezi au Kenya. <b>Sale A.</b> , Folefack D.P., Obwoyere O., Lenah N., Lenzemo W.V. and Wakponou E A.
3:24-3:36	Factors affecting integrated water management practices in Mwanja and Kaliu watershed in Machakos and Makindu. <b>Kagunyu A.W.</b> , Matiri F.M. and Kizito K.
3:30-3:45	<b>GENERAL DISCUSSION</b>
3:45-3:57	<b>HEALTH BREAK</b>
<b>Day 2, 22 October 2013</b>	
<b>SESSION 12B SOCIO-ECONOMICS</b>	
<b>Chairperson: Davies, Harris</b>	
<b>Rapporteur: Kathuli, P.</b>	
<b>Venue: Conference Hall 2</b>	
3:57-4:09	Farmers' risk perceptions and adaptation to climate change in Lichinga and Sussundenga, Mozambique. <b>Chichongue O.J.</b> , Karuku, G.N., Mwala, A.K. and Onyango, C.M.
4:09-4:21	Food security, a case of maize production in Kandara sub-county, Murang'a County. <b>Kamoni P.T.</b> , Kimigo J., Kibunja C.N., Esilaba A.O. and Gathaara V.N.
4:21-4:33	Gender dynamics influencing adoption of integrated watershed management technologies: the case of lower eastern Kenya. <b>Karanja-Lumumba T.</b> , Nyamwaro S., Ogama S. and Kizito K.
4:33-4:45	Smallholder farmers decision to adopt and utilize isfm technologies in Tororo district, Uganda. <b>Kasande G.</b>
4:45-4:57	Smallholder farmers' use and profitability of legume inoculant in western Kenya. <b>Mutuma S.P.</b> , Okello.J., Karanja N. and Woomer P.
4:57-5:15	<b>GENERAL DISCUSSION</b>

**DAY 3, 23 October 2013: FIELD EXCURSION**
**Route 1: KARI Perkerra and the National Irrigation Board Scheme through Mogotio for viewing of soil profile pit and classification**
**Route 2: Early visit to Lake Nakuru National Park and later to MEA Ltd. Fertilizer Plant**
**DAY 4 24 OCTOBER 2013**
**SESSION 13A: CLIMATE CHANGE**
**Chairperson: Maina Muniafu**
**Rapporteur: Nketia, Yeboah**
**Venue: Main Conference Hall**

Time	Presentation
8:30-9:00	TBD
9:00-9:12	Opportunities for coping with climate variability: a case of Mwanja and Makindu watersheds in lower Eastern Kenya. <b>Kalungu, W.J.</b> , K.P.C. Rao and Kwena Kizito
9:12-9:24	Exploring gender dynamics on perception of climate change on farming with focus groups in Machakos and Makueni counties, Kenya. <b>Wanzuu K J.</b> , Leal Filho W and Harris D
9:24-9:36	Improving livelihoods in semi-arid regions of Africa through reduced vulnerability to climate variability and promotion of climate resilience. <b>Kimani, S.K.</b> A.O. Esilaba S. Koala, J.M. Miriti J.K. Lekasi, P.N. M. Njeru
9:36-9:48	Integrating indigenous and conventional knowledge-based seasonal climate forecasts for farmers enhanced adaptation to climate variability in Tharaka-Nithi and Kitui counties. <b>Mugi E.W.</b> , Ngetich F.K., Muna M.W., Mugwe J.N., Mugendi D.N. and Mairura F.
9:48-10:00	Climate change adaptation planning in Kenya. Do scientific evidences really count? <b>Kwena, K.</b> , Ndegwa W., Esilaba, A.O., Nyamwaro, S.O., Wamae, D.K., Matere, S.J., Ruttoh, R. And Kibue, A.M.
10:00-10:12	Vulnerability to climate variability for agriculture systems in semi arid Kenya. <b>Ndegwa, W.</b> , Ngugi, R.K and Laishena, J.
10:12-10:24	Adaptation measures initiated by farmers due to climate change in India. <b>Shivamurthy, M.</b> Shankara, M.H., Rama Radhakrishna and Chandrakanth, M.G
10:24-10:45	<b>GENERAL DISCUSSION</b>
10:45-11:05	<b>HEALTH BREAK</b>

**DAY 4, 24 OCTOBER 2013**
**Session 13B: CLIMATE CHANGE**
**Chairperson: Jayne Mugwe**
**Rapporteur: Otim Maclean**
**Venue: Main Conference Hall**

11:05-11:17	Characterization of climate risks in dryland crop-livestock systems of Kenya. <b>Okwuosa E. A.</b> , Okoti M.O., Njeru C.M., Kitiem P., Macharia P., Mwaura J., Kaguthi E., Mwangangi B. and Wamuongo J. W
11:17-11:29	Opportunities for coping with climate variability: a case of Mwanja and Makindu watersheds in lower eastern Kenya. <b>Wangu L.</b> , Rao K.P.C. and Kizito K.
11:29-11:41	Effect of rooting depth, plant density and planting date on maize yield and water use efficiency in semi-arid Zimbabwe: modelling with AquaCrop. <b>Nyakudya, I.W.</b> and Stroosnijder Leo
11:41-11:53	Generating location specific future climates to assess impacts of climate change on agricultural systems. <b>Oyoo, A.</b> , Rao K.P.C. and Wangu L.
11:53-12:05	In-situ soil moisture conservation: utilization and management of rainwater for crop production. <b>Kathuli P.</b> and Itabari J.K.
12:05-12:17	Critical analysis of tillage practices with fertility levels in maize and populations in beans as adaptation measures to climate change to enhance food security at Kabete. <b>Onyango, J.W.</b> A.O. Esilaba, KPC Rao
12:17-12:29	Experimenting with smallholder communities for climate change adaptation in EastAfrica. Bajjukya, F. P. Kayuki C. K., and Shimwela Mpoki



12:29-12:41	On - station evaluation of maize genotypes for nutrients and water use efficiency in the semi arid lands of coastal Kenya. <b>Pole F.N.</b> , Saha H.M., Mangale N., Mzingirwa A.M. and Munyambu P.
12:41-13:02	<b>GENERAL DISCUSSION</b>
13:02-14:02	<b>LUNCH</b>

**DAY 4, 24 OCTOBER 2013**

**SESSION 14: CLIMATE CHANGE**

**Chair: C. K. Serem**

**Rapporteur: Nsubuga Benard**

**Venue: Main Conference Hall**

Time	Presentation
2.00 - 2.30	Impacts of climate change on performance of agricultural systems. <b>Rao K.P.C.</b> , Njiru E., Wafula B., Onyango J. and Esilaba A.O.
2.30-2:42	Adoption of water resource conservation under fluctuating rainfall regimes in Ngaciuma/Kinyaritha watershed, Meru County, Kenya. <b>Mutuma E.</b> , Mahiri O. and S. Murim
2:42-2:54	Aerobic Method of Rice Production: A Promising Cropping System for Improving Water Quality and Environment in Watersheds. <b>Shivamurthy, M.</b> Venkatesh Gandhi, R and Shailaja Hittalmani
2:54-3:06	The potential of sugarcane farming as a Climate Smart Agriculture in Jinja District, Uganda. <b>Nsubuga G.</b> , and Isabirye Moses
3:06-3:18	Effects of selected soil water conservation strategies on maize yield through farmer managed trials in the central highlands of Kenya. <b>Kiboi M.N.</b> , Muna M.W., Ng'etich F. K, Mugwe J.N., Mugendi D.N. and Wambugu. S
3:18-3:30	Effects of glyphosate based herbicide on weed management and maize performance under zero tillage conservation agriculture system in eastern Kenya. <b>Micheni A.</b> , Kihanda F., Kanampiu F. and Rimui M.
3:30-3:12	Enhancing food production in semi arid coastal lowlands Kenya through water harvesting technologies. <b>Muli M.B.</b> , Musila R. and Mzingirwa A
3:12-3:24	Integration of indigenous knowledge in agricultural information and communication systems for adaptation to climate change by smallholder farmers of coastal Kenya. <b>Achiando G. A.</b> and Birech R.
3:24-3:36	Potentials of organic fertilizers in climate change mitigation. <b>AyanfeOluwa O. E.</b> , AdeOluwa O. O. and Duramigba-Modupe V.O.
3:30-3:45	<b>GENERAL DISCUSSIONS</b>
3:45-3:57	<b>HEALTH BREAK</b>

**DAY 4 24 OCTOBER 2013: SESSION**

**15: CROP MANAGEMENT**

**Chair: Pierre S. Tsopjio**

**Rapporteur: J. Muthamia**

**Venue: Main Conference Hall**

3:57-4:09	Effect of types of fertilizers on soil chemical properties and yield of tomato ( <i>Lycopersicon lycopersicon</i> ) in alfisol, southwestern Nigeria. <b>Ayeni, L. S</b>
4:09-4:21	Effects of farmyard manure and mineral fertilizers on maize yield and soil properties in two districts of Rwanda. <b>Munyabarenzi I.</b> , Mochoge, B.E and Nabahungu L.
4:21-4:33	Enhancing soybean yields by increasing plant-available phosphorus through use of organic and inorganic sources. <b>Julius Murumba</b> , J. S. Tenywa, Ateenyi Twaha A. Basamba
4:33-4:45	African traditional vegetables as agents of isfm-clotalaria and amaranth farming. <b>Malala A.M.</b> , Kwena M.O and Muniafu M.M
4:45-4:57	Response and phosphorus utilisation efficiency by groundnut genotypes on fields of varying soil fertility in northern Uganda. <b>Othieno, A. P.</b> Ebanyat, & G. Olupot
4:57-5:15	<b>GENERAL DISCUSSION</b>

<b>DAY 4: 24 OCTOBER 2013</b>	
<b>Session 16: SOIL BIOLOGY</b>	
<b>Chair: Tematio Paul</b>	
<b>Rapporteur: Stella Matere</b>	
<b>Venue: Conference Hall 1</b>	
<b>Time</b>	<b>Presentation</b>
8:30-9:00	<b>Keynote Address:</b> Delivering BNF Technologies to Kenyan Small-Scale Farmers <b>Paul L. Woomeer</b>
9:00-9:12	Experimenting with smallholder communities for climate change adaptation in East Africa. <b>Baijukya, F.P.</b> Kayuki C. K., and Shimwela M.
9:12-9:24	Tillage Effects on Biological Nitrogen Fixation and Soybean Grain Yields in Western Kenya. Okoth, J.O., Nancy W. Mungai, Josephine P. Ouma, Fredrick P. Baijukya Influence of compost use on soil nutrients and maize yield in soils of western Kenya. <b>Mbau, S. K.</b> , Ayuke, F.O., Karanja, N. K.
9:24-9:36	Effectiveness of promising commercial bio-fertilizers on soybean production in Bungoma county, western Kenya. <b>Majengo C .O.</b> ; Okalebo, J.R.; Ng'etich W.; Mburu M.W.; Mutua, S.; Mutegei, E. and . Lesueur, D.
9:36-9:48	Diversity of soil invertebrate macro- fauna and their relationships with soil physiochemical properties in oil palm plantations in Bugala Island Kalangala , Uganda. <b>Isiko N. A., Sekyewa C. and Nkwiine C.</b>
9:48-10:00	Effect of Rhizobia inoculation and phosphorus on nodulation and yield of soybean ( <i>Glycine max</i> L merril) in central highlands of Kenya. <b>Ndung'u A.M.</b> , Mugwe J.N. and Mucheru M-Muna
10:00-10:12	Influence of phosphorus fertilized desmodium species on <i>S.hermonthica (del.) benth</i> seed germination and viability. <b>Ogola A.H.</b> , Odhiambo G.D., Okalebo J.R. and Muyekho F.
10:12-10:24	Bacterial diversity in Lake Nakuru and their potential utilization in agriculture and environment management. <b>Wanjohi, L.W.</b>
10:24-10:45	<b>GENERAL DISCUSSION</b>
10:45-11:05	<b>HEALTH BREAK</b>
<b>DAY 4: 24 OCTOBER 2013</b>	
<b>SESSION 17 ORGANIC RESOURCES</b>	
<b>Chair: J.B. Tumuhairwe</b>	
<b>Rapporteur: Mutuma, E.</b>	
<b>Venue: Conference Hall 1</b>	
<b>11:05-11:17</b>	Enhancing decomposition and improving the quality of rice straw compost and its response on lowland rice in Rwanda. <b>Hakizimana Crispin.</b> , John Baptist Tumuhairwe and Mambani Banda Pierre
<b>11:17-11:29</b>	Influence of compost use on soil nutrients and maize yield in soils of western Kenya. <b>Mbau, S. K.</b> , Ayuke, F.O., Karanja, N. K.
<b>11:29-11:41</b>	Interactive effects of soil amendments on soil exchangeable Aluminium and pH of an acid Mollic Andosol. <b>Lelei J. J.</b> and Onwonga R N.
<b>11:41-11:53</b>	Improving soil fertility using organic fertilizers in central Kenya. <b>Kathuku A. N.</b> , Kimani, S.K. Okalebo J.R. and Othieno C. O.
<b>11:53-12:05</b>	Decomposition rates and nutrient release patterns of <i>Tephrosia vogelii</i> and <i>Tephrosia candida</i> residues in Malawi. <b>Munthali, M. G</b> , Gachene, C.K. K, Karanja, N.K. and Sileshi, G. W.
<b>12:05-12:17</b>	Soil properties and crop yields under residues management of planted fallows on ultisols in Cameroon. <b>Kaho F.</b> , Yemefack M., Yongue-Fouateu R., Bilong P. and Amang-Abang J.
<b>12:17-12:29</b>	Scientific validation of farmers' perception of weed community distribution as indicators of soil quality in Uganda. <b>Tumuhairwe J K.</b> , Tenywa J. S. and Karuhanga M.
<b>12:29-12:41</b>	Soil fertility improvement using crop residues and azolla for sustainable production of rice and fish in irrigated rice-fish farming system in the Lake Victoria basin of Kenya. <b>Serrem C.K.</b> Nge'tich W.K. and Kemei M.K.
<b>12:41-13:02</b>	<b>GENERAL DISCUSSION</b>
<b>13:02-14:02</b>	<b>LUNCH</b>

<b>DAY 4: 24 OCTOBER 2013</b>	
<b>SESSION 18 LAND USE</b>	
<b>Chair: F. Baijukya</b>	
<b>Rapporteur: J. Gitari</b>	
<b>Venue: Conference Hall 1</b>	
<b>Time</b>	<b>Presentation</b>
2.00 - 2.15	Lead Paper: Soil conservation through sediment trapping: A review. <b>Mulatie M.</b> , Saskia D. Keesstra, Jantiene EM Baartman, Leo Stroosnijder
2:15-2:30	The potential of urea-treated fecal material in crop improvement. <b>Onesmus Semalulu</b> , Emery Yaolema Sindani, and Karsten Gjeffe
2.30-2:42	Influence of crop rotation, fertilization and tillage on infestation of roots of sorghum ( <i>Sorghum bicolor</i> ) by <i>Pratylenchus brachyurus</i> . <b>Mamoudou T.</b>
2:42-2:54	Effects of glyphosate based herbicide on weed management and maize performance under zero tillage conservation agriculture system in eastern Kenya. <b>Micheni A.</b> , Kihanda F., Kanampiu F. and Rimui M.
2:54-3:06	The hydrology of Wakitundu wetland , Uganda. <b>Antayung O.</b>
3:06-3:18	Assessment of dry season water management and soil temperatures in green maize and tomato production in Tabora, Tanzania. <b>Bagarama F.M.</b>
3:18-3:30	Participatory GIS in the lower Tana river forest complex. <b>Kathumo V.M.</b> , Gachene C.K.K., Gicheru P.T. and Kariuki P. C.
3:30-3:12	Socioeconomic factors and soil quality assessment in the rice farming systems in southern highlands of Tanzania. <b>Ngailo J.A.</b> , Mmari W.N., Malley Z.J.U., Kyando L.S., and Mwalukasa N.
3:12-3:24	Land holding and households' probabilities of adopting monoculture in Uganda. <b>Mwaura, F.</b>
3:24-3:36	Mineral and geochemical characterization of the weathering mantle derived from norites in Kekem (West Cameroon): evaluation of the related mineralization. <b>Tematio P.</b> , Kombou Nina Aurelie, Kengni Lucas, Nguetnkam Jean Pierre, and Kamgang-Kabeyene Véronique
3:36-3:48	<b>GENERAL DISCUSSIONS</b>
3:48-3:57	<b>HEALTH BREAK</b>
<b>DAY 4 24 OCTOBER 2013</b>	
<b>SESSION 19 INTEGRATED NUTRIENT MANAGEMENT (INM)</b>	
<b>Chair: Prof. Semoka</b>	
<b>Rapporteur: Alfred Micheni</b>	
3:57-4:09	Scale-up of soybean production in Rwanda to achieve improved livelihoods for farmers and improved soil fertility. <b>Uwimana I.</b>
4:09-4:21	Basal fertilizer effects on the development of the rhizosphere of rainfed rice in relation with vegetative growth and yield in mid-season drought-prone environment. <b>Kouamé René N'ganzoua</b> , Brahim Koné, Ettien Jean Baptiste, Yao-Kouamé Albert, Koné Daouda, Camara Mameri
4:21-4:33	Soil fertility and maize yields decline and options for replenishment for <i>Mollic Andosol</i> in Nakuru County. <b>Mwangi, H. G.</b> , Mugwe, J.N., Ngetich F.K., Maina M.P.D, Njeru P.N.M., and Njuguna M.N.
4:33-4:45	Diagnostic 'best-bet' soil fertility management technologies for potato production in nyandarua county in central Kenya. <b>Lekasi, J. K.</b> , Kimani, S. K., Njeru, P.N.M. and Miriti, J.M.
4:45-4:57	The African Soil Information Service (AFSIS) project on integrated soil fertility management, Kenya. <b>Esilaba, A.O.</b> , Kibunja, C., Kamoni, P.T., Kathuku, A.N., Mugambi, C.N., Ashiono, G., Gathaara, V.N., Kimigo, J., Adolwa, S., Githunguri, C., Radiro, M.P.O., Odendo, M., Onyango, E., Ogallo, F., A. Chek, A., Kibe, P.K., Etyang, T., Nambiro, E., Kihara, J.M., Huising, J. Zingore, S. and Okoth, P.
4:57-5:15	<b>General Discussion</b>

<b>DAY 4 24 OCTOBER 2013</b> <b>SESSION 20. ENHANCING APPLICATIONS OF ADAPTATION AND MITIGATION TO CLIMATE CHANGE VARIABILITY AND CHANGE</b> <b>Chair: Francis Kihanda</b> <b>Rapporteur: Onesmus Ssemalulu</b> <b>Venue: Conference Hall 2</b>	
Time	Presentation
8:30-9:00	CALESA: Adapting agriculture to climate change: Developing promising strategies using analogue locations in Eastern and Southern Africa. Leal W., Mannke F. and Trincheria I
9:00-9:12	Hypothesis of Hope revisited: Consequences of climate change for rural households' agricultural income. Harris D
9:12-9:24	Grain yield of selected crops at four climate analogue locations in Zimbabwe. Nyamangara J., Masvaya E.N., Tirivavi R., MunoDawafa A. and Harris D.
9:24-9:36	Rice husk and <i>typha australis</i> biochar improve water stress tolerance and yield of millet in Senegal. <b>Faye A.L.</b> , Wangolen, F.L., Belko, N.L. Asubonteng K.O., Togor, E.C., and Cisse, N.L.
9:36-9:48	Vulnerability and adaptation to climate change: A case of farmers in Namasagali Sub County, Kamuli district. <b>Munyagwa Frank</b> and Isabirye Moses
9:48-10:00	Climate change impacts and coping/adaptation strategies in Yatta district, Machakos County in semi-arid eastern Kenya. <b>Gatheru, M.</b> , Gichangi, E. M., Njiru, E.N. and Mungube, E.O
10:00-10:12	Enhancing food production in semi arid coastal lowlands Kenya through water harvesting technologies. <b>Muli M.B.</b> , Musila R. and Mzingirwa A.
10:12-10:24	Stakeholders' diverging interests and emerging resource use conflicts in apiculture in West Usambara Mountains, Tanzania. <b>Kimaro, D.N.</b> ; Sinyangwe J.; Mbeyale, G.E.; Kajembe, G.C. and Mogaka, H.
10:24-10:45	<b>GENERAL DISCUSSION</b>
10:45-11:05	<b>HEALTH BREAK</b>
<b>DAY 4 24 OCTOBER 2013</b> <b>SESSION 21 INTEGRATED NUTRIENT MANAGEMENT</b> <b>Chair: C. N. Kibunja</b> <b>Rapporteur: Mucheru-Muna M.</b> <b>Venue: Conference Hall 2</b>	
11:05-11:17	Upland rice response to fertilizer in Uganda. Kaizzi, K.C. Byalebeka, J. Semalulu, S. Alou, I., Williams Zimwanguyizza, Angella Nansamba, Emanuel Odama, and Charles s. Wortmann
11:17-11:29	The effects of application of integrated soil fertility management technologies on yields and benefits of beans in Kagera Region, Tanzania.. Merumba, M.S., Ndyetabula, I, Nkuba, J.M. William, M.M., Mukandala, I. Sayi, B., Mushongi, C.C., and Shmwela, M.
11:29-11:41	Evaluation of soils in south western Nigeria for response to single super phosphate fertilizer under screen-house conditions. Anetor , M. O., Omueti, J.A.I. and Oluwasemire, K.O.
11:41-11:53	Adapting resource use efficient methods into integrated soil fertility management for maize production in Tabora, Tanzania. <b>Bagarama, F.</b> , Majule, A.E. , Masibuka, K.C.
11:53-12:05	Soil chemical properties as influenced by organic inputs and mineral fertilizer in Mbeere District, Kenya. <b>Mucheru-Muna M.W.</b> , Ngetich F., Mugendi D.N., Mugwe J.N., Vanlauwe B., Diels J. and Merckx R
12:05-12:17	Response of orange fleshed sweet potato to arbuscular mycorrhizal fungi inoculation and fertilizer application in western Kenya. <b>Kundu C. A.</b> , Karanja N. K., Jefwa J., Ndolo P. J. and Mwangi E.
12:17-12:29	The use of phosphate solubilising rhizobia as ISFM technology tools in the agro ecological zone IV of Cameroon. <b>Fankem H.</b> , Ngo Nkot L., and Bahiha B. A. Makon P.C.
12:29-12:41	Bacterial diversity in Lake Nakuru and their potential utilization in agriculture and environment management. <b>Wanjohi L. W.</b>
12:41-13:02	<b>GENERAL DISCUSSION</b>
13:02-14:02	<b>LUNCH</b>

<b>DAY 4 , 24 OCTOBER 2013</b> <b>SESSION 22 : Integrated Nutrient Management</b> <b>Chair: Nesbert Mangale</b> <b>Rapporteur: John Munyoli Musyoka</b> <b>Venue: Conference Hall 2</b>	
Time	Presentation
2.00 - 2.18	Response of rice to different levels of nitrogen from urea and lablab in a sandy clay loam soil in Morogoro, Tanzania. <b>Mzimiri M. K.</b> , Ikerra S. T. and Semoka J. R. M.
2:18-2:30	Soil Properties and Yam Performance As Influenced By Poultry Manure and Tillage on An Alfisol In Southwestern Nigeria. <b>Adeleye, E.O.</b>
2.30-2:42	Ameliorating aluminium toxicity in soybean ( <i>Glycine max</i> (L.) merril) production with combinations of fertilizer materials on an alfisol in south – western Nigeria. <b>Adegoke, J.O.</b> and E.A.
2:42-2:54	Exploring the effects of application of integrated soil fertility management technologies (ISFM) on yields and benefits of improved cassava and sweet potato variety in Kagera region, Tanzania. <b>Merumba M. S.</b> , Ndyetabula I. L., Nkuba J. M., William M. M., Mukandala L., Sayi B., Mushongi C.C. and Shimwela M.
2:54-3:06	Maize growth response and phosphorus availability following busumbu phosphate rock application in a desmodium- maize rotation system. <b>Kifuko-Koech, M.N.</b> , J.R. Okalebo, C.O. Othieno, B.Vanlauwe, P. Pypers Maize.
3:06-3:18	Comparative effects of organic and inorganic phosphorus sources on maize yields at two acidic sites in western Kenya. <b>Opala P.A.</b> and Okalebo J.R., Othieno C.O. and Nyambati R.O.
3:18-3:30	How 50 years of organic and mineral fertilization regimes on lxisol affect soil P availability and symbiotic N <sub>2</sub> fixation in sorghum-cowpea rotation? <b>Delwendé I. K.</b> , Ouakoltio Traore, Y.A., Oberson, A. Lompo, F. Papaoba Michel SEDOGO, Emmanuel FROSSARD
3:30-3:12	Performance testing for soil laboratories as a contribution to soil fertility characterisation in southern highlands. <b>Ngailo, J.A.</b> ; Z.J.U Malley; R.L Mwamila and L. Kyando
3:12-3:24	The effects of application of integrated soil fertility management technologies (isfm) on yields and benefits of maize in Kagera region, Tanzania. <b>Merumba M.S.</b> , Ndyetabula I.L., Nkuba J.M., William M.M., Mukandala L., Sayi B., Mushongi C.C. and Shimwela M.
3:24-3:36	On - station evaluation of maize genotypes for nutrients and water use efficiency in the semi arid lands of coastal Kenya. <b>Pole F.N.</b> , Saha H.M., Mangale N., Mzingirwa A.M. and Munyambu P.
3:30-3:45	<b>GENERAL DISCUSSION</b>
3:45-3:57	HEALTH BREAK
<b>DAY 4, 24 OCTOBER 2013</b> <b>SESSION 23 AGRONOMY AND ECOSYSTEM RESTORATION</b> <b>Chair: Malley, Z.U.</b> <b>Rapporteur: Munyagwa Frank</b> <b>Venue: Conference Hall 2</b>	
3:57-4:09	Tillage and crop rotation effects on structural properties of two sandy clay loam soils in Zanyokwe irrigation scheme, South Africa. <b>Njaimwe A. N.</b> , Mnkeni P. N.S., Muchaonyerwa P and Wakindiki I.
4:09-4:21	Soybean yield response to fertilizer, manure and lime application in western Kenya <b>Wafula E. W.</b> , Chemining'wa G. N., Karanja N., Zingore S and Baijukya F.
4:21-4:33	The effect of beekeeping on vegetation restoration and conservation of degraded water sources and riverbanks in the west Usambara, Lushoto, Tanzania. <b>Mbeyale, G.E.</b> , Kimaro, D.N., John R., Pima, E. N and Kajembe, G.C.
4:33-2:45	State of Sahelian ecosystem in two villages in the Maradi region (Niger). <b>Savadogo Ouango</b>
4:45-4:57	Soil fertility evaluation for coffee ( <i>Coffea arabica</i> ) in hai and Lushoto districts, northern Tanzania. <b>Maro G.P.</b> , Mrema J.M., Msanya B.M. and Teri, J.M.
4:57-5:15	<b>GENERAL DISCUSSION</b>

**DAY 5 25 OCTOBER 2013**  
**SESSION 24: LAND USE AND CROP MANAGEMENT**



<b>Chair: P. Macharia</b>	
<b>Rapporteur: Kwena Kizito</b>	
<b>Venue: Main Conference Hall</b>	
<b>Time</b>	<b>Presentation</b>
<b>8:30-8:45</b>	Understanding the potential of tree tomato production in eastern Kenya for improved nutrition and food security. <b>Muriithi C.</b> , Matiri F., Kihanda F., Maina D. and Kasungu F.
<b>8:45-9:00</b>	The potential of cane cultivation as a clean development mechanism: exploring carbon sequestration at Kakira sugar estate, Uganda. <b>Sekajugo John</b> , Isabirye Moses and Raju D.V.N
<b>9:00-9:12</b>	Tillage and fertilizer effects in sole rice cropping in a degraded Nigerian Alfisol. <b>V.O. Aduramigba-Modupe</b> , O. J. Idowu and S. Olanipekun
<b>9:12-9:24</b>	Resource use efficiency in rice based farming systems: A case of Upland and Paddy Rice in Namasagali Sub-county Kamuli district. <b>Mabiriizi Julius</b>
<b>9:24-9:36</b>	Optimum crop enterprise combination in sugarcane based farming systems: A case of sugarcane and maize in Busedde Sub-county, Jinja district, Uganda. <b>Nsubuga Benard</b>
<b>9:36-9:48</b>	The Influence of some Soil Properties on the Growth Performance of <i>Tectona grandis</i> in Benue State. <b>A.O Adaikwu</b> and Ihuma, J.O
<b>9:48-10:00</b>	Characterization and Classification of Soils of Selected Areas in Benue State Southern Guinea Savanna of Nigeria. <b>Adaikwu A.O.</b> and Ali, A.
<b>10:00-10:12</b>	Use of the EM38 as a decision support tool for the identification of high yielding areas for the placement of pivots for rice cultivation. <b>Parigiani, J.</b> , Mohammed, K.M.
<b>10:12-10:24</b>	Utilization of plant health clinic (PHC) innovation for sustainable crop production in Embu county, central Kenya. <b>Murithi. C.</b> , F. Kihanda., Kinyua Z., Matiri F., Wanyoike T., Maina D. and Amboga S.
<b>10:24-10:45</b>	<b>GENERAL DISCUSSION</b>
<b>10:45-11:05</b>	<b>HEALTH BREAK</b>
<b>DAY 5 25 OCTOBER 2013</b>	
<b>SESSION 25: SOCIO-ECONOMICS</b>	
<b>Chair: M. Odendo</b>	
<b>Rapporteur: S. Makokha</b>	
<b>Venue: Main Conference Hall</b>	
<b>11:05-11:17</b>	Farmers Perception on Changes in Natural Resource Base at Kathekakai Settlement Scheme, Machakos District, Kenya. <b>Baaru M.W.</b> , Gachene C.K.K., Gathaara V.
<b>11:17-11:29</b>	The role of agro-input dealers in dissemination and communication of soil fertility management knowledge: the case of Siaya and Trans Nzoia counties, Kenya. <b>Etyang T.B.</b> , Okello J.J., Zingore S., Okoth P.F., Mairura F.S., Murethi A. M. and <sup>5</sup> Waswa B.S.
<b>11:29-11:41</b>	Common bean value chain analysis and development for improved livelihoods in the central highlands of Kenya. <b>Bett E.K.</b> , Mugwe J.N., Ayieko D.M and Macharia J.
<b>11:41-11:53</b>	Rhizobium inoculant (biofix <sup>®</sup> ) production technology – a success story. <b>Muriuki E.M.</b> , Wafullah T.N, Karanja N.K., Gachene C.K.K. and Ndegwa D,M
<b>11:53-12:05</b>	Transforming livelihoods in africa through soils research and development by climate change adaptation/mitigation, enhanced food security and market access. <b>Kalifa Coulibaly</b> , Amadou M. Diallo, Mahamadou Koutou, Mamadou Sangaré, Bismarck H. Nacro
<b>12:05-12:17</b>	Land and water resources management in Nkambe highlands-Cameroon: Challenges and perspectives. <b>Nfor J.T.</b> , Achankeng U.B and Maurice E.T.
<b>12:17-12:29</b>	Stakeholders' diverging interests and emerging resource use conflicts in apiculture in west Usambara mountains, Tanzania. <b>Kimaro D.N.</b> , Sinyangwe J., Mbeyale G.E., Kajembe, G.C. and Mogaka, H.
<b>12:29-12:41</b>	Farmers' perception of conservation agriculture in Laikipia East district in Kenya. <b>Waweru G.</b> , Cornelis W and Okoba B.
<b>12:41-13:02</b>	<b>GENERAL DISCUSSION</b>
<b>13:02-14:02</b>	<b>LUNCH</b>

<b>DAY 5 25 OCTOBER 2013</b> <b>SESSION 26A: INTEGRATED NUTRIENT MANAGEMENT (INM)</b> <b>Chair: Prof. P.Wandahwa</b> <b>Rapporteur: Jokasta Kalungu</b> <b>Venue: Conference Hall 1</b>	
Time	Presentation
8:30-8:15	Lead Paper: Optimizing fertilizer recommendations in Africa (OFRA). <b>Kayuki Kaizzi</b> , Lydia Wairegi, and Charles Wortmann
8:15-9:00	Factors influencing the adoption of conservation agriculture as an adaptation strategy to climate change.a case study of Ngata Division, Nakuru County. <b>Mugo.B.J</b> , Nyanganga J, Hoka A, and Njeru P.N.M
9:00-9:12	Integration of commercial microbiological products into soil fertility practices as a potential option for acclimatization and growth of tissue culture banana in Kenya. <b>Kavoo-Mwangi A.M.</b> , Kahangi E.M., Ateka E., Onguso J. and Jefwa J.M.
9:12-9:24	E ffect of enrichment and rate of cattle manure on nitrogen uptake and yield of tea ( <i>Camellia sinensis</i> ). <b>Vivian M. Kekana</b> , Isaiah M. Tabu, David Kamau
9:24-9:36	Screening some promising rice cultivars for rooting ability in low management condition. <b>Oikeh Sylvester</b> , Brahima Koné, Youboué K. Emile, Sorho Fatogoma, Kouamé R. N'ganzoua, Angui T. Pascal, Yao-Kouamé Albert
9:36-9:48	Soil fertility status, quality of available manure and its implication on soil fertility maintenance in the peri-urban areas of semi-arid eastern Kenya. <b>Itabari J.K.</b> , Njarui D.M.G. and Kathuli P.
9:48-10:00	Modelling nitrogen dynamics in tea soils. <b>Sitienei K.</b> , Kamau D. M., Home P. G. and Wanyoko J. K.
10:00-10:12	Economic suitability of selected phosphorus sources on soybean yield in central highlands of Kenya. <b>Abuli J. S.</b> , Mugwe J N., Muchru-Muna M. and Mugendi D N.
10:12-10:24	N uptake and yields of soybean ( <i>Glycine max</i> (L.)) as influenced by manure, lime and mineral P fertilizer in central highlands of Kenya. <b>Verde, B.</b> , Danga, B. O. and Mugwe, J. N.
10:24-10:45	<b>GENERAL DISCUSSION</b>
10:45-11:05	<b>HEALTH BREAK</b>
9:36-9:48	Soil fertility status, quality of available manure and its implication on soil fertility maintenance in the peri-urban areas of semi-arid eastern Kenya. <b>Itabari J.K.</b> , Njarui D.M.G. and Kathuli P.
9:48-10:00	Modelling nitrogen dynamics in tea soils. <b>Sitienei K.</b> , Kamau D. M., Home P. G. and Wanyoko J. K.
10:00-10:12	Economic suitability of selected phosphorus sources on soybean yield in central highlands of Kenya. <b>Abuli J. S.</b> , Mugwe J N., Muchru-Muna M. and Mugendi D N.
10:12-10:24	N uptake and yields of soybean ( <i>Glycine max</i> (L.)) as influenced by manure, lime and mineral P fertilizer in central highlands of Kenya. <b>Verde, B.</b> , Danga, B. O. and Mugwe, J. N.
10:24-10:45	<b>GENERAL DISCUSSION</b>
10:45-11:05	<b>HEALTH BREAK</b>

<b>SESSION 26B: INTEGRATED NUTRIENT MANAGEMENT (INM)</b> <b>Chair: Walter Leal</b> <b>Rapporteur: F. Kaho</b> <b>Venue: Conference Hall 1</b>	
11:05-11:17	Effects of manure, lime and mineral P fertilizer on soybean yields and soil fertility in a humic Nitisol in the central highlands of Kenya. <b>Verde, B.</b> , Danga, B. O. and Mugwe, J. N.
11:17-11:29	Status of commercial macadamia nurseries in central kenya and incidence of seedling chlorosis. <b>Muriuki, A W.</b> , Gitonga J., Kiuru P., Wepukhulu B. and Cheluget W.
11:29-11:41	Applicability of hand-held x-ray fluorescence analyzer for rapid characterization of soil elemental compositions. <b>Nyambura M.</b> , Towett E K., Nyandika H., Chacha R., Shepherd K.



	D. and Gatari M.J.
11:41-11:53	Capacity building on spectral diagnostic techniques for land health surveillance. <b>Weullow E.</b> , Sila A., Aynekulu E. and K. Shepherd
11:53-12:05	Utilising soil fertility replenishment measures for nutrient use efficiency in maize production, Western Kenya. <b>Alwang'a S.K.</b> , Okalebo J.R., Osundwa M., Wairimu K.N. and Oluko P.
12:05-12:17	Tillage and cover crop effects on soil penetration resistance, aggregation and organic carbon fractions in northern Nigeria. <b>Lawal, H. M</b>
12:17-12:29	Effect of inputs application on yields of soybean and climbing bean in a maize - legume rotation system in central Kenya. <b>Mugwe J. N.</b> , Mucheru-Muna M., Muthamia J. and Mugendi D.
12:29-12:41	Effect of soil amendments on growth and yield of beans ( <i>phaseolus vulgaris</i> l.) in acidic soils of Nyeri county, central Kenya. <b>F M Kihanda</b> and J M Gachingiri
12:41-13:02	<b>GENERAL DISCUSSION</b>
13:02-14:02	<b>LUNCH</b>

<b>DAY 5 25 OCTOBER 2013</b>	
<b>SESSION 27. AGRONOMY AND CROP MANAGEMENT</b>	
Chair: Cyrus Githunguri	
Rapporteur: E. Nassiuma	
Venue: Conference Hall 2	
<b>Time</b>	<b>Presentation</b>
<b>8:30-8:45</b>	Assessment of genetic variability among Kenyan soybean ( <i>Glycine max</i> (l.) merill) accessions and other introductions. <b>Wanderi S.W.</b> , S.M. Githiri., Sibiya J. and Muthomi J.
<b>8:45-9:00</b>	Economics of maize-legume production in western Kenya. <b>Odendo M.</b> , Ndinya C., Muyekho F. and Onyango E.
<b>9:00-9:12</b>	Effects of different maize ( <i>Zea mays</i> l.) – soybean ( <i>Glycine max</i> (l.) merrill) intercropping patterns on yields and growth parameters. <b>Matusso J.M.M.</b> , Mugwe J.N. and Mucheru-Muna M.
<b>9:12-9:24</b>	Improving land productivity and combating desertification through pigeon pea-based cropping systems in semi-arid lands of Kenya. <b>Kibunja C. N.</b> , Sijali I.V., Esilaba A.O., Kitonyo E.M., Maingi S.W., Mwangi J.A. and Heng L.
<b>9:24-9:36</b>	Soybean yield response to fertilizer, manure and lime application in western Kenya. <b>Wafula E. W.</b> , Chemining'wa G. N., Karanja N., Zingore S and Baijukya F.
<b>9:36-9:48</b>	Effects of different maize ( <i>Zea mays</i> l.) – soybean ( <i>Glycine max</i> (l.) merrill) intercropping patterns on yields and its economics. <b>Matusso J.M.M.</b> , Mugwe J.N. and Mucheru-Muna M
<b>9:48-10:00</b>	Optimum use phosphorous, potassium and sulphur on soybean yield on different positions on hills in isingiro south western Uganda. <b>Gumisiriza R.</b>
<b>10:00-10:12</b>	Maize Response to Rock Phosphate Applied Under Two Maize Cropping Systems
<b>10:12-10:24</b>	Influence of cereal-legume cropping system on <i>Striga hermonthica</i> control and maize grain yield in eastern Uganda. <b>Namutebi V.</b> , Mulumba L. and Bisikwa J.
<b>10:24-10:45</b>	<b>GENERAL DISCUSSION</b>
<b>10:45-11:05</b>	<b>HEALTH BREAK</b>
<b>SESSION 28. AGRONOMY AND CROP MANAGEMENT</b>	
Chair: S. Nguluu	
Rapporteur: A. Njaimwe	
<b>11:05-11:17</b>	Improving nitrogen management under rice production in lowlands eastern Rwanda. <b>Chuma B. Andre</b>
<b>11:17-11:29</b>	Cassava: a promising food security crop in Mutomo a semi-arid food deficit district in Kitui county of Kenya. <b>Githunguri C. M.</b> , Lung'ahi E.G., Musili R. and Amata R.
<b>11:29-11:41</b>	Effects of conservation agriculture practices on soil moisture and weed incidences in mid-altitude agro ecologies of Malawi. <b>Kamwana F.</b> , Kamalongo D., Nyagumbo I. and Siyeni, D.
<b>11:41-11:53</b>	<b>Response of common bean grain yield to <i>Rhizobium</i> inoculation in Mbeya region, Tanzania.</b> Mmari W. N. and Kilango M.



<b>11:53-12:05</b>	Effects of selected soil water conservation strategies on maize yield through farmer managed trials in the central highlands of Kenya. <b>Kiboi M.N.</b> , Muna M.W., Ng'etich F.K, Mugwe J.N., Mugendi D.N. and Wambugu. S.
<b>12:05-12:17</b>	Integrating scientific and farmers' evaluation of water harvesting and integrated soil fertility management technologies on sorghum productivity in central Kenya. <b>Njeru P. N. M.</b> , Mugwe J., Mucheru-Muna M., Maina I., Mugendi D. Mwangi D. M., Amboga J.S., Lekasi J.K., Kimani S. K., Miriti J.M., Gitari J., Mwangi H. and Muriithi F.
<b>12:17-12:29</b>	Farmers' up-take response to soil fertility management practices disseminated by the National Agricultural Research Organization (NARO), Pallisa district, Eastern Uganda. <b>Otim M.</b> , Kyazze F. and Isubikalu P.
<b>12:29-12:41</b>	Making farmer recommendations from experimental data: a case study of Gucha area of Kisii County. <b>Makokha S N.</b> and Kamoni P. T.
<b>12:41-13:02</b>	<b>GENERAL DISCUSSIONS</b>
<b>13:02-14:02</b>	LUNCH

**DAY 5 25 OCTOBER 2013 SESSION 29: POSTER/EXHIBITION SESSION**

Chair : Mathias Magunda

Rapporteur: Mazimbiri, M.K.

Venue : Poster/Exhibition Room

Time	Presentation
<b>2:00-3:00</b>	Farmers' up-take response to soil fertility management practices disseminated by the national agricultural research organization (NARO), in Pallisa district, eastern Uganda. <b>Otim M.</b> , Kyazze F. and Isubikalu P.
	Enhancing smallholder farmers' adaptive capacity to rainfall variability and soil fertility problems by the use of their tacit knowledge. a case of Chipepo in southern Zambia. <b>Mubanga K.H.</b> , and Umar B.B.
	Validation and up scaling of appropriate agri-biotechnologies for improving rural livelihood in Africa. <b>Shivamurthy M.</b> and M.G. Chandrakant h
	Gender perceptions, understanding and adaptive strategies to climate change and variability by smallholder farmers in semi-arid South Sudan. <b>Mogga M.L.</b> , Wafula B.M. and Mogaka H.
	Climate change and determinants of organic manure use to combat soil fertility declining in the semi arid district of Kibwezi (Kenya). <b>Aale A.</b> , Folefack D.P., Obwoyere O. and Lenah N.
	Use of hand-held x-ray fluorescence analyzer for rapid screening of soils. <b>Nyambura M.</b> , Towett E K., Nyandika H., Chacha R., Shepherd K D. and Gatari M. J.
	Options for developing bee honey market for Lushoto district, Tanzania. <b>Konga N.</b> , Kimaro D. N., Hella J. P., and Kasenge V.
	Rice husk and Typha australis biochar improve water stress tolerance and yield of millet in Senegal. Faye A., Wangolen F., Belko N., Asubonteng K.O., Togor E. C. and Cisse N.
	Response of Common Bean Grain Yield to <i>Rhizobium</i> Inoculation in Mbeya Region, Tanzania. <b>William N. M.</b> and Michael Kilango
	Mineral fertilizers for improved productivity of climbing bean ( <i>Phaseolus vulgaris L.</i> ) in the South-eastern Rwanda. <b>Celestin, N.P.</b>
	Enhancing the status of human nutrition and food security in Africa through Integrated Soil Fertility Management (ISFM) and Small Scale Irrigation – The Case of N2Africa project. <b>Musyoka, J.M.</b>
	Drought mitigating technologies: lessons learnt from sorghum and cowpea production in semi-arid areas of Embu County, Eastern Kenya. <b>Njeru P. N. M.</b> , Maina I, Mugwe J, Mucheru-Muna M, Mugendi D, Lekasi, J.K, Kimani S. K, Miriti J, Mugo.B.J, Mwangi H, Oeba V. O, A.O. Esilaba and Muriithi F.
	Performance of cowpea and sorghum under different moisture conservation and nutrient management techniques in the drought-prone Tharaka Districts of Eastern Kenya. <b>Gitari, J.</b> , Muhammad, L., Njuguna, E., Murithi, F., and Pelletier, B.
	Adapting agriculture to climate change: An evaluation of yield potential of common bean and pigeon pea under cool-wet climatic conditions in Nyahururu, Central Kenya <b>J.M. Miriti, J.W. Onyango, A.O. Esilaba, K.P.C. Rao, S. K. Kimani, J.K. Lekasi, P.N. M. Njeru</b>



	Trace Elements in Soils from Tanzania: Application of TXRF Analysis. <b>Galgallo, A.H.</b> , M. J. Gatari, M.J., Maina, D.M., Shepherd, K.D., Nyambura, M., Nyandika, H., Karuga, H., Gichohi, B.M.
	Constraints in Irrigated Lowland Rice Cultivation As Affected by the Harmattan <b>Konan Kouamé Firmin</b> , Traoré Migninan Joachim, Brahim Koné, Gala Bi Trazié Jeremi, Yao-Kouamé Albert
	Screening Some Promising Rice Cultivars for Rooting Ability in Low Management Condition <b>Oikeh Sylvester</b> , Brahim Koné, Youboué K. Emile, Sorho Fatogoma, Kouamé R. N'ganzoua Angui T. Pascal, Yao-Kouamé Albert
	Towards the evolution of climate change mitigated farming systems; The Indigenous Knowledge Link. <b>Sessanga, S.M.</b>
	Constraints in Irrigated Lowland Rice Cultivation As Affected by the Harmattan. <b>Konan Kouamé Firmin</b> , Traoré Migninan Joachim <sup>1</sup> , Brahim Koné, Gala Bi Trazié Jeremi, Yao-Kouamé Albert
	Effect of maize variety and Nitrogen levels in the control of striga weed in western Kenya. <b>Mambafu, R.O.</b> , Karuku, G., Ariga E., Vanlauwe, B., and Roing, K.
<b>3:00-4:00</b>	<b>ASSS Business meeting</b>
<b>4:00-4:15</b>	<b>HEALTH BREAK</b>
<b>4:15-5:15</b>	<b>SSSEA Business meeting</b>
<b>SESSION 30 CLOSING CEREMONY</b>	
Chair: ASSS	
Rapporteur: SSSEA	
Venue: Main Conference Hall	
<b>5:15-6:00</b>	<b>Closing ceremony</b> <b>Governor, Nakuru County</b>
<b>2:30-3:30</b>	<b>LUNCH</b>



## **THEME I: ENHANCING APPLICATIONS OF ADAPTATION AND MITIGATION TO CLIMATE CHANGE VARIABILITY AND CHANGE**

### **TOWARDS THE EVOLUTION OF CLIMATE CHANGE MITIGATED FARMING SYSTEMS; ITHE INDIGENOUS KNOWLEDGE LINK**

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The climate change phenomenon has direct and indirect influences and effects on livelihoods both at grassroots and global levels. The unsatisfactory food security status, coupled with the persistent production chain challenges particularly in the Least Developed Countries (LDCs) put in question the attainment of the Millennium Development Goal 1 (MDG1). In the cross-country survey undertaken in Uganda, both questionnaires and interviews were employed to explore the Indigenous Knowledge (IK) status as regards the climate change influences on farming and livelihoods at the grassroots. Respondents in all regions acknowledged, though to varying extents and intensities, the climate change phenomenon as reflected by its influence on farming activities and production trends. The respondents in 75% of the districts that had, in the past distinct in the past, characteristically wet and prolonged dry (drought) periods (seasons) revealed pronounced effects attributed to climate change. Coping and mitigation mechanisms were more evident in the identified 75% of the districts whereas the central region of Buganda had, so far, not significantly adjusted to the climate change phenomenon. The role of Indigenous Knowledge (IK) in harmonizing the climate change detection, coping and/or mitigation measures was deemed viable, practical and low-cost for the majority of the stakeholders participating in the evolution of appropriate (farming Methods/Practices) to mitigate the climate change effects our farming systems.

### **INFLUENCE OF AGRO-CLIMATIC CONDITIONS AND FERTILIZER USE ON DIFFERENT PEST MITE MANAGEMENT OPTIONS IN CASSAVA PRODUCTION**

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Cassava production is reported to be constrained by low soil fertility, pests and diseases coupled with poor rainfall amount in Sub-Sahara Africa (SSA). In a study on the influence of agro-climatic conditions, fertilizer use and inclusion of biological control agents in comparison with chemical control, it was found that environmental factors played a major role to root yield. Higher moisture led to increased beneficial predacious mites while fertilizer input increased final yield of the crop. Cassava



green mite (CGM) *Mononychellus progresivus* Doreste management option choice depended on the prevailing agro-climatic conditions of the sites. The cool-wet site had the least pest spider mite pest and fairly moderate number of predacious mites with root yield being of the medium (28 t ha<sup>-1</sup>) while hot-dry conditions of the eastern lowlands had higher CGM numbers and subsequently the least yield weight (13 t ha<sup>-1</sup>). The highest leaf damage score of cassava was 3-4 severity level per leaf of the hot-dry eastern lowlands. The warm-humid coastal site plot had the least pest densities and highest predacious mites, subsequently with the highest yield of >30 t ha<sup>-1</sup>. Thus, environmental conditions fluctuations resulted to the pest and beneficial predacious mite population dynamics peaks and drop during the production period with the final root yield as the resultant product in relation to soil fertility and moisture inputs.

## **DETERMINANTS OF FARMERS' CHOICE OF TECHNOLOGICAL OPTIONS FOR ADAPTING TO CLIMATE VARIABILITY: A CASE OF EASTERN UGANDA**

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Adaptation is considered an appropriate response to climate change and variability. Recent studies in climate research suggest the need to focus on adaptation research that seeks to investigate actual adaptations at the farm level, as well as the factors that appear to be driving them. Information on farmers' level empirical evidences is essential in informing policy and development strategies that attempt to boost farmers' adaptation to the changing climate. Based on this, the study uses the Heckman sample selectivity model to identify farmers' perception and adaptation to climate variability in Eastern Uganda. Adaptation to climate variability and change requires that farmers using traditional techniques of agricultural production first notice that the climate has altered, and then identify potentially useful adaptations or actions and implement them. Data for this study was obtained from 353 household interviews, 23 Key Informant Interviews and 9 focus group discussions drawn from three sample districts of Mbale, Pallisa and Sironko. This study shows that farmer's perception of rainfall adequacy or variation is significant in explaining farmers' decision to adopt adaptation technologies. Other factors that positively and significantly affect farmer's choice of adaptation technology are; gender of head of household, household size, and access to output markets. This study finds no significant relationship between technology adoption and extension services, unlike most studies. Yet, access to information showed positive relationship with technology adoption. The results underscore the need for appropriate weather information to guide decision making of which adaptation technologies to adopt, combined with farmers knowledge of changing climate. In addition, household socio-economic factors and access to markets should not be ignored in the design and implementation of adaptation measures. This can be supported by building



social protection mechanisms at community level, or supporting households to build economic assets if labour is to be hired. Lastly, in provision of extension services, the mode of extension service delivery, the messages and the targeting is critical if extension is to contribute to technology adoption and subsequently increased agricultural productivity.

### **DROUGHT MITIGATING TECHNOLOGIES: AN OVERVIEW OF CASSAVA AND SWEETPOTATO PRODUCTION IN MUKUYUNI DIVISION MAKUENI DISTRICT IN SEMI-ARID EASTERN KENYA**

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Cassava and sweetpotato are resistant to drought and are mainly propagated through stem cuttings or vines producing starchy tuberous roots, which provide much needed carbohydrates in the tropics. A study was carried out in June 2010 to obtain a general overview of cassava and sweetpotato production in Matiliku Division Makueni District in Semi-Arid Eastern Kenya as a prelude to the establishment of a seed system for the two crops using elite KARI varieties as drought mitigating technologies. The results show that about 90% of the farmers put between 0.125 and 0.25 acres under cassava cultivation. The number of years under cassava and sweetpotato production ranged between 1 and 20 years with only a few farmers indicating to have been growing cassava for a period above 20 years. The majority of farmers were growing local cultivars of the two crops. The main method of utilizing cassava was boiling and eating as a snack (45%). Over 77.8% of the respondents indicated the origin of their cassava and sweetpotato cultivars as other farmers. The main method of utilizing sweetpotato was boiling and eating as a snack (56.3%). 3.1% of the farmers mixed sweetpotato with beans and maize and consumed it as a stew while another 3.1% have not utilized sweetpotato at all. Only 3.1% fed sweet potato to livestock. The rest, 28.1% sold sweetpotato in the local market. The majority of farmers, 38.9%, had attained the Primary School level of education, were farmers, and owned a cellphone. Those with a secondary level of education owned a cellphone and a postal address.

### **CASSAVA: A PROMISING FOOD SECURITY CROP IN MUTOMO A SEMI-ARID FOOD DEFICIT DISTRICT IN KITUI COUNTY OF KENYA**

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Cassava is important in the provision of the much-needed carbohydrates in the tropics and sub-Saharan tropics. It is also a major source of subsistence and cash income to farmers in agroclimatically-disadvantaged regions areas of Kenya. Cassava is ideal for production in marginal and drought prone areas, which comprise about 80% of Kenya. However, despite this great potential, its utilization as food security and income generating crop remain low in these areas. One of the



major constraints to cassava production includes lack of adequate disease and pest free planting materials. This is also greatly exacerbated by its slow multiplication rate. KARI Katumani has established cassava agronomic demonstrations, seed multiplication and distribution programmes. 18,000 cuttings of five elite cassava cultivars, KME 990005, KME 990132, Ex-Mariakani, and MM96\_5280, were obtained from KARI Kiboko Sub-Center and used in the establishment of multiplication and demonstration plots in Mutomo district Kitui County during year 2012 short rains in November. Six onfarm trials in Mutomo were monitored four months later in February 2013 and crop performance information collated. Observations showed cassava cultivar MM96\_5280 had established and was performing significantly better than the other cultivars under rainfed conditions in all the six farms where it had been distributed in Mutomo. Cultivar MM96\_5280 had a good stay-green ability, high drought tolerance, high cassava mosaic and brown streak virus diseases tolerance, and vigorous. It is crucial that the training of extension officers and farmers on good agricultural practices with emphasis on cassava diseases and pests' management, processing, utilization, and marketing be accelerated in Mutomo. There is need to continue with the assessment of performance by other elite cassava cultivars in Mutomo in order to accelerate adoption of their cultivation and utilization in Mutomo with a view to improving food security and wealth creation. Finally, it seems that the participation of institutions that were providing knowledge management and sharing services in this project will play a major role in making the farmers adopt cassava as a drought mitigating crop in this drought prone area.

## **ADAPTING TO CLIMATE CHANGE: LESSONS LEARNT FROM CASSAVA FARMING IN MUTOMO, KENYA**

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Although knowledge is power, the real power is the ability to turn knowledge into action. To do this on the climate change adaptation front, we need to understand how key research messages can be communicated to different audiences and implemented into practice. One of the key challenges of climate adaptation strategies is that there is no one-size-fits-all approach. Every community needs a locally contextualised plan, cognisant of local needs, socio-cultural and economic environment. This paper will analyse how communities are adapting to climate change in Mutomo, Eastern Kenya while discussing challenges faced, lessons learnt and providing possible recommendations.



## EFFECTS OF INTEGRATION OF IRRIGATION AND MINERAL NUTRIENT MANAGEMENT IN SEED POTATO (*Solanum tuberosum* L.) PRODUCTION ON WATER, NITROGEN AND PHOSPHORUS USE EFFICIENCIES

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Potato (*Solanum tuberosum* L.) is the world's fourth important food crop after wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and maize (*Zea mays* L.) because of its great yield potential and high nutritive value. For increased productivity inorganic N fertilizers have become extremely important in correcting declining soil fertility, seed tuber yields and quality. Another factor that has limited seed potato production in many parts of Kenya is unreliable rainfall. Knowledge on water, mineral nutrient use efficiencies on potato grown under different irrigation regimes, nitrogen and phosphorus will help predict the best application rates for optimal seed potato production and yield. A study was conducted at the Horticultural Research and Teaching Farm of Egerton University to determine the effect of integration of irrigation water supply, nitrogen (N) and phosphorus (P) nutrient application on water, N and P use efficiencies. The three factors were tested in a split-split plot design. Irrigation water supply was assigned to main plots, N to subplots and P to sub-subplots. The treatments were replicated three times and the trial repeated once. The treatments consisted of three irrigation water rates (40%, 65% and 100% field capacity), applied throughout the potato growth period through drip tube lines. Nitrogen was supplied as urea (46% N) at four rates (0, 75, 112.5 and 150 kg N/ha), each in two splits, with the first half at planting and the second at 5 weeks after planting. Phosphorus was supplied at planting time as triple superphosphate (46% P<sub>2</sub>O<sub>5</sub>) at four rates (0, 115, 172.5 and 230 kg/ha P<sub>2</sub>O<sub>5</sub>, which translated into 0, 50.6, 75.9, 101.2kg P/ha). Each plot measured 1.8 m x 2.25 m and 1 m paths separated adjacent plots. Each experimental unit consisted of 7 rows each with 7 tubers. Data on seed potato yield was collected from each treatment and subjected to variance and regression analyses, and significantly different means separated using Tukey's Studentized Range (HSD) Test at P = 0.05. 100% compared to 65 and 40% irrigation water supply resulted in relatively high N and P use efficiencies, but decreased water use efficiency. Application of intermediate to high N and P nutrient improved the water, N and P use efficiencies. It is recommended to apply low to intermediate irrigation water, intermediate to high N and P to increase their use efficiencies during seed potato production.



## SITUATION ANALYSIS OF CLIMATE CHANGE ASPECTS IN KENYA

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Given that climate change and variability have become one of the greatest threats to food security and livelihoods, a baseline study was conducted to understand the current situation of CC scenarios in Kenya. The study sought to determine the current status of CC projects that have been undertaken in Kenya in the past five years. Major CC themes and sensitive productive sectors to CC were conceptualised in which the study was based. The baseline survey targeted key informants in academic, research and policy arenas. It was observed that adaptation, mitigation and capacity building accounted for 60, 17 and 23% of the projects sampled. Agricultural sector (crops) accounted for most of CC projects, accounting for 36% as well as 40% of all projects on adaptation. Agriculture, livestock and environment sectors accounted for 30% each of the mitigation projects. It is established that most projects undertaken in Kenya on CC arena have been on adaptation, capacity building and mitigation. CC projects undertaken in Kenya were in agriculture and livestock sectors. Although considerable efforts appear to have been put in adaptation to CC, more needs to be done, especially in agriculture and water sectors, which are important in Kenya's economy.

## AN ASSESSMENT OF GENDER SENSITIVE ADAPTATIONS OPTIONS TO CLIMATE CHANGE IN SMALLHOLDER AREAS OF ZIMBABWE, USING CLIMATE ANALOGUE ANALYSIS AND CONSIDERING FARMER PERCEPTIONS

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Current projections suggest that the impacts of warmer climates on smallholder production by the middle of this century, are expected to be mainly negative. Both the livelihoods and food security of smallholder households can be improved through suitable strategies for handling climate-induced risks and socio-economic and biophysical constraints. This paper describes the use of climate analogue areas together with an assessment of farmers' perceptions, within the framework of the project CALESA. In particular, it considers them as tools for climate-risk analysis



and assessment of adaptation options. The importance for mainstreaming gender sensitive options for climate change planning and policy is also herewith illustrated. Climate analogues for 2050s were identified in smallholder areas of Zimbabwe based on 30 years meteorological data. Pairs of sites with similar annual rainfall totals, which differed by 2-4 degrees Celsius in mean annual temperature (following the forecast effects of global warming for the 2050s) consist of Chiredzi which represent Matobo for drier areas, and Kadoma for wetter areas, which represent Mazowe/Goromonzi. Preliminary results for the 2010/2011 cropping season show different preferences for crop management strategies, particularly between the dry analogue pair, with respect to crop choices as well as soil and water management strategies. In drier areas, implications are for increased uptake of small grains, in 2050s climates. For wetter climates, soil and water management strategies are important options for smallholders. Gender issues for differently managed households seem to vary across sites. At drier sites, gender issues include labour for production and processing of the small grains, against a background of male labour migration. At wetter sites, access to draft power, labour, agricultural assets, social and financial capital in differently managed households are important for increasing adoption of effective crop management strategies.

#### **THE POTENTIAL OF SUGARCANE FARMING AS A CLIMATE SMART AGRICULTURE IN JINJA DISTRICT, UGANDA**

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An agricultural economy makes Uganda to be highly vulnerable to the damages of climate change such as extensive droughts and floods. Advances in estimating carbon sequestration in agricultural landscapes has since 2013 enabled carbon payments to farmers through the Climate Smart Agriculture (CSA) concept. However, the availability of information on the sequestering potential of each land use type within the CSA concept is limited. Using the RothC-26.3 model to assess the amount of C sequestered the state of food security and resilience to climate damages, sugarcane farming systems were evaluated in the framework of the CSA concept. Despite the high carbon sequestration potential, sugarcane farming systems are associated with low net annual income that cannot sustain a household of 6 with an average farm size of 5 ha. Therefore, sugarcane land use types fall short of the CSA criteria and cannot be considered as climate smart agriculture.



## **FACTORS INFLUENCING THE ADOPTION OF CONSERVATION AGRICULTURE AS AN ADAPTATION STRATEGY TO CLIMATE CHANGE. A CASE STUDY OF NGATA DIVISION, NAKURU COUNTY**

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Soil degradation as a result of poor ploughing methods is one of the major challenges in agricultural production in many parts of the world, especially in developing nations like Kenya. Even though a number of conservation agricultural technologies were introduced to reduce the problem, adoption of these practices remains below expectation. The aim of this study was to identify the factors that influence farmers' decision to adopt conservation agriculture in Ngata Division of Nakuru County. The results showed that age, access to credit, education and contact with extension agents influenced adoption. Farming experience, family size, farm size had no significant influence on adoption. There is need to educate more farmers through extension programs so as to increase adoption. Credit facility especially loans should be made simple to improve the adoption of conservation Agriculture in the study area.

## **EXPERIMENTING WITH SMALLHOLDER COMMUNITIES FOR CLIMATE CHANGE ADAPTATION IN EAST AFRICA**

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Climate change has recently emerged as the most significant threat to sustainability of human livelihood and the environment at a global scale. In this paper we present findings of a study on the potentials of integrated soil fertility management (ISFM) options to enhance farmers' coping and adaptation strategies to climate change and variability in diversified cereal-root crops and banana based farming systems in the Lake Victoria ecoregion of East Africa. The study was conducted through a survey of 480 households from 6 villages in Bukoba and Missenyi Districts, Tanzania, and 2 villages in Tororo district, Uganda. Drawing on the findings of the survey, we developed strategies for communities to test some of the potential ISFM. Through Participatory Action Research (PAR) approaches, criteria for establishment and implementation of 15 learning Centres (LC) to promote co-learning and accelerated exchange of technical information among farmers (and with service providers), while testing different ISFM options for increased crop productivity were developed. Tested options include use of mineral and organic fertilisers, improved maize varieties for tolerance to pest and diseases, Soil moisture conservation and exploitation of biological nitrogen fixation (BNF) through rhizobial inoculums on



soybean. Drawing on the results obtained from the learning centres, farmers entered another cycle of participatory evaluation and reflection in order to develop adaptation strategy for agriculture against the major identified climatic factors/impacts. The study revealed high awareness among farmers about climate change and variability, about 80%, 91% and 83% of survey households in Bukoba, Missenyi and Tororo districts, respectively. Our results show that farmers in East Africa explain climate change and variability from its impacts and efforts to communicate the science of climate changes to them has remain rudimentary and fraught with what are perceived to be contradictory and unreliable messages. The study also shows absence of social institutions and arrangements that enhances collective/participatory decision making process. Experimentation with farmers revealed that use of best-bet ISFM technologies including fertilisers (mineral and organic), improved crop varieties (high yielding and drought and pest tolerant/ resistant) can more than double crop yields (compared to what is obtained now). We conclude that with a wake of climate change and variability, it is probably the time we should resume popularisation of ISFM, along with the efforts to create awareness on climate change and variability.

#### **EFFECT OF ROOTING DEPTH, PLANT DENSITY AND PLANTING DATE ON MAIZE YIELD AND WATER USE EFFICIENCY IN SEMI-ARID ZIMBABWE: MODELLING WITH AQUACROP**

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The challenge in semi-arid areas is to increase food production under low and poorly distributed rainfall. Higher food production can be achieved by increasing crop water use efficiency (WUE) through optimum soil fertility management appropriate practices including selection of deep- rooting cultivars, appropriate plant density and planting dates. The objective of Effect of rooting depth, plant density and planting date on maize yield and water use efficiency in semi-arid Zimbabwe: modelling with AquaCrop. The study was to explore AquaCrop's use in selecting adaptive practices for improving maize yields and WUE under rainfed smallholder farming conditions in Zimbabwe. AquaCrop was tested without calibration by comparing simulated canopy development, biomass and rootzone soil water with field measurements. The model was subsequently applied to optimize rooting depth, planting density and planting date for increasing yields and WUE. Simulations were done with rainfall data for 25 seasons from Rushinga, Zimbabwe. AquaCrop simulated canopy cover development fairly well and simulated biomass accumulation showed good agreement with measured values. The model overestimated soil water, and observed final biomass and grain yield were 81 and 75 % of the simulated values respectively. Effects of varying rooting depth and plant density ( $P < 0.05$ ) were observed in normal seasons. Increasing rooting depth from 0.30 m to 0.60 m increased grain yield from 5.6 to 7.0 t ha<sup>-1</sup>. Increasing plant density (plants ha<sup>-1</sup>) from 17500 to 32500 increased grain yield from 4.0 to 6.0 t ha<sup>-1</sup>. Planting



date did not show significant effect on maize yield and WUE. Drainage below the rootzone was at least 40 % of the non-productive water losses in normal and wet seasons whilst evaporation contributed 46 % in dry seasons. In order to improve yield and WUE, we recommend incorporation of deep-rooting legumes e.g. pigeonpea, adopting deeper-rooting cultivars and practices that improve rooting depth, a final plant density of 32500 plants ha<sup>-1</sup>; and practices that reduce evaporation in dry years. Further research should include participatory field testing of results from this study.

## **CHARACTERIZATION OF SEASONAL RAINFALL VARIABILITY AND DROUGHT PROBABILITY OF THE SEMI ARID AREAS OF MBEERE REGION IN EMBU COUNTY, KENYA**

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Rain-fed agricultural productivity has continually declined due to unpredictable and unreliable rainfall patterns. Embu County has experienced declines in food production partly due to inadequate understanding of intra-seasonal rainfall variability to develop optimal cropping calendar. This study characterized inter/intra seasonal rainfall variability and drought probabilities in Embu County (Machang'a and Embu stations). Cumulative Departure Index (CDI), Rainfall Anomaly Index (RAI) and Variance (CV) and probability parameter statistics were utilized in the analyses. Homogeneity testing recorded zero Nil-values, 100% Non-Nil-values. Homogeneity plot showed restricted deviations of the rescaled cumulative deviations around the zero mark and homogeneity was accepted at 99% probabilities. Probabilities of rainfall exceeding 213.5mm and 258.1mm during LRs and SRs were 90% respectively. High variability was observed in rainfall amounts (314 and 586.3mm) (CV=0.41 and 0.36) during LRs and (438.7 and 497.1mm) (CV=0.56 and 0.38) during SRs in Machang'a and Embu respectively. Daily rainfall distribution depths were highly skewed; small proportion of rainy days supplying a high proportion of rainfall. Variability in rainy days were CV=0.26 and 0.08 during LRs and CV=0.88 and 0.27 during SRs in the stations respectively. Monthly rainfall variability were high in March (CV=0.98 and 0.61) and October (CV=0.80 and 0.66) in stations respectively. These showed that SRs and Machang'a region experienced high rainfall variability. Probabilities of dry-spells within growing months were high (81%) and (60%) in Machang'a and Embu respectively. To optimize yield in the area, use of soil-water conservation and supplementary irrigation, crop selection and timely accurate rainfall forecasting should be prioritized.



## **THE INTRINSIC VALUES AND ADAPTATION TO CLIMATE-SMART PRACTICES IN KENYA: USING MEANS-END ANALYSIS**

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Appropriate and effective adaptation efforts on climate change depend on what people perceive to be of importance to preserve and attain, which in turn depends on their fundamental values and goals. The study assesses the motivations for farmers to adopt diverse climate-smart practices in Kenya. It also examines gender and decision-making process in adapting to climate-smart practices. Qualitative technique of “laddering” was applied in interviewing farmers. Means -end analysis was used in hierarchical mapping of the decision-making processes on the choice of climate-smart practices, the desired outcomes and definitive values that influence the action. The results show that farmers adopt several climate-smart practices to minimize negative consequences of weather variability. It also finds gender differences in adaptation practices and motives and intrinsic values. Farmers are motivated to adopt practices that improve extrinsic goals of farm productivity, food security, income and that reduce possible death of livestock because of drought. In addition, farmers desire to triumph developmental goals of poverty reduction through investments, savings and asset accumulation in the face of weather variability and climate change. The uptake of climate-smart practices are ultimately motivated by intrinsic values, which include self-enhancing values, independent, and good health, security, peace, happiness and benevolence. The study discusses the policy implications in designing effective adaptation measures with respect to farmers’ values and priorities.

## **ADAPTING AGRICULTURE TO CLIMATE CHANGE: AN EVALUATION OF YIELD POTENTIAL OF MAIZE, SORGHUM, COMMON BEAN AND PIGEON PEA VARIETIES IN A VERY COOL-WET REGION OF NAYANDARUA COUNTY**

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Soil and water conservation, use of more adaptive crop genotypes and crop diversification are widely accepted as some of the management practices that can help reduce agriculture vulnerability to impacts of climate change. A study was conducted to evaluate the yield potential of maize, sorghum, common bean and pigeon pea varieties under different water management, plant densities and fertility levels in Nyahururu, Central Kenya. The study involved three experiments. The first experiment evaluated the growth and performance of three varieties (early

maturing: EM, medium maturing: MM and late maturing: LM) of maize, sorghum, pigeon pea and common bean. The experimental design was a completely randomized block design (RCBD) replicated three times. The second experiment evaluated maize and sorghum response to water conservation and three fertiliser rates (0, 20 and 40 kg N/ha). The third experiment assessed the effect of water conservation measures on crop yields of common bean and pigeon pea grown under three plant densities (low, medium and high). Tied ridge tillage was used as the water conservation measure and disc plough as the control in the second and third experiments. Results showed that water conservation in general did not have a significant effect on crop yield though they were improved. The medium density pigeon pea gave the highest grain (719 kg/ha) followed by low (688 kg/ha) and high plant density (687 kg/ha). Similar trends were observed with common bean grain and dry matter yield. Tied ridges tended to lower maize yield compared to flat tillage while it increased sorghum yields but the difference was insignificant. When average across the tillage systems, the highest maize grain (5011 kg/ha) and dry matter (14067 kg/ha) yield was obtained in plots without N fertilizer. Sorghum dry matter was highest (14067 kg/ha) in plots with 40 kg N/ha and lowest (7903 kg/ha) in plots without N fertilizer. In the variety experiment, the EM pigeon pea variety (ICPL 84091) yielded the greatest grain (881 kg/ha) while the late maturing variety (ICEAP 00040) gave the least (565 kg/ha). The LM maize variety (DK8031) yielded the highest grain (5701 kg/ha) and dry matter (18843 kg/ha). The LM sorghum variety (Macia) had 47% and 49% dry matter yield advantage over MM (Kari Mtama 1) and EM (Gadam) varieties, respectively. The yields for common bean varieties tended to vary with seasons.

#### **TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) YIELD PERFORMANCE UNDER ELEVATED DRY SEASON TEMPERATURES AS AN ADAPTATION TO CLIMATE CHANGE IN TABORA, TANZANIA**

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Tomato (*Lycopersicon esculentum* Mill.) is an important income generating plant during the dry season in Tanzania. The dry season is characterized by low humidity, high evaporation, high air temperatures and increased soil temperatures. Tomato growth performance is sensitive to elevated temperatures. However, smallholder farmers grow tomato cultivars without discriminating their yield performance differences. Assessment of tomato tolerance to dry season elevated temperatures was investigated with smallholders'. The objective was to identify tomato varieties that perform better under high season temperatures. Six tomato genotypes were evaluated between July-October in 2012. Four tomato cultivars (Oxyl, Tanya Mkulima, Tanya Kibo and Tengeru) were grown in randomized block design between July and October. On-farm assessment of three tomato cultivars; Anna, Griffon and Tanya Mkulima was carried out by planting tomato seedlings the first week of September. Meteorology data between July-October that, the maximum



daily temperature (34.2°C), monthly evaporation (168.2mm-226.6mm), mean air temperature, (15.1°C -19.7°C), and air humidity (49%-44.6%). Highly significant difference ( $P < 0.001$ ) in tomato yield was recorded on tomato cultivars; OxyL, Tanya Mkulima, and Tengeru for early August, mid August but not for the late (late August) planted crop. High temperatures increase tomato susceptibility to red spider mites (*Tetranychus evansi* Baker&Prichard). On-farm tomato genotypes assessment showed significant yield differences between Grifforn, Anna and Tanya Mkulima. Results further show that significant yield difference in tomato yield were recorded for early August, mid August and early September planted tomato. Grifforn and Tengeru cultivars were less tolerant to elevated temperatures.

#### CHARACTERIZATION OF SEASONAL RAINFALL VARIABILITY AND DROUGHT PROBABILITY OF THE SEMI ARID AREAS OF MBEERE REGION IN EMBU COUNTY, KENYA

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Drier parts of Embu County endure high atmospheric heat, prolonged dry spells, declining soil fertility and erratic rainfall patterns with large and growing population segments occasioning continued declines in agricultural productivity. Farmers' limited understanding of spatio-temporal rainfall distribution, plant-water-nutrient interactions, poor water and soil conservation techniques continue to impede optimal agricultural productivity. Hitherto, the much-needed information on inter/intra seasonal variability of rainfall is still inadequate despite its critical implication on soil-water distribution, WUE, Nutrient Use efficiency (NUE) and crop yield. This study sought to quantify and characterise inter/intra seasonal rainfall variability as the first step towards combating the effects of unpredictable rainfall patterns, prolonged dry spells and droughts in Mbeere District of Embu. To quantify seasonal rainfall variability, long-term daily rainfall data was subjected to preliminary homogeneity testing and frequency analyses based on normal distribution functions and transformation. Homogeneous seasonal rainfall amounts and number of rainy days was then subjected to variability quantification for both Long Rain (LR) during March-April-May (MAM) and Short Rain (SR) during October-November-December (OND) growing seasons. Long term rainfall trends and deviations from the average were evaluated using Cumulative Departure Index (CDI) based on normalized means of both seasonal and annual rainfall amounts within the period of record. Rainfall Anomaly Index (RAI) was then used to evaluate seasonal variability based on both negative and positive anomalies in seasonal and annual average rainfall. From the results, the rescaled cumulative deviations (RCD) had zero outliers for both seasons in the two stations restricting the homogeneity around the zero mark of RCD. The Number of NIL-values (below



threshold) were zero while Non-Nil Values (above threshold were 100%. A plot of homogeneity showed deviations from the zero mark of the RCD not crossing probability lines (thus homogeneity was accepted at 90%, 95% and 99% probabilities). There was at least 90% chance of receiving rainfall greater than 213.5 mm in MAM and rainfall amounts exceeding 258.1 mm during long rain seasons (OND) at both Machang'a and Embu respectively. Variability in seasonal rainfall showed that, in spite of the near homogeneity in the mean onset and cessation dates, the former was highly variable on an inter-annual scale. The two rainfall seasons are innately dissimilar and therefore require specific cropping in agro-ecological zone (Low Midland 4 and 5) LM4 and LM4-5. It is possible that farmers in (Inner Lowland 5) IL5 have been missing an opportunity by under-utilizing MAM rainfall. In terms of drought projection and probability, it was evident that the distribution of daily rainfall was vastly skewed with high frequency of occurrence dry spell events. The distribution of daily rainfall depths was also highly skewed, a comparatively small proportion of rainy days supplying a high proportion of the rainfall. The results should be incorporated in implications of climate variability and vulnerability assessment in semi-arid areas of Embu County.

#### **CHARACTERIZING ACCESS TO CLIMATE INFORMATION AND SERVICES BY THE VULNERABLE GROUPS IN SEMI-ARID KENYA**

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Women and the elderly living in semi-arid environments of Kenya are vulnerable to the frequent exposure to impacts of changing climate and need to access climate information and services to build their adaptive capacity. This study characterised the channels through which the vulnerable people in a semi-arid area of Kenya access climate information and services from data collected from randomly selected sample in cross sectional survey using structured questionnaire. Over 70% of both women and the elderly perceived change in rainfall, drought, floods, human and livestock diseases to have been "severe" to "very severe" over the last five years. Majority of women (88.5%) most preferred radio while the elderly (83%) most preferred indigenous knowledge to access climate information and services. Women consistently rated radio higher ( $P < 0.05$ ) than the elderly for delivering reliable information, explaining details and use of local language understood to them. However, Principal Component Analysis (PCA) indicated that comprehensive informing on climatic hazards and support services for adaptation to changing climate is from extension service unlike the other channels which delivered information only on climatic hazards. The study concluded that combination of extension agents, radio and local administration would be more effective for disseminating climate information and services to vulnerable people in marginal areas. Capacity building for extension service is needed in interpretation of weather data to enable them effectively disseminate climate information and services to vulnerable people of arid and semi-arid environments.



## CLIMATE CHANGE ADAPTATION PLANNING IN KENYA: DO SCIENTIFIC EVIDENCES COUNT?

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The effects of climate variability and change are undeniably clear in Kenya. Climate change extremes such as floods and seasonal droughts are already undermining Kenya's economic growth and the prosperity of her people. Precise estimates of climate change impacts, vulnerability, and cost and benefits of potential mitigation and adaptation measures are required to develop policies, plans and strategies to reverse this trend. A study was conducted in Kenya to assess the extent which scientific information has been used to inform climate change adaptation policies, plans and strategies. The study interrogated two major policy documents guiding climate change adaptation planning in the country, namely, the National Climate Change Response Strategy (NCCRS) and the National Climate Change Action Plan (NCCAP) for use of scientific information in their formulation. It also interviewed policy makers in the Central Government, Government departments, public universities and national research institutes. Both documents made fairly good use of evidence contained in technical reports, especially the United Nations Framework Convention on Climate Change (UNFCCC), World Bank and Food and Agriculture Organization of the United Nations (FAO) reports. However, they made very minimal, less than 20%, reference to the hard scientific facts offered by journals, books and workshop proceedings. Similarly, only about 6% of the respondents used the climate change information to develop mitigation and adaptation plans, training curricula, and Research & Development programs. The rest, over 76%, rarely used it for planning purposes. This could be attributed to limited knowledge of appropriate methodology to distil relevant decision-relevant information from the spectrum of available information on climate change projections, availability of the information in user-unfriendly formats, and lack of information sharing protocols. It is clear from the foregoing that there is a big disconnect between researchers and policy makers that needs to be fixed.



## **CLIMATE CHANGE AND DETERMINANTS OF ORGANIC MANURE USE TO COMBAT SOIL FERTILITY DECLINING IN THE SEMI ARID DISTRICT OF KIBWEZI, KENYA**

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Soil fertility is declining in many parts of sub-Saharan Africa due to various factors including climate change and human action. This article analyzes the socioeconomic factors influencing the use of organic manure to adapt to the declining soil fertility due to climate change in the semiarid region of Kibwezi in Kenya. A multinomial *logit* model is estimated to isolate the variables affecting the use of the strategy. The results show a correlation between socioeconomic variables and the use of organic manure in the face of declining soil fertility. Thus, we find that socioeconomic variables such as marital status, local expertise, access to resources, social relations in the village on the one hand, and the level of education of household heads to other hand, have respectively a significant influence on the probability of use of organic manure at the 5% and 10%. Other factors relevant a priori, in the model have no significant effect on the choice of the strategy by farmers, although they influence its choice. Thus, for a more efficient use of this strategy, development actors must mobilize themselves to support the farmers in their adaptation process for a sustainable agricultural development in the region.

## **EFFECTS OF SELECTED SOIL WATER CONSERVATION STRATEGIES ON MAIZE YIELD THROUGH FARMER MANAGED TRIALS IN THE CENTRAL HIGHLANDS OF KENYA**

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Small holder farmers in the Central highlands of Kenya have experienced a decline in crop yields in the recent decades due to continuous cropping without addition of adequate fertilizers and manures and nutrient loss through crop harvest, soil erosion and leaching. The problem is intensified by low and erratic rainfall, low inherent water storage (by the soils) and poor water harvesting techniques in the region leading to high rate of runoff carrying away soil nutrients essential for crop growth. Various soil water conservation techniques can lead to better use of rainfall, conservation of soil nutrients and an increase in farmers crop yield. The study area was in Meru South and Mbeere sub-counties. The objectives of the study were to evaluate the SWC strategies used in the central highlands of Kenya, assess the effects of selected soil water conservation (SWC) strategies on maize yields in the central highlands of Kenya, evaluate the effect of selected SWC strategies on soil organic matter through the farmer managed trials and to assess if the selected options reduce



the risks associated with rainfall distribution.. The key variables measured included biomass and grain yield, rainfall quantity, soil organic matter, labor cost and input prices. A farmer's interview schedule was conducted to collect both qualitative and quantitative data. Descriptive statistics such as frequency and percentages was used to analyze the data. The field experiment data was subjected to analysis of variance (ANOVA). Mean differences separated between treatments was examined using LSD at the 5% level of significance. Stability analysis was used to assess if the improved options effectively reduce the risk associated with rainfall distribution and timing of planting. The results were, from the survey 90 households were interviewed per sub-county and 78% of the HHs practice SWC strategies. The results from the field experiments showed that tied ridging (TR) increased maize grain yields by 85%, mulching (MC) by 80% compared to a conventional practice during the LR. Minimum tillage (MT) was found not to have much effect on the grain yield. During the short rain (SR) season maize yield increased by 62%, 43%, and 12% under TR, MC, and MT respectively. The soil organic matter was improved by 54%, 47%, and 22% under MT, TR and MC respectively during the LR and by 45%, 16% under MT, and MC respectively during the SR season. Risk reduction was evident under TR and MC while MT showed less reduction of the risks. From the planting dates early planting led to 35% increase in grain yields. The study would contribute and recommend the effective soil water conservation strategies under erratic rainfall with the aim to increase maize productivity in the study area.

## **EXPLORING GENDER DYNAMICS ON PERCEPTION OF CLIMATE CHANGE ON FARMING WITH FOCUS GROUPS IN MACHAKOS AND MAKUENI COUNTIES, KENYA**

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This paper presents findings from 16 focus group discussions which took place in June 2012 at Makueni and Machakos Counties with a view of understanding farmers' perception on gender role in regard to climate change in their farming systems. Total of 192 farmers from 10 villages were randomly selected to participate at the focus group discussions (FGDs). During the discussion, men were found to have noticed increased use of manure and fertilizer for fertility replenishment where as their female colleagues from both Counties noticed increased use of hybrid seeds as a remedy for dealing impacts of climate change and variability. All FGDs from Makueni wanted to adopt drip irrigation to deal with unreliable rainfall. In Machakos, female participants wanted to adopt drip irrigation while the men were in favour of greenhouses. Drip irrigation was preferred by FGDs of participants aged 18-54 years while greenhouses was preferred by participants aged 45-54 years of age. The impacts associated with climate change and variability at household level was increased conflicts between the husband and wife as well as increasing work load for women. The farmers suggested that policy interventions aimed at cushioning them



against food insecurity and harsh climatical changes taking into account gender sensitive integration measures.

## **IMPROVING LIVELIHOODS IN SEMI-ARID REGIONS OF AFRICA AND ASIA THROUGH REDUCED VULNERABILITY TO CLIMATE VARIABILITY AND PROMOTION OF CLIMATE RESILIENCE: A REVIEW**

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Climate change is expected to be one of the major threats to sustained economic growth leading to extended poverty in semi-arid regions of sub Saharan Africa (SSA) and Asia. The areas of highest vulnerability are the health sector, food production, biodiversity, water resources, and rangelands. Climate change will likely create increasingly high temperatures and dry conditions across much of the globe in the next 30 years, especially along large parts of Eurasia, Africa and Australia. Many of the world's most densely populated regions will be threatened with severe drought conditions. It will likely have a profound and negative impact on livelihoods of many rural and urban communities, which could lead to changes in land use. It is estimated that the Eastern regions of Africa will experience reduced average rainfall (although some areas may experience increased average rainfall) exposing agriculture to drought stress and a rise in temperature. The situation will be worsened by the interaction of multiple stresses factors occurring at various levels, which will negatively impact agricultural productivity. Many policy makers in governments are unaware of this long-term climatic impact, often leading to land use changes, and governments have low or no adaptive strategies or capacity to make people aware of climate change and climatic impacts in the long-term. Adaptation and mitigation strategies are two general responses to manage effects of climate change and variability. Although adaptation represents the best coping option against agricultural output reduction and hence resulting in improved livelihood of small holder farmers; mitigation actions will contribute to global efforts of greenhouse gas emissions reduction, sequestration of carbon as practical measures for climate change recovery, taking advantage of the carbon storage capacity of tropical environment and improving ecosystem services of the natural resource. This paper highlights measures which can be put in place to improve incomes and livelihoods in semi-arid regions of Africa and Asia through reduced vulnerability to climate variability and promotion of climate resilience in development investments, enhancing biodiversity, increasing yields and lowering greenhouse gas emissions.



## **INTEGRATING INDIGENOUS AND CONVENTIONAL KNOWLEDGE-BASED SEASONAL CLIMATE FORECASTS FOR FARMERS ENHANCED ADAPTATION TO CLIMATE VARIABILITY IN THARAKA-NITHI AND KITUI COUNTIES**

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Climate variability a condition that has a negative impact on crop productivity has affected many small-holder farmers in the arid and semi-arid lands (ASALs). Small-holder farmers in the study area are faced with this constraint and have consequently made effort at local level to utilize indigenous knowledge in addition to the already available conventional knowledge to assist in reducing the impacts of climate variability. This study was therefore undertaken with the aim of identifying the indigenous knowledge and preparedness techniques employed in coping with climate variability by small-holder farmers in the study area, integrate the indigenous and conventional knowledge of climate forecasting and assess how households' socio-economic factors influence the level of adaptation to climate variability. The study was conducted in Tharaka and Kitui-Central districts, Tharaka-Nithi and Kitui counties respectively and used both primary and secondary data. Data collected included: Indigenous and conventional knowledge of climate forecasting employed by small holder farmers; Household demographic and socio-economic characteristics; Impacts of climate variability on agricultural productivity and farmers' preparedness techniques to cope with this; Rainfall and temperature data from Kenya Meteorological Department (KMD). The research design for data gathering involved a triangulation approach to simultaneously collect both quantitative and qualitative data. Sampling strategy involved a purposive sampling in combination with snow balling technique and random sampling. Global Positioning System (GPS) was used to map the exact area of study. There were significant differences on the use of indigenous knowledge of climate forecasting in the two counties. The main strategies in use included checking the behaviour of trees, animals, sky, moon and wind. Indigenous knowledge of climate forecasting was found to be more reliable (60%) than the conventional knowledge (40%) in respect to adapting to climate variability. Factor analysis on 10 adaptation measures to climate variability identified 5 main factors that explained 64% of the original data on adaptation strategies employed by small-holder farmers in the study area. The five Varimax- rotated factors were designated as a good description of the level of adaptability. The 5 factors were consequently retained for subsequent analyses which involved a Multinomial Logit Regression (MNL) to predict the influence of various socio-economic factors on the level of adaptation to climate variability. Six variables were significant in influencing the level of adaptation to climate variability; gender, age, marital status, education level and main occupation of household head and total land size owned by the household. The study is envisaged to enrich the knowledge of extension service providers and small-holder farmers in the study area



by providing a better adaptation to climate variability and this is envisaged to ultimately improve agricultural production for the small-holder farmers.

## **INTEGRATING FARMERS AND SCIENTIFIC METHODS FOR EVALUATING CLIMATE CHANGE MITIGATION OPTIONS TOWARDS SORGHUM PRODUCTIVITY IN EMBU COUNTY**

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Embu County is characterized by poor harvest due to rainfall distribution; among other factors leading to declining poverty levels as a result of climate change. A study was conducted to evaluate comparisons of farmer's evaluation and scientific method on various climate change mitigation technologies for increased sorghum (*Sorghum bicolor* (L.) Moench) and cowpea (*Vigna unguiculata* L.) productivity in Mbeere south District. Three hundred and sixty six smallholder farmers were invited to evaluate thirty six plots laid out in Partially Balanced Incomplete Block Design (PBIBD) replicated three times. The treatment which were overall rated as 'good' was tied ridges with a mean score of (2.9), mean rank (2873.87) and yielding (3.7t/ha) under sole sorghum plus external soil amendment of 40 Kg P /ha + 20 Kg N /ha+ Manure 2.5t/ha. This was closely followed by tied ridges and contour furrows overall rated 'good' best three under the same soil fertility management options with a mean score ranging from 2.65 to 2.8 and yielding 2.7 t/ha to 3.7 t/ha. However, the treatments which were poorest overall rated as 'poor' were experiment controls with a mean score below (1.43), mean rank (1101.24) and yielding as low as (0.7 t/ha). Therefore, integration of minimal organic and inorganic inputs under various water harvesting technologies could be considered as an alternative option towards food security as a way of climate change mitigation options for semi arid areas for of Embu County.

## **VULNERABILITY TO CLIMATE VARIABILITY FOR AGRICULTURE SYSTEMS IN SEMI ARID KENYA**

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In the semi arid parts of Kenya, climate variability manifests in the form of extreme hydrological events (droughts and floods), short dry spells, extreme temperatures, onset and cessation of seasonal rainfall. These events affects agriculture systems which provide support for large populations. The assessment of vulnerability



unveils hidden weaknesses and strengths of human society towards a certain stressor or hazard. Climate variability affects the agriculture sector in all aspects including production, distribution and consumption. The impacts that climate variability typically produce among small holder agriculture communities in Kenya has devastating effect on their livelihoods. In this study, vulnerability is analysed in terms of its relation to the hazard posed by climate variability on small holder agriculture systems in Kenya. Using district disaggregated estimations an ex-ante vulnerable of climate variability on agriculture systems in Machakos and Makueni counties has been done. Factor analysis was used to identify indicators from selected variables. Vulnerability indicators identified were used to derive indices for describing complex livelihood realities in simple terms. The analysis of vulnerability index considers that the 'adaptation deficit' and excessive vulnerability to current climate variability is a good proxy of future vulnerability to climate variability. The theoretical foundation of this vulnerability assessment is the baseline for the methodological development of vulnerability indicators which capture the exposure, sensitivity, and capacities of agriculture systems of small holder communities concerning climate variability. A map of vulnerability Index based on a composite index of main indicators for exposure, sensitivity adaptive capacity has been developed. From the research, climate vulnerability to agriculture systems in the semi arid areas varies according to moderations of socioeconomic and institutional development and not as directly from exposure to climate variability.

#### ADAPTATION MEASURES INITIATED BY FARMERS DUE TO CLIMATE CHANGE IN INDIA

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This study documents the field impressions of farmers before and after climate change (of the year 2000) in the eastern dry agro-climatic zone of India. Fall in rainy days and rainfall concomitant with raise in daily temperature after 2000 has been acknowledged widely by farmers. This is corroborated by the rainfall and temperature. These factors exacerbated groundwater extraction for irrigation and domestic needs. In order to cope with the predicament, farmers shifted to late sowing varieties of ragi (*Eleusine coracana*), groundnut (*Arachis hypogaea*) and most other crops. Farmers adopted soil and water conservation measures such as farm ponds, ridges and dead furrows and mulching. A sizeable proportion of farmers had dairy (63%). Farmers with groundwater irrigation cultivating rice (*Oryza sativa*) / mulberry silkworms (*Bombyx mori*) followed suit. Those using conventional irrigation, shifted to drip irrigation, cultivating horticulture crops. While drip irrigation was used for broad spaced tree / horticulture crops earlier to 2000, farmers adapted drip irrigation even for narrow spaced tomato (*Solanum lycopersicum*), flowers, and banana crops. Case study of a vulnerable woman farmer



indicated that by participating in the groundwater market, the farmer purchased groundwater to cultivate vegetables, rear three local cows which provided her steady flow of income from milk. Her flock of sheep increased from 8 to 40, enhancing income from sheep by 300%. Thus, coping mechanisms were to sustain incomes and to be resilient due to climate change crisis. The raise in day temperature resulted in sun scorch, body weakness, body pain and associated disorders. These increased medical expense and the difficulty in working in the fields. Awareness and understanding of climate change has not reached grassroots and the challenge for social scientists and educators, in agriculture is in capacity building endeavors. These are inbuilt in the proposed model using synergies from program development, program delivery and program impact.

### **CHARACTERIZATION OF CLIMATE RISKS IN DRYLAND CROP-LIVESTOCK SYSTEMS OF KENYA**

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The complex form of resource management and vastness of dry lands in Kenya make it very difficult to assess risks associated with climate change. In this paper, we propose the use of a framework for exploration of climate risk assessments. The qualitative risk matrix encouraged stakeholder involvement and classified climate impacts into four severity categories: minor, moderate, major and severe. The likelihood of occurrence of impacts ranges from unlikely to extremely likely. A combination of Likelihood and severity determine the risk level. The assessment followed four steps where stakeholders documented risks and their consequences in matrices. Climatic impacts with Extreme risk level were droughts and sea water intrusion while. reduced and erratic rainfall had an overall high-risk level The climat factors are of greatest concerns to inhabitants in the ASALs and should be incorporated into adaptation decisions.



## **EFFECT OF TEMPERATURE AND RAINFALL ON MAIZE GROWTH AND YIELD UNDER DIFFERENT FERTILIZER (UREA, NPK, COMPOST) APPLICATION. A CASE STUDY OF RUBENGERA AND BUSOGO SECTORS IN RESPECTIVE WESTERN AND NORTHERN PROVINCES OF RWANDA**

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Temperature and rainfall variability associated with soil infertility have been and continue to be the principal sources of fluctuations in global food production in Rwanda. This study aims at investigating the combined effect of temperature and rainfall and soil fertility on maize crop growth and yield. The research was conducted in Western province (Rubengera sector) and Northern Province (Busogo sector) from March to June 2012. For collecting data, an experiment was conducted in both sectors and was laid out in a randomized block design (RBD) with urea (180kg/ha), NPK (361kg/ha) and compost (200kg/ha) application and had three replications in each site to homogenize the soil conditions in two sites. Data on maize growth and yield in both sites was analyzed using a two-way analysis of variance. The results showed significant differences among treatments and between both sites at 30, and 90 days, except at 60 days at ( $P < 0.05$ ). The highest mean plant height in Busogo site was 3.0367m given by NPK treatment while in Rubengera site, it was 2.9933 m. For the diameter, the analysis of variance showed significant difference between two sites at 60 and 90 days after planting at ( $P < 0.05$ ) except at 30 days after planting. The highest mean plant diameter in Busogo site was 27.16 mm given by NPK treatment and in Rubengera site, it was 26.86 mm given by the control. For the yield, the analysis of variance showed significant difference among treatments and between both sites at the harvesting time. The highest mean maize yield in Busogo site was 8.8 kg given by NPK treatment. In Rubengera site, it was 7.96 kg given also by NPK treatment. As the study was done under similar soil conditions, the difference in yield and growth was due to temperature and rainfall variability. There were also various influences of temperature and rainfall on maize yield and growth. Long-term database collection is recommended.



## **EFFECTS OF GYPHOSATE BASED HERBICIDE ON WEED MANAGEMENT AND MAIZE PERFORMANCE UNDER ZERO TILLAGE CONSERVATION AGRICULTURE SYSTEM IN EASTERN KENYA**

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Maize production lags behind the population demand in eastern Kenya regions, and this is attributed to weeds competition with the crop for various growth resources, among other factors. A study was conducted in the region to determine the effects of Glyphosate based herbicides on weeds management and maize performance. The first (LR 2011), second (SR 2011) and third (LR 2012) season's trial results observed that the glyphosate based herbicides are effective means of weed management in maize grown under zero tillage conservation agriculture systems. Roundup Turbo applied at 2.5 lits ha<sup>-1</sup> and the three (1.5, 2.5 and 3.0 lits ha<sup>-1</sup>) tested rates of Roundup Weathermax herbicide performed comparatively well in terms weeds control and therefore improving maize grains and shoot biomass. In addition the product did not have any noticeable phytotoxicity on the crop. Likewise the herbicides treated plots resulted in improved NB compared to results from un-weeded and the conventionally tilled fields. The crop yields significantly ( $p \leq 0.05$ ) differed between un-weeded and weed controlled treatments (both conventional and herbicide methods). Conventionally tilled treatment gave an average grain yield of 3.6 t ha<sup>-1</sup> that was not significantly different from those from zero tillage treatments. The lowest grain yield (0.1 t ha<sup>-1</sup>) was acquired from un-weeded treatment and significantly ( $p \leq 0.05$ ) differed from those of conventional and herbicides treatments. The study concluded that the use of Glyphosate based herbicide is an appropriate and economic approach for weed management in maize grown under zero tillage conservation agriculture systems.

## **ENHANCING FOOD PRODUCTION IN SEMI ARID COASTAL LOWLANDS KENYA THROUGH WATER HARVESTING TECHNOLOGIES**

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About 35% of coastal lowland Kenya is classified as semi-arid lands, and food production in these areas is constrained by low soil moisture. To address the constraint, two studies were conducted during the 2010 long rains, 2011 long rains and, both 2011 and 2012 short rains seasons to evaluate the performance of drought tolerant maize varieties under different water harvesting technologies (Zai pits, tied ridges and conventional). The treatments were laid out in a split plot design with water harvesting methods as the main plots and maize varieties as the sub-plots. Four maize varieties (DK8031, DUMA 43, KDV1 and PH4) were evaluated under the three water harvesting technologies for the first experiment. For the second experiment, four maize plant population treatments of 3 (P3), 5 (P5), 7 (P7) and 9 (P9) plants per pit were used. Maize variety DUMA 43 was used alongside the four plant



populations. The results for both experiments indicated that the maize yields in zai pits and tied ridges treatments were significantly ( $P < 0.05$ ) higher than for conventional treatment and the population of 5 plants per pit had significantly ( $P < 0.05$ ) higher grain yield than the rest of treatments.

## **GREEN INFRASTRUCTURE FOR ENHANCING SOIL-WATER-PLANT NUTRIENT BALANCE AND CLIMATE CHANGE ADAPTATION ON SMALLHOLDER FIELD**

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Use of vetiver as a green infrastructure can address African farmers' ecological problems through protecting farmlands on steep lands. In addition, it offers the opportunity to integrate smallholders into the green economy as it sequesters carbon, keep water and nutrient fluxes within the system, sustain high crop yield with climate change adaptation potentials. This is particularly important as more slopes are converted to agricultural lands due to increase in population density and poverty. Thus, the study investigated the optimal strip width for increases in soil productivity and farmers' preferences for space. The study planted maize and cassava in between vetiver field structures (VFS) installed on the contour at 5, 15, 25 m apart and compared it with Farmers' Practice (FP) on a 45 % slope and quantified the amount of soil displaced, water and plant nutrient losses and crop yields. Vetiver installed at 5 m surface interval spacing significantly enhanced carbon sequestration indicating potentials for GHGs mitigation and reduced N, P, Ca, Mg, Na and K losses when compared with FP. Vetiver allowed only 7 % rainfall lost as against 29 % on FP this demonstrates the climate change adaptation potentials of vetiver. Soil displaced under FP was 68 times higher than the soil loss tolerance limit of 12 t ha<sup>-1</sup> yr<sup>-1</sup> whereas under VFS at 5, 15 and 25 m it was 2½, 13 and 12 times higher. Maize grain yield were 35, 23 and 24 % higher on the VFS field at 5, 15 and 25 m respectively when compared to FP. The corresponding values for cassava fresh tuber were 43, 32 and 29 % higher. Unlike other technologies, vetiver grass contributes to the livelihood of the farmers by providing raw material for house thatching, handicrafts and fodder for livestock during lean seasons.

## **CASSAVA FARMING TRANSFORMING LIVELIHOODS AMONG SMALLHOLDER FARMERS IN MUTOMO A SEMI-ARID DISTRICT IN KENYA**

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Cassava produces about 10 times more carbohydrates than most cereals per unit area, and is ideal for production in marginal and drought prone areas like Mutomo, which comprise about 80% of Kenya's land mass. Mutomo district situated in Kitui County in semi-arid Eastern Kenya was one of the areas that were selected for the establishment of a cassava seed system in a bid to improve food security. In 2009, a



needs assessment was carried out in Mutomo which resulted in community groups agreement to start the Mutomo Cassava Production and Processing Association (MUKAPA). The project involved more than 100 households which established high-yielding, disease and drought-resistant cassava varieties developed by the Kenya Agricultural Research Institute (KARI). During the last quarter of year 2012, A team of journalists, extension and research officers went out on a fact finding tour to assess the impact the introduction of elite cassava had on the livelihoods of participating farmers in Mutomo using photography and focussed group discussions. The study established that climate change is real and has negatively affected smallholder farmer families in Mutomo and as such it was prudent to introduce drought tolerant crops like cassava in order to improve food security as a climate change adaptation technology. It was evident the elite cassava varieties from KARI were supplying the much needed carbohydrates in an affordable form. The assessment also established water scarcity is a major development-limiting factor in Mutomo that needed urgent attention. The Mutomo community had shed "*Mwolyo*" the handout mentality through adoption of appropriate technologies for this place like growing, processing, marketing, and consumption of cassava. Cassava roots were mainly marketed as fresh roots for chewing and boiling. Cassava cuttings and cakes on sale in the Mutomo market suggested that demand for cassava was rising and only need upscaling. Being dominated by agro-pastoralists, it was obvious that cassava and other crops that take more than four months before being harvested do not fit well into the system and this is an area that has to be addressed to pre-empt potential conflicts.

#### **INTEGRATION OF INDIGENOUS KNOWLEDGE IN AGRICULTURAL INFORMATION AND COMMUNICATION SYSTEMS FOR ADAPTATION TO CLIMATE CHANGE BY SMALLHOLDER FARMERS OF COASTAL KENYA**

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Indigenous technical knowledge is an accumulated experience over time, which could provide insightful guidance into management of climate variability if it was identified and recognized. This study aimed at identifying and integrating indigenous knowledge (ITK) for adaptation to climate change by smallholder farmers in coastal Kenya. The study was able to identify existing ITK that farmers use. These include planting of drought -tolerant crops (44%) to cope with floods and 58% for erratic rainfall. 66.9% of the respondents also indicated that they use traditional crop varieties to cope with drought. Based on the results, it is recommended that policy interventions be employed in creating strategies that would encourage identification and recognition of ITK and its inclusion into scientific agricultural practices that would enable farmers to plan for and cope with current climate risks and adapt to future climate change. This would ensure sustainability and vitality in improving agricultural production for food security.



## POTENTIALS OF ORGANIC FERTILIZERS IN CLIMATE CHANGE MITIGATION

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Climate change is a reality in this present time, as inconsistency of climatic factors from year to year over some time now reveals. Climate change has impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Thus the need to do everything possible to mitigate the effects of climate change by reducing the emissions of the green house gases (GHGs). Agriculture has great potential to mitigate climate change by reducing the buildup of the GHGs in the atmosphere as organic fertilizers may prove a large depository for excess carbon dioxide. There was a review of the performance of some of the several organic fertilizers that had been evaluated by several authors relative to the mineral fertilizers and therefore see if the farmers stand to loose anything in terms of yield by adopting the use organic fertilizers. The reports from all the authors considered in this review shows that the use of organic fertilizers improved yield and also compared favourably and sometimes performed significantly better than the mineral fertilizer. Therefore the need to encourage farmers to use organic fertilizers in place of mineral fertilizer thereby reducing the emission of CO<sub>2</sub> and N<sub>2</sub>O hence mitigate climate change while the yield of crops is sustained and even improved.

## HYPOTHESIS OF HOPE REVISITED: CONSEQUENCES OF CLIMATE CHANGE FOR RURAL HOUSEHOLDS' AGRICULTURAL INCOME

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The Hypothesis of Hope (Cooper *et al.*, 2009) postulated that adoption by farmers of existing improved technologies (crop varieties and management techniques) could more than compensate for predicted yield losses as a consequence of climate change. Based on this hypothesis, a research project, 'CALESA - Climate Analogue Locations in Eastern and Southern Africa', initiated in January 2011, has collected household data from four sites in Zimbabwe and four sites in Kenya. In each country, sites were chosen in pairs matched for rainfall (a 'wet' pair and a 'drier' pair) but differing in mean annual temperature by 2-3 degrees Celsius. The objective was to investigate differences in agricultural practices associated with differences in temperature and the interaction between those differences and rainfall. A simple relationship was developed between net returns per hectare and household assets and used to model the consequences of a range of climate-related reductions in yield (and net returns) for household incomes at all eight sites.



## IMPACTS OF CLIMATE CHANGE ON PERFORMANCE OF AGRICULTURAL SYSTEMS

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There is growing evidence that the climate change is not only real and happening but is occurring at more rapid pace than previously anticipated. The planet is expected to continue to warm even if the global community agrees and cuts the emissions to zero level until the energy stored in the system reaches an equilibrium level. As per the available projections, most parts of Eastern Africa will be warmer by about 3°C by midcentury. The fact that we are going to live in an increasingly warmer climate raises several questions: what changes will climate change bring to Eastern Africa? What impact will these changes have on agriculture in the region? How can we mitigate and adapt to the negative impacts of climate change? Crop simulation models such as APSIM mimic the growth and development of crops. The models integrate the data on weather, soil, and crop management to predict crop growth and yield under a range of management practices. These models when used with downscaled climate change scenarios will provide insights to key questions about climate change impacts on crop production. Effects of climate change on maize production were simulated at three locations in Kenya viz., KampiYaMawe, Katumani and Embu using crop simulation model APSIM and MarkSim-GCM generated future climates to mid and end century periods. Results indicate that under low input systems, maize grain yields are expected to increase under climate change scenarios compared to the baseline situation. This is partly due to the projected increase in rainfall and partly due to increased mineralization and availability of nitrogen. However, the model predicts a significant decline in biomass yields mainly due to a reduction in the crop growing period. These results are discussed in relation to the changes in water availability and response to fertilizer and other management practices. It also identifies potential management practices that can reduce the negative impacts and increase or sustain yields under future climates.



## **INTEGRATING FARMERS AND SCIENTIFIC METHODS FOR EVALUATING CLIMATE CHANGE MITIGATION OPTIONS TOWARDS SORGHUM PRODUCTIVITY IN EMBU COUNTY**

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Embu County is characterized by poor harvest due to rainfall distribution; among other factors leading to declining poverty levels as a result of climate change. A study was conducted to evaluate comparisons of farmer's evaluation and scientific method on various climate change mitigation technologies for increased sorghum (*Sorghum bicolor* (L.) Moench) and cowpea (*Vigna unguiculata* L.) productivity in Mbeere south District. Three hundred and sixty six smallholder farmers were invited to evaluate thirty six plots laid out in Partially Balanced Incomplete Block Design (PBIBD) replicated three times. The treatment which were overall rated as 'good' was tied ridges with a mean score of (2.9), mean rank (2873.87) and yielding (3.7t/ha) under sole sorghum plus external soil amendment of 40 Kg P /ha + 20 Kg N /ha+ Manure 2.5t/ha. This was closely followed by tied ridges and contour furrows overall rated 'good' best three under the same soil fertility management options with a mean score ranging from 2.65 to 2.8 and yielding 2.7 t/ha to 3.7 t/ha. However, the treatments which were poorest overall rated as 'poor' were experiment controls with a mean score below (1.43), mean rank (1101.24) and yielding as low as (0.7 t/ha). Therefore, integration of minimal organic and inorganic inputs under various water harvesting technologies could be considered as an alternative option towards food security as a way of climate change mitigation options for semi arid areas for of Embu County.

## **CALESA: ADAPTING AGRICULTURE TO CLIMATE CHANGE: DEVELOPING PROMISING STRATEGIES USING ANALOGUE LOCATIONS IN EASTERN AND SOUTHERN AFRICA**

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This paper describes the project CALESA, lead by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and performed in cooperation with the Kenya Agricultural Research Institute (KARI), Kenya Meteorological Department (KMD), Zimbabwe Meteorological Department (ZMD), Midlands State University (MSU), and the Hamburg University of Applied Sciences (HAW) in Germany. Using



a combination of model-based *ex ante* analyses and iterative field-based research on station and in farmers' fields, the project has tested potential agricultural adaptation strategies for rainfed agriculture in the semi-arid and dry sub-humid tropics. This has been achieved through choosing four currently important crop production zones (two in Kenya and two in Zimbabwe) and then identifying corresponding 'spatial analogue locations' for each production zone, providing eight study locations in all. This paper presents the project, its methods, the approaches used and outlines some of the results reached. A strong element of participatory research with farmers within the project locations, coupled with a special emphasis to gender issues, has ensured that the project activities and outputs may be replicable elsewhere in Africa.

## **OPPORTUNITIES FOR COPING WITH CLIMATE VARIABILITY: A CASE OF MWANIA AND MAKINDU WATERSHEDS IN LOWER EASTERN KENYA**

**Wangui L., Rao K.P.C. and Kizito K.**

Rainfed agricultural systems in semi-arid Kenya are highly vulnerable to climate variability and the same is going to be further exacerbated by the projected changes in climate. One of the areas where significant impacts of climate on agriculture are felt Climate change is expected to bring changes in the climates of increase the temperature and Climate variability has resulted in increased vulnerability of smallholder farmers in marginal areas of Kenya where there is limited capacity to adapt to changing climate. Soil and Water Conservation (SWC) technologies can play an important role in mitigating the negative effects of climate variability. Field surveys were conducted in Mwanja and Makindu watersheds with an aim of identifying opportunities for coping with climate variability through adoption of SWC technologies. Adoption of existing SWC technologies and the perceptions of adopters and non-adopters were evaluated. A total of 380 farmers randomly selected from 12 villages were involved in the study. Data were analysed using descriptive statistics and frequencies in SPSS version 11.5. Terracing is the most adopted technology in both sites while tied ridges (16%) and mulching (37%) are the least adopted technologies in Mwanja and Makindu watersheds respectively. Common reasons provided by farmers for adopting SWC technologies was benefits accrued which included increasing yields/productivity, reducing erosion and run off and increasing the infiltration capacity of the soil. High cost was perceived the constraint by non-adopters of the existing SWC technologies. The insights from the study are useful for future planning of Mwanja watershed which is an analogue location for Makindu watershed.



## **CRITICAL ANALYSIS OF TILLAGE PRACTICES WITH FERTILITY LEVELS IN MAIZE AND POPULATIONS IN BEANS AS ADAPTATION MEASURES TO CLIMATE CHANGE TO ENHANCE FOOD SECURITY AT KABETE**

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Trials were carried out in 2012/2013 short and 2013 long seasons at Kabete site representing a warm/wet environment in Kenya to determine for maize, the appropriateness of combining fertilizer levels and for beans, population levels with tied ridges as adaptation measures under changing climate. The maize experiment consisted of three fertilizer levels of 0, 20 and 40 kg/ha N while the bean experiment had three spacings of 12, 15 and 20 cm in a split plots design. The experiments were replicated thrice and consisted of conventional tillage (N) and tied ridges (TR) as main plots representing the two soil water management practices while the three soil fertility options (in maize N<sub>0</sub>, N<sub>20</sub> and N<sub>40</sub>) or spacings (12, 15 and 20cm) were sub plots in a Completely Randomized Block Design. The ridges were tied at intervals of 1 m and spaced at recommended crop spacings (i.e. 75cm for maize and 45cm for beans) and the crop planted on the slope of the ridge in 6 by 5 m plots. Basal phosphate (P<sub>2</sub>O<sub>5</sub>) fertilizer in the form of Triple Superphosphate (TSP) was applied at planting time at the rate of 40kg/ha. Nitrogen in the form of Calcium Ammonium Nitrate was applied at 20 Kg/ha in the 20 and 40 N treatments at planting and further 20kg/ha N top dressed in the 40 treatment level. Harvesting was done at physiological maturity of grain which was air dried. Statistical analysis was done of the treatments and comparisons done of the adaptation advantages of the treatments. Tied ridging increased maize yields at the medium fertilizer level of 20 (+5.22%) but were negative under both zero (-15.56%) and 40 kg/ha application of fertilizers (-5.42%). In the short season, increased bean spacing from 12 to 20 decreased yields under normal (-13.6%) and tied ridges (-37.3%) but remained higher at populations of 12 and 15. In the long season increasing bean population from spacing of 12 cm to 20 had no advantage and under tied ridging compared to normal tillage. Tied ridging as a climate change adaptive measure should not be instituted as a blanket recommendation across rainfall regimes, crops, fertilization levels or plant populations and is more advantageous in drier seasons.

## **GENERATING LOCATION SPECIFIC FUTURE CLIMATES TO ASSESS IMPACTS OF CLIMATE CHANGE ON AGRICULTURAL SYSTEMS**

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One of the problems in assessing the impacts of climate change on agricultural systems is the lack of location-specific changes in climate. While fairly accurate projections about the expected changes in climate are available at global and regional levels, uncertainty prevails over the precise nature of these changes at local level.



Without knowing what will be changes in climate at local level, it is extremely difficult to plan and develop appropriate adaptation strategies, programs, and technologies. Considering the need for these projections, several downscaling techniques have been developed to derive location specific future climates using the current trends in local climate and outputs from the global circulation models. MarkSim-GCM is one such tool developed by the CCAFS program of CGIAR to generate location-specific weather data for future climates, using six climate models and the ensemble average and three greenhouse gas emission scenarios that were part of the IPCC's Fourth Assessment Report. The tool can also be used to generate daily data that are characteristic of current conditions, based on the WorldClim dataset, an interpolated surface of weather station data from around the world mostly covering the years 1960-1990. Using MarkSim-GCM, we generated baseline and future climates to mid and end century periods for five different locations in Kenya viz., KampiYaMawe, Katumani, Kabete, Embu and Nyahururu. The model accuracy was evaluated by comparing the observed data at these locations with the model generated baseline conditions. In general there is a 83% agreement between generated and simulated baseline climates, even though all model generated baselines simulated higher annual rainfall. All models also predicted an increase in both max and min temp which ranged between 8 and 2 degrees Celsius with the maximum temperature showing a higher increase in the A2 high emission scenario than the b1 low emission scenario within the end century time scale, while no difference in the magnitude of change between the two was observed within the mid century time scale. However among the locations Embu, Katumani and KambiYaMawe were expected to experience greater increase than Kabete and Nyahururu. In case of rainfall, all GCMs predicted an increase in the annual rainfall to both the mid and end century periods while most predicted a decrease in seasonal (both SR and LR) rainfall, particularly in the LR season in almost all locations; apart from KampiYaMawe. The GCM A2 high emission scenarios particularly predict a reduced rainfall situation in the LR season with ranges of declines between 494 mm and 8 mm. Four of the six models predicted a decline in long rain season (LR) rainfall in four of the five locations to midcentury while two GCMs predicted that the rainfall will decrease in all locations by end century from the current levels. It is only at KambiYaMawe that all GCMs predicted an increase in rainfall in both time scales. The change in annual, SR season and LR season rainfall varied from 113% - 7%, 116% - 1% and 88% - 2% respectively to end century.

## **IN-SITU SOIL MOISTURE CONSERVATION: UTILIZATION AND MANAGEMENT OF RAINWATER FOR CROP PRODUCTION**

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In-situ rainwater conservation technologies tested in semi-arid eastern Kenya have been reviewed. These technologies are the Fanya juu terraces, Contour bands, Negarims, Trapezoidal bunds, on-farm Micro catchments, Zai pits, Tumbukiza, Tied ridges, Deep tillage and Sub soiling and ripping. These technologies hold rainwater on farms storing it on soil surface thus rendering it more infiltration time and raising



the overall soil moisture status which would not be attained in absence of these interventions. Zai pits, tumbukiza and deep tillage when used together with soil fertility improvements has potential to increase crop yields by 4-10 times when compared to other similar fields conventionally cultivated. Tied ridging when used with fertilizer, manure or their combination has potential to increase crop yields by 100-300%. Sub soiling and ripping similarly increases crop yields by 50-100% when used together with soil fertility improvements. Micro catchment technology at 1:1 and 2:1 catchment to cultivated land ratio has potential to increase crop yields although it is not widely practiced due to land limitation. Use of fertilizers and or manures with in-situ soil moisture conservation leads to improved water use efficiency by crops planted in the semi-arid eastern Kenya. Manure has been shown to increase soil moisture profile irrespective of used in-situ soil moisture conservation technology. It is proposed that whatever in-situ rainwater conservation technologies are used, manure should be an integral part of the technology for increased soil moisture conservation and utilization by crops for increase crop production and food security in the semi-arid eastern Kenya..

#### **ON - STATION EVALUATION OF MAIZE GENOTYPES FOR NUTRIENTS AND WATER USE EFFICIENCY IN THE SEMI ARID LANDS OF COASTAL KENYA**

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About three quarters (75%) of the land in coastal Kenya is either arid or semi-arid. Crop failure, especially for maize, is very common in the region. Despite this situation, farmers persistently plant maize every season. Rainfall in arid and semi-arid areas is usually low, erratic and unevenly distributed. Crop yields are extremely low due to not only inadequate soil moisture but also low and declining soil fertility. This therefore calls for integrated technological intervention to address the problem. In the sub-humid regions of coastal Kenya, 24% of land receives enough rainfall to sustain crop production during the long rains (LR) season. However, during the short rain (SR) season, low amount of rainfall is received, and crop failure is common. In a normal year, two thirds of the total annual rainfall is received during the LR season. Despite the prevailing situation, farmers continue growing maize during the SR season and therefore risk crop failure. Some farmers also plant maize varieties meant for long rain season hence increasing the risk of crop failure. The study was therefore designed to evaluate maize varieties and water harvesting tillage technologies and their effect on the performance of maize in order to come up with a recommendation on the suitable maize varieties for planting under the relatively harsh environments. The results indicate that rainwater harvesting is not critical when the season is wetter than normal in the arid and semi-arid environments. Despite the excellent performance of PH4, CCM and Mdzihana, these maize varieties cannot be recommended for the semi-arid areas since the high yields were realized under above normal rainfall. There is need for further research to



identify the maize varieties that would be appropriate for the areas that normally receive low rainfall.

## GRAIN YIELD OF SELECTED CROPS AT FOUR CLIMATE ANALOGUE LOCATIONS IN ZIMBABWE

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Predicted warmer climates are likely to negatively affect production systems and expose smallholder farmers in sub-Saharan Africa, whose adaptive capacity is limited mainly due to poverty, to food insecurity. We studied the performance of selected varieties representing short, medium and long duration growth periods of four crops (maize (*Zea mays* L.), sorghum (*Sorghum bicolor* (L.)), groundnut (*Arachis hypogaea* L.) and cowpea (*Vigna unguiculata* (L.)) at two pairs (wet and dry) of 2050s climate analogue sites. Climate analogues, based on 30 years meteorological data, were identified in smallholder areas of Zimbabwe. The sites were Kadoma (722 mm annual mean rainfall; 21.8°C annual mean temperature) which was the higher-temperature analogue site for Mazowe (842mm annual mean rainfall; 18.2°C annual mean temperature) for wetter areas, and Chiredzi (541mm annual mean rainfall; 21.3°C annual mean temperature) which was the higher-temperature analogue site for Matobo (567mm annual mean rainfall: 18.4°C annual mean temperature) for drier areas. First season (2011/12) results showed that for the wetter pair, maize and groundnut grain yields were significantly higher at the cooler site (Mazowe). Sorghum yields were not significantly different between the sites and there was no grain yield for cowpea at the cooler site due to a fungal disease. Varietal yield differences were only significantly higher ( $P < 0.05$ ) at the cooler site for groundnut where the short duration variety had the highest yield (3809 kg/ha) and the medium duration variety the lowest yield (1420 kg/ha), compared with 140-355 kg/ha at the hotter site where growth was poor for all varieties. For the drier sites, maize, sorghum and cowpea grain yields were higher at the cooler site (Matobo) compared with the hotter sites (Chiredzi) but varietal differences were not significant. Results for the second season (2012/13) will be presented.



## **RICE HUSK AND *TYPHA AUSTRALIS* BIOCHAR IMPROVE WATER STRESS TOLERANCE AND YIELD OF MILLET IN SENEGAL**

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Senegal is a Sahelian country where most of the soils are very sandy receiving less than 800mm per year. Charred biomass (Biochar) was so far mostly known for substitution of fire wood energy to minimize the pressure on already small available natural resources. Since scientific evidences elsewhere indicate that soil amendment with biochar enhances among others, nutrients availability to plant as well as soil water holding capacity, the potentialities of rice husk and *Thypha australis* biochar on improving water stress tolerance and yields of millet (V-SOSAT-C88) were investigated in a randomized bloc design with 4 replicates in greenhouse. At 6 weeks after in green house, addition of  $\frac{1}{2}$  NPK crops' recommended dose rate to 5 t ha<sup>-1</sup> of *Typha australis* or rice husk biochar as well as 5 t ha<sup>-1</sup> of *Typha australis* biochar + 2 t ha<sup>-1</sup> of cow manure increased total dry biomass of millet plants to 82.65%, 77.41% and 22.46% respectively in comparison to the control plant treatment. These same treatments enhanced also chlorophyll concentration in plant leaves (+37, 63% et 36,33% respectively) as well as leaf stomata conductance (42.3; 52.7 and 40,2%). In demonstrating field trials at ISRA-CNRA research center of Bambey, these treatments increased millet yields by 52% 66.5% and 37.3% compared to control plants. This study gives insights that in addition to solving environmental challenges, judicious use of biochar as soil amendment at small scale farming in dry sandy soil such as Senegal, could improve soils' proprieties and enhance cereals production.

## **CRITICAL ANALYSIS OF TILLAGE PRACTICES WITH FERTILITY LEVELS IN MAIZE AND POPULATIONS IN BEANS AS ADAPTATION MEASURES TO CLIMATE CHANGE TO ENHANCE FOOD SECURITY AT KABETE**

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Trials were carried out in 2012/2013 short and 2013 long seasons at Kabete site representing a warm/wet environment in Kenya to determine for maize, the appropriateness of combining fertilizer levels and for beans, population levels with tied ridges as adaptation measures under changing climate. The maize experiment consisted of three fertilizer levels of 0, 20 and 40 kg/ha N while the bean experiment had three spacings of 12, 15 and 20 cm in a split plots design. The experiments were replicated thrice and consisted of conventional tillage (N) and tied ridges (TR) as main plots representing the two soil water management practices while the three soil



fertility options (in maize N<sub>0</sub>, N<sub>20</sub> and N<sub>40</sub>) or spacings (12, 15 and 20cm) were sub plots in a Completely Randomized Block Design. The ridges were tied at intervals of 1 m and spaced at recommended crop spacings (i.e. 75cm for maize and 45cm for beans) and the crop planted on the slope of the ridge in 6 by 5 m plots. Basal phosphate (P<sub>2</sub>O<sub>5</sub>) fertilizer in the form of Triple Superphosphate (TSP) was applied at planting time at the rate of 40kg/ha. Nitrogen in the form of Calcium Ammonium Nitrate was applied at 20 Kg/ha in the 20 and 40 N treatments at planting and further 20kg/ha N top dressed in the 40 treatment level. Harvesting was done at physiological maturity of grain which was air dried. Statistical analysis was done of the treatments and comparisons done of the adaptation advantages of the treatments. Tied ridging increased maize yields at the medium fertilizer level of 20 (+5.22%) but were negative under both zero (-15.56%) and 40 kg/ha application of fertilizers (-5.42%). In the short season, increased bean spacing from 12 to 20 decreased yields under normal (-13.6%) and tied ridges (-37.3%) but remained higher at populations of 12 and 15. In the long season increasing bean population from spacing of 12 cm to 20 had no advantage and under tied ridging compared to normal tillage. Tied ridging as a climate change adaptive measure should not be instituted as a blanket recommendation across rainfall regimes, crops, fertilization levels or plant populations and is more advantageous in drier seasons.

#### **CRITICAL UTILIZATION FOR FOOD SECURITY OF MAIZE AND SORGHUM UNDER WATER HARVESTING AND FERTILIZERS AS ADAPTIVE MEASURES TO CHANGING CLIMATE IN SMALLHOLDER FARMS IN KENYA**

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Trials were carried out with maize (DK8031 variety) and sorghum (KARI Mtama 1) at two analogue sites representing a wet/cool (Ol Joro Orok) and a wet/warm climate (Kabete) in 2011 short and 2012 long seasons. Three fertilizer levels of 0, 20 and 40 kg/ha N in the form of Calcium Ammonium Nitrate in a Completely Randomized Block Design (CRBD) in split-split plots design representing conventional tillage (N) and tied ridges (TR). The trial was laid using "split-split-plot design". The main plots represented the two soil water management practices (W<sub>0</sub> and W<sub>1</sub>), sub-plots three soil fertility options (F<sub>0</sub>, F<sub>1</sub> and F<sub>2</sub>) and sub-sub-plot two crops (C<sub>1</sub> and C<sub>2</sub>). The treatments were replicated thrice. The ridges were tied at intervals of 1 m and spaced at 75cm between rows and the crop planted on the slope of the ridge with maize and sorghum intra row spacings of 30 and 20cm respectively. Basal phosphate (P<sub>2</sub>O<sub>5</sub>) fertilizer in the form of Triple Superphosphate (TSP) was applied at planting time at the rate of 40kg/ha. 20 Kg/ha N were applied in the 20 and 40 N treatments in 6 by 5 m plots at planting and 20kg/ha N top dressed in the 40 treatment level. Data was collected on days-to-flowering, to physiological maturity, above ground biomass and grain yields. Analysis assessment of the results show that tied ridges decreased yields both under zero N application



and under application of 40kg/ha but increased when 20 kg/ha was applied. In the wet warm climate, maize yields increased by 32% when fertility levels were raised from 0 to 40kg/ha while under tied ridges this increment was 43%. It is therefore not advantageous to institute tied ridging both when there is no fertilizer application and when the fertilizer rates are higher than 20Kg/ha. Only modest N (i.e. 20kg/ha) is required if it is to be accompanied by fertilizer application at Kabete otherwise higher fertility levels can be instituted without engaging labour into constructing tied ridges. At Ol joro orok increasing the fertility rates decreased the yields under normal tillage by 10.9% and under tied ridges by 31.6%. This implies that institution of tied ridges is not necessarily advantageous except under lower fertility levels (i.e. 0, 20kg/ha). There is therefore an option to use tied ridges without fertilizers at this site.

### **DROUGHT MITIGATING TECHNOLOGIES: LESSONS LEARNT FROM SORGHUM AND COWPEA PRODUCTION IN SEMI-ARID AREAS OF EMBU COUNTY, EASTERN KENYA**

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The lower parts of Embu County in Eastern Kenya are characterized by poor harvest due to rainfall distribution; among other factors leading to declining poverty levels. Rain-fed agricultural productivity has continually declined due to unpredictable and unreliable rainfall patterns. The decline in crop productivity has been as a result of inadequate understanding of intra-seasonal rainfall variability to develop optimal cropping calendar. A study was conducted to access the effect of various water harvesting and integrated soil fertility management technologies for enhanced sorghum (*Sorghum bicolor* (L.) Moench) and cowpea (*Vigna unguiculata* L.) productivity in Mbeere South Sub-County. The field experiment was laid out in Partially Balanced Incomplete Block Design (PBIBD) with a total of 36 treatments replicated three times. The treatments of tied ridges and contour furrows under sorghum alone and intercrop plus external soil amendment of 40 Kg P /ha + 20 Kg N /ha + manure 2.5 t/ha had the highest grain yield of 3.1 t/ha. The soil fertility levels differed significantly from one another ( $p=0.0001$ ) in terms of sorghum and cowpea grain yield. Generally, all experiment controls had the lowest grain yields as low as 0.3 t/ha to 0.5 t/ha. Therefore, integration of minimal organic and inorganic inputs under various water harvesting technologies could be considered as an alternative food security initiative towards climate change mitigation for Mbeere South Sub-County, Embu County in Eastern Kenya.



## THEME II: INTEGRATED NUTRIENT MANAGEMENT

### EVALUATION OF SOYBEAN [*Glycine max* (L.)Merr.] GENOTYPES IN CENTRAL AND NORTH RIFT VALLEY OF KENYA

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Multi-environment trials (MET) are carried out to identify superior and stable soybean genotypes and to understand the effects of genotype and environments on soybean performance. The interaction between genotypes and environments results in significant differences in the performance of genotypes when tested in various environments. The purpose of the study was to quantify protein and oil content of fifteen soybean genotypes, determine their performance in terms of yield and yield components and identify high yielding soybean genotypes for human food and feed consumption in the test environments. The experiment was laid out in a complete randomised block design in three replicates. The results indicated significant ( $p \leq 0.01$ ) effect due to, genotype and genotype  $\times$  environment for days to 50% flowering and harvest maturity, plant height, number of pods and nodes per plant, seeds per pod, seed yield, 100 seed weight, oil and protein content. The combined analysis mean seed yield was 1267.8 kg ha<sup>-1</sup>. Genotype G8 (Nyala) produced the highest yield of 1600.9 kg ha<sup>-1</sup> while G14 (TGX 1835-10E) produced the lowest yield of 661.7 kg ha<sup>-1</sup> across the environments. The mean oil content ranged from 21.9% for G13 (931/5/34) to 16.6% for G14 (TGX 1835-10E) while the mean protein content ranged from 40.3 for G12 (TGX 1740-2F) to 35.2% for G13 (931/5/34) across the environments. Genotype G8 may be recommended for production in Njoro II and Nakuru West while genotype G3, G4, and G11 maybe recommended for Eldoret, Lanet, Nakuru West and Njoro I respectively

### THE EFFECT OF SOIL NUTRIENT INTENSIFICATION AND OMISSION REGIMES ON MAIZE YIELD IN THE SOUTHERN RANGELANDS OF MAKUENI COUNTY IN SEMI-ARID EASTERN KENYA DURING THE LONG RAINS

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The southern rangelands of semi-arid eastern Kenya, which are prone to erratic rainfall, drought, and other vagaries of nature, results to limited smallholder farmers

livelihood options in addition to making crop production a risky undertaking resulting in rampant food insecurity and poverty. Unpredictable rainfall and soil variability influenced by large scale inter-seasonal and inter-annual variability resulting in frequent extreme weather events is among the major risk factors affecting agricultural production and food security negatively in the sub region. A study was initiated at Kambi ya Mawe to identify combinations of management practices that can be considered ecological intensification, and to use such practices to improve yields over time at a faster rate than farmer practice, while minimizing adverse environmental impacts. Maize was planted and subjected to four soil amelioration treatments. Results show maize plants grown under 100% agro-ecological intensification (AEI) (Mavuno + ZnSO<sub>4</sub> + Urea full rate) produced significantly higher grain yields than those under 50% AEI (Mavuno + Urea ½ rate), nil fertilizer, and DAP + Urea full rate. However, plants grown under 100% AEI (Mavuno + ZnSO<sub>4</sub> + Urea full rate), 50% AEI (Mavuno + Urea ½ rate), and nil fertilizer produced significantly higher biomass and harvest index than those produced under DAP + Urea full rate. Maize plants grown under 100% (AEI) (Mavuno + ZnSO<sub>4</sub> + Urea full rate), 50% AEI (Mavuno + Urea ½ rate), and DAP + Urea full rate, produced significantly taller plants than those under nil fertilizer. However, plants grown under DAP + Urea full rate produced significantly greater leaf area than those under 100% (AEI) (Mavuno + ZnSO<sub>4</sub> + Urea full rate), 50% AEI (Mavuno + Urea ½ rate), and nil fertilizer. Maize plants had similar vigour irrespective of soil amelioration treatment. On the other hand plants supplied with 100% AEI - Mavuno + ZnSO<sub>4</sub> + Urea full rate, 50% AEI - Mavuno + Urea ½ rate, and DAP + Urea full rate had significantly higher stay-green ability than those under control (nil fertilizer).

#### UPLAND RICE RESPONSE TO FERTILIZER IN UGANDA

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Upland rice (*Oryza* spp.) yields are low in Uganda, partly because of little fertilizer use. Yield response to nitrogen, phosphorus, and potassium application and economically optimal nutrient rates (EOR) were determined. Three on-station trials and two clusters of on-farm trials were conducted in Uganda at approximately 1000 m elevation. Mean grain yield, with hulls, was 1.3 and 3.7 t ha<sup>-1</sup> with 0 and 100 kg ha<sup>-1</sup> N applied, respectively. Grain yield response to applied P compared with N was less, and mean yield was not increased with K application. Depending on fertilizer cost relative to grain price (CP), mean EOR ranged from 54 to 92 kg ha<sup>-1</sup> N and 17 to 30 kg ha<sup>-1</sup> P. Equations were determined for yield response, estimation of EOR, and the benefit:cost ratio (BC) for fertilizer N and P use. Grain N concentration and N harvest index at EOR were 1.55 and 55%, respectively. Mean recovery efficiency, partial factor productivity, and agronomic efficiency declined with increasing N rate



and were 75%, 41 kg kg<sup>-1</sup>, and 28 kg kg<sup>-1</sup>, respectively, at the EOR. Fertilizer N and P use can be highly and moderately profitable, respectively, for upland rice production in Uganda. Maximizing net return on finance-constrained investment in fertilizer use needs to consider CP and smallholder investment capacity rather than net return ha<sup>-1</sup>.

## THE EFFECTS OF APPLICATION OF INTEGRATED SOIL FERTILITY MANAGEMENT TECHNOLOGIES ON YIELDS AND BENEFITS OF BEANS IN KAGERA REGION, TANZANIA.

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Beans are an important component in the cropping systems of farmers in Kagera region. Here we explore different integrated soil fertility management (ISFM) options as a strategy to improve beans yield. The baseline survey conducted in 2011 showed that the average grain beans yields in farmers' fields was < 1 tha<sup>-1</sup> as compared to 2-3.5 tha<sup>-1</sup> from on station beans trails. The reasons for low bean yields are declining soil fertility, use of poor bean germplasm and agronomic practice by farmers in the region. We tested the effect of phosphorus (TSP) and nitrogen (CAN) fertilizers, improved beans varieties and spacing on bean yields in Bukoba, Misenyi, and Muleba districts of Kagera region during 2010-11 season. TSP was applied at the rate of 20 kg Pha<sup>-1</sup> and CAN at the rate of 30 kg Nha<sup>-1</sup> to both bush bean variety *Lyamungo 90* and climbing bean variety *Selian 2006* at the spacing of 50 cm x 20 and 50 cm x 30 cm, respectively. The demonstration fields were established using RCBD in three replications. The plots size was 10 m x 10 m. Before planting soil samples were collected and analyzed for particle size distribution (soil texture), pH, organic carbon (O.C), total nitrogen (N), available phosphorus (P) exchangeable cations (calcium, magnesium, potassium and sodium) and cation exchange capacity (CEC) using standard methods outlined by National Soil Service, 1990 and Moberg, 2000. Agronomic and socio-economic data collected, were processed and analyzed using Gen-stat and excel programs, respectively. The laboratory soil results showed that the soils in all sites were acidic to moderate acidic, with very low to low organic carbon, low to medium total N, low to medium extractable P, low to medium exchangeable K, low to medium exchangeable Ca, and low to high exchangeable Mg (Landon 1999). The results also showed that there was significant difference (P≤0.001) in crops response to the application of TSP and CAN fertilizers within the treatments and districts but no significant difference (P≤0.001) was observed across the districts. There was significantly (P≤0.001) increased climbing bean grain and biomass yields of 3.76 tha<sup>-1</sup> and 0.36 tha<sup>-1</sup>, respectively and bush bean grain and biomass yields of 2.30 tha<sup>-1</sup> and 0.76 tha<sup>-1</sup>, respectively as compared to 0.21-0.86 tha<sup>-1</sup> when fertilizer(s) was not applied ( control). Likewise, application of TSP at the rate of 20 kg P kg<sup>-1</sup> and CAN at the rate of 30 kg N ha<sup>-1</sup> gave net profit of 639.33 USD and 2,151.33 USD from climbing beans and bush bean, respectively as compared to net



loss of 342 USD and 70.67 USD from climbing bean and bush bean, respectively, when fertilizers were not applied. The research suggested more investigation on the rate(s) of TSP and CAN to be applied for optimum beans yields, net profit together with in depth economic analysis including the returns to labour and investment.

### **SOIL FERTILITY STATUS, QUALITY OF AVAILABLE MANURE AND ITS IMPLICATION ON SOIL FERTILITY MAINTENANCE IN THE PERI-URBAN AREAS OF SEMI-ARID EASTERN KENYA**

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A study of nutrient status of cropland soils and the quality of farmyard manure applied on the farms was undertaken in the peri-urban areas of Wote town in Makueni county and Wamunyu market in Machakos county in semi arid Eastern Kenya, with the aim of recommending appropriate soil fertility maintenance strategies for enhancing productivity of vegetables and fodder. Soil and manure samples were collected from 54 farms and analysed at the National Agricultural Research Laboratories. Results of soil analysis indicated that with the exception of nitrogen, phosphorus, organic carbon and Zinc, the other nutrient elements analyzed for were present in adequate quantities. Results of manure analysis indicated that with the exception of nitrogen, phosphorus and zinc, the other nutrient elements analyzed for were present in adequate quantities. It was concluded that due to the low levels of nitrogen in the farmyard manure and the insufficient quantities available on farm, application of manure alone cannot maintain soil fertility for sustainable crop and livestock production. It was, therefore, recommended that the available quantities of farmyard manure should be augmented with inorganic fertilizers, particularly nitrogenous fertilizers.

### **MODELLING NITROGEN DYNAMICS IN TEA SOILS**

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Nitrogen fertilization is important in tea cultivation due to high removal in crop harvesting. Field investigation was conducted for one year in tea plots at Tea Research Foundation of Kenya (TRFK), Kangaita station in Kirinyaga, Central Kenya, to assess dynamics of nitrogen. In order to support nutrient management in tea, a simulation model which considers the temporal dynamics of nitrogen in the tea environment was used. The model N-Vino was validated to reproduce the nitrogen dynamics in tea soils. Seventy percent of the simulated soil minimum N values ranged within the standard deviation of the observed soil minimum N values. Ninety percent of the soils water content, another variable used for the model validation could be reproduced at this level of accuracy. The results however, are considered sufficient for practical use in tea fertilizer management.



## EVALUATION OF SOILS IN SOUTH WESTERN NIGERIA FOR RESPONSE TO SINGLE SUPER PHOSPHATE FERTILIZER UNDER SCREEN-HOUSE CONDITIONS

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Application of Single Super Phosphate (SSP) fertilizer in soils with inadequate phosphorus (P) should elicit crop response. However, there is an indication of inconsistent response behavior to SSP fertilizer in some Nigeria soils despite their low available P. This study identified major soil types in south western Nigeria that are un-responsive to P fertilizer application under screen-house and soil properties that are related to this un-responsiveness behavior condition were determined. Maize seeds were sown in 3.0 kg soils treated with phosphorus fertilizer rates at 0, 30, 60 90 and 120 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> arranged in a complete randomized block design and replicated three times. Most of the locations responded to initial P application except for Fashola 2 which produced significantly higher maize shoot yield in control soils. There were five other locations where no-response was observed. Multiple regression analysis showed that PSI was influenced by the sand, clay and organic matter contents of the soils. Phosphorus response behavior can be explained by the available P levels, PSI and soil texture.

## ECONOMIC SUITABILITY OF SELECTED PHOSPHORUS SOURCES ON SOYBEAN YIELD IN CENTRAL HIGHLANDS OF KENYA

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Soybean is an important legume compatible with the smallholder farming systems in central highlands of Kenya. However, low P and N, a situation prevalent in the central highlands of Kenya, can limit its performance. This study assessed the economic suitability of different phosphorus sources in soybean production. The study areas were Kigogo in Meru County and Kamujine in Tharaka Nithi County. The trial was laid out in randomized complete block design (RCBD), having 13 treatments with four replications each on a 4.0 m by 4.5 m plot size. The P sources were Triple Super Phosphate (TSP), Minjingu rock phosphate, Mavuno fertilizer, diammonium phosphate (DAP), animal manure and fortified manure (animal manure with Minjingu fertilizer at 1:1 ratio) all providing 30 kg P ha<sup>-1</sup>. Diammonium phosphate (DAP) was reference input as it has both P and N and was the farmers' choice in the study area. Data collected were biomass and grain yields and soybean



and fertilizer market prices. Data was analyzed using analysis of variance (ANOVA) and means separated using t-test and Least Significant Difference (LSD) ( $P < 0.05$ ). The study used value cost ratio (VCR) to assess economic suitability of the various P sources. The least costly source of P was DAP and therefore recommended for use in soybean production with consideration for liming to address possible reduction in soil pH.

### **N UPTAKE AND YIELDS OF SOYBEAN (*Glycine max* (L.)) AS INFLUENCED BY MANURE, LIME AND MINERAL P FERTILIZER IN CENTRAL HIGHLANDS OF KENYA**

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In Kenyan central highlands, the declining soil fertility continues to be the major cause of low food production due to its effects on crop productivity. Soybean (*Glycine max* (L.) Merrill) as one of the most important legumes crop is being introduced in the region with expectance of increasing yields. However, low levels of soil N and other plant nutrients and soil acidity are seen as the major causes impairing goal achievement. To evaluate the influence of manure, lime, P fertilizer and their combination on N uptake and soybean performance an experiment was conducted in Embu Agricultural Training Collage comprising 9 treatments. The treatments included manure (0, 5 and 10 t ha<sup>-1</sup>), Lime (0 and 2 t ha<sup>-1</sup>) and P fertilizer (0, 30 and 60 kg P ha<sup>-1</sup>). The experiment was in a Randomized Complete Block Design with 4 replicates in plots of 4x4.5m. The treatments significantly influenced N uptake. The uptake was recorded in order manure > manure + P fertilizer > manure + lime. Soybean yields responded well to application of manure both alone or combined to lime and TSP. According to obtained results it was concluded that organic and inorganic resources have potential to enhance N uptake and soybean and other crops yields in Central Highlands of Kenya.

### **EFFECTS OF MANURE, LIME AND MINERAL P FERTILIZER ON SOYBEAN YIELDS AND SOIL FERTILITY IN A HUMIC NITISOL IN THE CENTRAL HIGHLANDS OF KENYA**

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Soybean (*Glycine max* (L.) Merrill) is one of the most important legume crops being introduced into the smallholder farming systems of the Central Highlands of Kenya (CHK) for soil health improvement, income and improved household nutrition. However, phosphorus fixation, depletion of soil nutrients and soil acidity are major causes of low yields. The objective of this study was to evaluate effects of manure application, liming and phosphorus application on soil properties and soybean performance. The study consisted of 9 treatments: manure (0, 5 and 10 t ha<sup>-1</sup>), Lime (0 and 2 tha<sup>-1</sup>) and P fertilizer (0, 30 and 60 kg P ha<sup>-1</sup>). The experiment was laid out in a randomized complete block design (RCBD) with 4 replicates in plots of 4x4.5m.



Manure and lime significantly reduced exchangeable acidity and increased soil pH. Application of manure alone or combined with lime or P fertilizer also increased Mg and K. Treatments that had sole lime, lime combined with manure and manure combined with P applied gave a significant increase in exchangeable Ca. Soybean yields responded well and significantly to application of manure either alone or combined with lime, P or both. These results showed the potential role of lime, manure and P fertilizer in improving soil fertility and soybean yields.

## STATUS OF COMMERCIAL MACADAMIA NURSERIES IN CENTRAL KENYA AND INCIDENCE OF SEEDLING CHLOROSIS

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Kenya is the fifth largest producer of macadamia (*Macadamia* spp.) after Australia, Hawaii, South Africa and Guatemala. Since the improvement of nut prices in the world market in 2004, there has been a steady rise in demand for seedlings accompanied by mushrooming of private nurseries. Propagation nurseries however have to combat with seedling chlorosis which is attributed to a deficiency of iron or magnesium. The disorder can cause substantial losses in young rootstock and grafted seedlings. In a project designed to resolve this serious nursery problem, one objective was to establish the scale of macadamia seedling chlorosis in major producing areas of Kenya. A situational analysis was carried out in commercial nurseries in central Kenya to capture various nursery management practices and the incidence of macadamia seedling chlorosis followed by descriptive analyses of the data using Statistical Package for Social Sciences (SPSS) 12.0. 63% of the nurseries were certified, 81% were male operated, and 56% of the operators had received formal training on nursery management. Half the nurseries grew other tree seedlings in addition to macadamia which was found in 75% of the nurseries. Kiambu 3 and Murang'a 20 were the preferred macadamia varieties. 56% of the nurseries used own red soil, 19% used virgin forest soil and 44% re-used potting media soil. Most nurseries used fertilizers (81%) and manure (88%) in the potting media, 88% grafted their own seedlings and 95% applied supplemental irrigation. 88% of operators were familiar with macadamia seedling chlorosis which was cited as a persistent problem in 44% of the nurseries. The disorder was mostly attributed to soil reuse and pest infestation. Only a handful of operators (6%) related it to iron deficiency. The study confirmed that macadamia seedling chlorosis was a widespread and persistent problem in commercial nurseries that resulted in substantial loss to seedlings.



## **ADAPTING RESOURCE USE EFFICIENT METHODS INTO INTEGRATED SOIL FERTILITY MANAGEMENT FOR MAIZE PRODUCTION IN TABORA, TANZANIA**

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Assessment of resource use-efficient is an important tool for establishing sound Integrated Soil Fertility Management practices in a given socio-economic community. We studied different sources of locally available organic fertilizers. Animal manures, ashes of different origin, tobacco leaf residues and oil palm processing residues to a large extent can for a base for ISFM establishment. The use of high quality NPK with Ca, Mg S and Zn will have a big role to play in improving crop productivity. The characteristics of particular farming systems provide the potentials and challenges of ISFM establishment. Locally available gypsum should be used in soil amelioration to improve soil health. Enhancement of locally available organic and inorganic resources should be promoted with support of field experiments to formulate the base for ISFM practices. There was a highly significant difference at ( $P=0.001$ ) on maize grain yield following application of inorganic and organic fertilizers. Results show that modest rates of organic manures, ash and gypsum application have a positive effect on the soil. Recommendations are given on the importance of parallel assessment of local resources for ISFM practices establishment.

## **APPLICABILITY OF HAND-HELD X-RAY FLUORESCENCE ANALYZER FOR RAPID CHARACTERIZATION OF SOIL ELEMENTAL COMPOSITIONS**

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Laboratory analysis has at its disposal a wide range of chemical, physiochemical and physical methods that can be used to characterize and evaluate soil fertility and quantify pollutants. Developments in analytical techniques have enhanced the use of multi-nutrient extractants, allowing for a shift towards multi-element analyses, and a decrease in detection limits by several order of magnitude. Chemical methods are progressively being replaced by reliable physical or physiochemical methods that are more sensitive, faster and more selective, making it possible to determine the very low concentrations of elements. One such technique is hand-held X-ray fluorescence (HHXRF) spectroscopy which has the potential to provide information about the quantities of individual elements in soil that are essential for the growth of crops (e.g. copper) and those that may be undesirable (e.g. lead). Our results indicated that determination of element concentrations in soils with HHXRF were comparable for most elements with those of total element concentrations measured



using total X-ray fluorescence spectroscopy (TXRF). Thus, HHXRF could be used to directly analyze total element composition of soils in the field and on prepared samples and may provide a basis for low cost soil chemical characterization and mapping.

## **CAPACITY BUILDING ON SPECTRAL DIAGNOSTIC TECHNIQUES FOR LAND HEALTH SURVEILLANCE**

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Land degradation and soil fertility depletion are major drivers of food insecurity and natural resource depletion in sub-Saharan Africa. Investing in new agricultural technology and building of capacity in its use is an essential development pathway for the region. The Africa Soil Information Service (AfSIS) is pioneering innovative methodologies, products, tools, and systems to improve the way that soils are evaluated, mapped, and monitored, making it one of the most innovative projects in field of soil science today. For these key objectives to be successfully met, provision of training and education to strengthen individual and institutional capacities on how to produce and interpret soil information obtained in the region is a key component of the project. Rapid direct soil assessment using visible, infrared and x-ray light is one key technology. Within the last four years, during phase-one of the project a total of 848 people were trained in soil spectroscopy, which included scientists, laboratory technicians, and PhD and MSc students drawn from national research institutions and universities from 9 African countries: Kenya, Ethiopia, Tanzania, Malawi, Mozambique, Cameroon, Cote d'Ivoire, Nigeria and Mali. Further, over 650 individuals drawn from different parts of the world have been exposed to these new methods of acquiring soil information.

## **SOIL CHEMICAL PROPERTIES AS INFLUENCED BY ORGANIC INPUTS AND MINERAL FERTILIZER IN MBEERE DISTRICT, KENYA**

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Farmers in central highlands of Kenya experience declining agricultural productivity majorly due to soil desiccation and soil fertility depletion. In order to increase crop productivity, and reduce production risks, improved nutrient use efficiency is required. One way of reversing the trend of declining land productivity in smallholder farms in Kenya, is believed to be the combined application of organic and mineral sources of nutrients. In order to investigate this, field trials were

established in a dry land environment in Central Kenya, at Machang'a. The objective of the research was to assess the effect of organic and inorganic inputs on soil nutrients in semi arid regions of the Central Highlands of Kenya. The study was carried out in Mbeere District, Kenya from 2004 to 2010 and the trial followed a randomised complete block design with three replications. The treatments consisted of four organic sources (*Tithonia diversifolia*, *Lantana camara*, *Mucuna pruriens*, and goat manure) combined with mineral nitrogen fertilizer, sole fertilizer and a control. Goat manure was superior in terms of improving soil chemical properties such as soil pH, magnesium, potassium, calcium and nitrogen across the sites. Soil pH declined in most of the treatments, more so with the combinations of organics and mineral fertilizers compared to the sole application of organics such as *Lantana camara*, *Mucuna pruriens* and manure. Calcium in the soil increased significantly in sole *Lantana camara*, sole manure and *Tithonia diversifolia* + 30 kg N ha<sup>-1</sup> treatments (t-test,  $p = 0.029$ ,  $p = 0.022$ , and  $p = 0.0264$ , respectively). Soil potassium increased significantly in manure + 30 kg N ha<sup>-1</sup> (t-test,  $p = 0.017$ ). Soil organic carbon decreased in all the treatments except in the sole manure treatment and manure + 30 kg N ha<sup>-1</sup>. The decline in soil organic carbon was significant in sole *Lantana camara*, *Lantana camara*+ 30 kg N ha<sup>-1</sup>, sole *Tithonia diversifolia*, *Tithonia diversifolia* + 30 kg N ha<sup>-1</sup>, sole *Mucuna pruriens*, *Mucuna pruriens*+ 30 kg N ha<sup>-1</sup>, fertilizer (60 kg N ha<sup>-1</sup>) and control treatments (t-test,  $p = 0.012$ ,  $p = 0.033$ ,  $p = 0.0224$ ,  $p = 0.0166$ ,  $p = 0.0349$ ,  $p = 0.0129$ ,  $p = 0.0004$  and  $p = 0.0341$ , respectively). Goat manure needs to be promoted among farmers in the drier areas because of its good performance in improving soil properties.

#### UTILISING SOIL FERTILITY REPLENISHMENT MEASURES FOR NUTRIENT USE EFFICIENCY IN MAIZE PRODUCTION, WESTERN KENYA

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Soil acidity and fertility depletion, particularly nitrogen (N) and phosphorous (P) deficiencies are major limitations to food production in Sub-Saharan Africa including Kenya. The purpose of this study was to determine the nutrient use efficiencies in maize production in the main maize producing counties in Kenya i.e. Trans-Nzoia, Uasin-Gishu and Siaya. The study was an on-farm experiment done at various farms whereby out of all the farmers present, 10 farmers were chosen from each county to achieve a total of 30 farmers. The rates of fertilizer applications were derived following the Kenya FURP (Fertilizer Use Recommendation Project, 1994) recommendations of 75Kg N/ha plus 26Kg P/ha. The plots were arranged in an incomplete randomized block design and all the yield data subjected to one -way analysis of variance (ANOVA). The initial soils characterization indicated that the soils were low in soil pH, available P (<10mgP/kg), total N (<0.2%) and organic carbon (<4.0%). The Agronomic Nutrient Use Efficiency (ANUE) of nitrogen and phosphorous was found to be highest in DAP +Lime at an



average of 14.41kg grain/kg P & 5.14kg grain/kg N while it was lowest in Minjingu plots at an average of 11.60kg grain/kg P & 4.02kg grain/kgN. Although there was no significant effect ( $p < 0.05$ ) DAP + Lime plot still gave the highest mean yields recorded at 5.56 tons/hectare while the Rotuba with  $\frac{1}{2}$  DAP plot gave the lowest yields among the plots with treatments at a mean of 4.83 tons/hectare. There was no significant difference in the yields of the treatments at  $p < 0.05$  but there was a significant difference between the treatments and the control plots which realized a mean of 1.75 tons/ha.

## TILLAGE AND COVER CROP EFFECTS ON SOIL PENETRATION RESISTANCE, AGGREGATION AND ORGANIC CARBON FRACTIONS IN NORTHERN NIGERIA.

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Soil cultivation can hasten depletion of soil fertility as it accelerates decomposition of organic matter and exacerbate emission of carbon dioxide into the atmosphere, thereby increasing global warming. A two cropping season trials were conducted in years 2011 and 2012 at the Institute For Agricultural Research field Samaru, (11°11'N, 06°36'E, and altitude 686m) in the Northern Guinea Savanna ecological zone of Nigeria. In order to assess the effect of tillage and cover crops on soil organic carbon fractions, aggregate stability and soil penetration resistance. The treatments consisted of three tillage practices namely No - tillage (NT), involves no soil tillage except boring planting holes; Reduced tillage (RT), here the field will be harrowed once and conventional tillage (CT), where the field will be ploughed, harrowed and ridged. alongside five cover crops which are no cover crop, NC (bare), *Centrosema pascuorum* (CP), *Macrotyloma uniflorum* (MU), *Glycine max* (GM) and *Curcubita maxima* (CM) laid out in a split plot design replicated three times. The tillage practices and cover crops formed the main and sub treatments respectively for this study. Soil samples were taken from depths 0-5, 5-10, 10-15 and 15-20cm. All measured carbon fractions varied significantly with all tillage systems, cover crops and soil depth. NT resulted in a higher concentration of Dissolved organic carbon, total organic carbon and silt plus clay associated carbon in the two years of study but fine particulate organic carbon was better enhanced by CT in the first year then RT in the second, while there was a 9% increase in intra aggregate organic carbon over the first year in NT system as opposed to 3% decrease in the CT but surprisingly a 29% increase was observed for RT. However silt plus clay associated carbon was significantly higher in CT system in the first year but was lowest in the 2<sup>nd</sup> year when NT was highest probably due to exacerbations of carbon by disruption of soil aggregate during cultivation. Most Total organic carbon and silt plus clay associated carbon were best sequestered by CP and CM in the first year while MU, GM and CM were better in sequestering these carbons in the 2<sup>nd</sup> year. In year 2011 there was no significant difference observed among the Fine Particulate Organic Carbon (FPOC), however in 2012 soil on treatment plots with no cover crops produced the highest concentration



of FPOC (also known as labile carbon) which are easily lost due to cultivation. Most carbon fractions were best concentrated at 0-5 and 5-10cm soil depth compared to 10-15 and 15-20cm. Soil penetration resistance (PR) were in the order of NT>RT>CT and it increased with increasing sampling dates i.e. (4>8>12 weeks after sowing) while CM was effective all through the sampling periods in presenting the least resistance to penetration in both years of study. PR increased progressively with soil depth, with depth 15-20cm having the highest soil PR. Aggregate stability by both Geometric mean diameter and Mean weight diameter were not significantly influenced by both tillage systems and covert crops in year 2011 however, in year 2012 stability of soil were better depicted by GMD where NT and RT presented 5.3% better stability than CT. however all cover crops especially MU and GM were better in improving soil aggregate than the NC.

### **EFFECT OF INPUTS APPLICATION ON YIELDS OF SOYBEAN AND CLIMBING BEAN IN A MAIZE - LEGUME ROTATION SYSTEM IN CENTRAL KENYA**

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Climbing bean and Soybean have potential to contribute to increased food production, incomes and improved soil fertility. This work reports results of soil input application on yields of climbing beans and soybeans in a maize-legume rotation in 4 districts of varying agro-ecological and socio-economic conditions in the central highlands of Kenya. The work was carried out for four seasons from March 2010 to March 2011. The inputs evaluated were sole manure, manure plus fertilizer, tithonia plus fertilizer and sole fertilizer. There was an increase in yields in all input treatments beyond the control treatment. However, manure, manure plus fertilizer and tithonia plus fertilizer gave consistently the highest yields in all the four seasons. Soybean yields in these treatments ranged from 1.3 to 2.2 t /ha, while maize ranged from 4 to 6.6 t/ha. The treatments increased yields by more than 130% over the control in most treatments. Similar trends were observed with regard to biomass yield for climbing beans, soybean and maize. In addition, yields varied across the seasons and highly depended on rainfall distribution within the seasons. In seasons of good rainfall, yields were almost double those obtained during the seasons with poor rainfall.

### **EFFECT OF SOIL AMENDMENTS ON GROWTH AND YIELD OF BEANS (*PHASEOLUS VULGARIS* L.) IN ACIDIC SOILS OF NYERI COUNTY, CENTRAL KENYA**

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Common Bean (*Phaseolous vulgaris* L) is the most important grain legume in Nyeri District. Dry grain yields have remained low at 0.22 to 0.3 t/ ha due to several biotic



and abiotic constraints. The main abiotic constraints are deficiency of nitrogen (N) and phosphorus (P) and low soil acidity. This study was conducted to determine the effect of one-time application of organic and inorganic soil amendments on the soil pH. The treatments used were Lime 2t ha<sup>-1</sup>; Kelphos fertilizer 375 kg ha<sup>-1</sup>; DAP 200kg ha<sup>-1</sup>; manure 4 ha<sup>-1</sup>; manure 4 ha<sup>-1</sup>+Kelphos 375 kg ha<sup>-1</sup>; manure 4 ha<sup>-1</sup>+DAP 200kg ha<sup>-1</sup>, lime 2t ha<sup>-1</sup>+DAP 200kg ha<sup>-1</sup>, lime 2t ha<sup>-1</sup>+Kelphos 375 kg ha<sup>-1</sup> and control. The experiment was laid out in a Randomised Complete Block Design with three replications. The after harvest soil analysis of the top soil in each of the plots showed increase of soil pH by margins ranging from 0.27 to 0.78 units with lime and kelphos and manure contributing to the highest increase in that order. Above ground dry biomass yield increased significantly when compared to the control with lime+DAP having the highest yield, followed by Kelphos, lime 4.17 and manure 4.14 t/ha. Dry grain yields increased from 0.66t/ha (control) to 1.83 t/ha (lime+DAP), lime+Kelphos 1.6 t/ha and manure 1.58 t/ha. Manure gave the highest return to cost of amendment at 558.80% followed by lime with 420.28% and lime+DAP with 251.45%. Manure is recommended as amendment option for production of beans in acidic soils of Nyeri district.

## RESPONSE OF MAIZE CROP TO SULPHUR IN RUVUMA REGION, TANZANIA

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Good growth and productivity of crops require availability of necessary nutrient elements in balanced proportions. In mid 2000s, inadequate responses of maize crop to Urea were observed in Ruvuma region. It was also reported that, blending of Urea and Sulphate of Ammonia (SA) improved maize yields. Field observations and soil testing from 2008 to 2009 revealed deficiency of sulphur in soils of Ruvuma region. This study aimed to establish rate of S-nutrient to apply for optimum maize production and monitor changes in soil reaction. Researchers-designed and researchers-farmer implemented and managed experiment in three districts: Namtumbo (Suluti), Songea (Mletele) and Mbinga (Mtama and Kitanda). Composite soil samples (0-30cm) were taken and analyzed for physical-chemical properties. In 2010/11 to 2011/12 cropping seasons, 5-treatments were imposed on RCBD, replicated three times per site in plots sizes of 5m x 5m. Treatments had control (no external S and N nutrients applications), Urea alone and three blends of 10, 20 and 30 kg S/ha as SA, and Urea, all adjusted to 100 kg N/ha. All treatments received basal applications of 20 kg P/ha as TSP and 20 kg K/ha as Muriate of Potash. Maize yield was a main data collected. Optimum S-rate was estimated by using curvilinear regression analysis and differentiation of the quadratic response equation as:  $\partial y / \partial x = 0$ . Soil results revealed acidic soils in all sites, with pH ranging 5.49 - 5.89. All soils show low level of N, P, S and Ca for optimum maize production. The rate of 10 kg S/ha increased maize grain yield by about 1t/ha. In depth analysis using curvilinear regressions and differentiation of the derived equation ( $Y = -9.97X^2 + 249.95x + 2370.1$ ) revealed that 12.53 kg S/ha is plateau point of grain yield response. There were no



consistent pH changes, which suggest that applications of these small amounts of SA are not harmful. Economic optimum rate of about 11kg S/ha is recommended for maize production in Ruvuma.

## **SCALE-UP OF SOYBEAN PRODUCTION IN RWANDA TO ACHIEVE IMPROVED LIVELIHOODS FOR FARMERS AND IMPROVED SOIL FERTILITY**

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The introduction of grain legume crops into the subsistence agriculture farming systems in Rwanda has a big impact to contribute significantly to the national food security through improved soil health and higher crop yields to smallholder farmers. Soybean crop was grown in rotation with maize in Mother Demo trials in three Districts in Eastern Province of Rwanda. The project has been built for the objectives of showing farmers, through demonstration plots, the value of use of improved crop varieties, mineral fertilizers and crop husbandry, making access to improved seeds and appropriate mineral fertilizers, building capacity of farmers and extension staffs on the use of improved agricultural technologies such as integrated soil fertility management options. The dominant soil type in the trials sites were the Sandy soil clay with an average of pH range of between 4.8 and 6.7. The Nitrogen and phosphorus levels ranged from 0.04 to 0.18 % for Nitrogen; 6.9 to 83.2 ppm for phosphorus. The objective was to demonstrate to farmers the benefits of maize and soybean crop rotation farming system, and also of applying chemical fertilizers combined with organic fertilizers to legume crops like soybean. Data collected included soil samples at 0-20 cm depth before the demos were planted in order to determine the baseline fertility status of the demos sites, climate data, date of planting, height. Soil samples will be taken after the harvest to see the treatment effect. Other parameters to be measured during the crops harvest include biomass production and grain yield.

To achieve these objectives, last season we decided to put in place nine trials on integrated soil fertility management with soybean and maize in three Districts. The design was to have four blocs with four different treatments and four repetitions. For soybean we did 4 treatments composed by, one treatment as a control, follow by TSP treatment, another for organic manure treatment and then a combined Organic Manure plus TSP. For maize, we had Control; DAP+ Urea; Organic Manure; and lastly DAP+Urea+Organic Manure. The results showed that the combination of using TSP+OM has produce better results where the yield of soybean has increased from 0.9 ton/ha to 2.2 ton/ha. And for Maize, the combination of DAP+UREA+ OM has produce up to 3.7. Ton/ha on an open pollinated variety.



## **BASAL FERTILIZER EFFECTS ON THE DEVELOPMENT OF THE RHIZOSPHERE OF RAINFED RICE IN RELATION WITH VEGETATIVE GROWTH AND YIELD IN MID-SEASON DROUGHT-PRONE ENVIRONMENT**

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Annual rain fall reduction and variability are associated with increasing duration of mid-season drought period under bimodal rainfall pattern in West Africa. This situation is limiting the success of basic drought management strategies in rainfed rice production that account for about 80% of cultivated rice surface in sub-region. To enhance adaptation of rice to the actual climate, an agronomic trial was conducted in order to improve rice rhizosphere (root depth, root length density, soil exploration rate by root), its vegetative growth (height, tillers, leaf) and yield (1000 grains weight and grain yield). Additive fertilizer treatments including Nitrogen-N (urea), phosphorus-P (STP), potassium-K (KCl), calcium-Ca (SO<sub>4</sub>Ca), magnesium-Mg (SO<sub>4</sub>Mg) and zinc-Z (SO<sub>4</sub>Zn) was laid out in a complete block design on Arenosols of foot slope, in a guinea savanna ecology of Côte d'Ivoire. No fertilizer treatment was the control and the roots were studied by profile method and data was transformed by RACINE<sup>®</sup>. No significant difference was observed for leaf number and plant height by treatment at successive development stages, but treatments K, KP and KN induced faster growth rate of root and deeper root development enhancing the improving effects of P and N on root elongation and ramification respectively. Meanwhile, decreasing effect of Ca<sup>++</sup> was observed for these parameters even if combined with Mg and Zn which are also potential root improvers. Applying KN was recommended for highest root length density; soil exploration rate, grain filling and yield in the studied ecology. Supplying soil deficient nutrients was further advised as basic concept for mitigating mid-season drought adverse effect in a given environment.

## **SOIL FERTILITY AND MAIZE YIELDS DECLINE AND OPTIONS FOR REPLENISHMENT FOR *MOLLIC ANDOSOL* IN NAKURU COUNTY**

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Land degradation and declining soil fertility as a result of loss of soil organic matter SOM has been identified as the cause of low crop yields and food insecurity in Kenya. A study to investigate the cause of SOM decrease and the effect of organic and inorganic fertilizer was initiated in central rift.



The effect of methods and levels of farm yard manure FYM (organic) and inorganic fertilizer application was carried out for 3 years at two sites in Njoro and Lare of Nakuru County. The main treatments consisted of 3 rates fertilizer: 6t/ha, 3t/ha + 65 kg/ha DAP and 130 kg DAP/ha and 3 methods of manure application: planting holes, furrows and broadcasting. The trial was laid up in a split plot RCBD with 3 replicates. Results showed that the furrow method of manure application gave significantly ( $p < 0.05$ ) higher yields than broadcast method in the third year, while in the first and second year there was no significant differences among the 3 methods. Application of both FYM combined with DAP i.e. 3t FYM/ha + 65kg/ha gave significantly higher yields ( $p < 0.05$ ) than either organic or inorganic applied separately. There was also a slight increase of soil acidity which was attributed to reduced SOM and the depletion of the bases Ca, Mg, K by 5 years of maize mono-cropping. Continuous land fragmentation, continuous mono-cropping, inadequate organic and inorganic inputs, and accelerated soil erosion have caused soil fertility loss and yield decline in the area. Sustainable options may include substituting maize with higher margin crops for land parcels  $\leq 1$ ha to empower farmers to afford inorganic fertilizer and organic inputs, crop rotation to boost SOM. Encourage use of fossil fuel, reforestation and agro forestry including growing fruit trees in blocks to mitigate soil erosion and discourage land fragmentation of high potential agricultural lands.

#### **DIAGNOSTIC 'BEST-BET' SOIL FERTILITY MANAGEMENT TECHNOLOGIES FOR POTATO PRODUCTION IN NYANDARUA COUNTY, CENTRAL KENYA**

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Irish potato is the second most important food crop in Kenya after maize. However in recent time soil fertility decline has been attributed to be one main cause of decline in potato yields in prominent growing areas comprising the Greater Nyandarua County, Central Kenya. The objective of the study was to test economic viability of existing technologies for improving and sustaining soil fertility in mixed farming system by use of integrated soil fertility approaches. This study was conducted at the KARI Oljoro Orok station and in Bahati at Mzee Gakuru's farm sites located within Nyandarua County with potato used as the test crop. The composition of the different treatments that were applied in the trial were: (T1) Mineral fertilizers 17:17:17 at 200 kg ha<sup>-1</sup> (T2) Mineral fertilizer CAN, TSP, and MOP (T3) Manure alone 10 t/ha (T4) Manure 5 t/ha combined with mineral fertilizer 17:17:17 at 100 kg ha<sup>-1</sup> and (T5) Unfertilised control. No significant differences in ware potato yield were observe at the KARI Oljo Orok station, but at Mzee Gakuru's farm yield were significant ( $p < 0.05$ ) with yields ranging between 13.7 and 22.3 t ha<sup>-1</sup> equivalents to 50 and 89 bags per acre, for the control and half manure half fertilizer treatments, respectively. An assessment of economic viability of the tested technologies indicated that since treatment five (T<sub>5</sub>) was the control (none use of fertilizers and/or manure), it is can be concluded that the use of manure and fertilizer gives better economic benefits than the none use of fertilizers and/or manure. The highest



Marginal Rate of Return (M.R.R = 354%) was obtained from the application of mineral fertilizer 17:17:17 at 200kg/ha, followed by T<sub>4</sub> and T<sub>2</sub> and lastly T<sub>3</sub>. It is worth noting that the application of manure alone (T<sub>3</sub>) compared to the control, gives an M.R.R of 157%. This further implies that manure application gives better returns than the control. It is also worth noting that the change from either use of fertilizers or manure alone (T<sub>1</sub>, T<sub>2</sub>, & T<sub>3</sub>) to the use of a combination of both (T<sub>4</sub>) has positive economic gains, M.R.R of 164, 318 & 438% respectively.

### **EFFECT OF ENRICHMENT AND RATE OF CATTLE MANURE ON NITROGEN UPTAKE AND YIELD OF TEA (*Camellia sinensis*)**

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Tea *Camellia sinensis* is one of the most important cash crops in Kenya. The economic yield, two leaves and a bud are periodically harvested hence placing a lot of demand for the nutrients. Inorganic fertilizer NPK(S) 25:5:5:5 is generally recommended for the optimum supply of nutrients and crop yield. Non-judicious use of the inorganic fertilizer however acidifies the soil and pollutes the environment. Integrated soil fertility management, the combined use of organic and inorganic fertilizer, is recommended for improved crop yield and soil health. An experiment was carried out to determine the effect of enriching cattle manure with inorganic fertilizer 25:5:5:5s and varying the application rate on nitrogen uptake and yield of tea. Enriched and sole cattle manure up to a rate of 150kg N/ha increased the level of N in mature leaf. The N content in the mature leaf was highest under inorganic fertilizer NPKS 25:5:5:5 application. Enriching cattle manure with inorganic fertilizer significantly increased the crop yield.

### **DISSEMINATION OF INTEGRATED SOIL FERTILITY MANAGEMENT TECHNOLOGIES BY THE AFRICAN SOIL INFORMATION SERVICE PROJECT IN KENYA**

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This paper reports on the results from the Bill and Melinda Gates Foundation (BMGF) / Alliance for a Green Revolution in Africa (AGRA) funded African Soil Information Service (AFSIS) Project, which was implemented by the Tropical Soil Biology and Fertility (TSBF) Institute of the International Centre for Tropical Agriculture (CIAT) in collaboration with the Kenya Agricultural Research Institute (KARI) in Kenya from January 2009 to December 2012. In this paper three objectives out of five AFSIS objectives were achieved. These include development of digital soil maps and establishment soil health surveillance system in SSA, provide evidence-based, spatially explicit soil management recommendations to national research and extension providers and services of the countries involved and build capacity, serve end users, monitoring and evaluation, and management support. The project developed digital soil maps and established a soil health surveillance system in Kenya. This was done by setting-up data, metadata, case definitions, spatial sampling and interpretation standards, acquiring, digitizing and spectrally characterizing soil legacy data; assembling, processing and interpreting remote sensing data and existing national soil maps, collecting and analyzing soil health data from representative sentinel sites, and generated high resolution digital maps of soil functional properties in Kenya, including soil degradation status and biophysical and socioeconomic risk factors. Land Degradation Surveillance Framework (LDSF) was used for site selection. Legacy data collected through literature searches showed increasing levels of publication and focus on maize as a test crop under mineral and organic fertilizer application among other things. Validation studies in Western, Central and Eastern Kenya showed that three mineral fertilizer blend (NPK) and higher altitudes gave higher maize yields compared to NP fertilizer blends and lower altitude zones. An investigation was conducted on the application of the DeNitrification - DeComposition (DNDC) model to maize cropping systems under organic and mineral fertilizers management practices in western Kenya. This study revealed that field-derived grain yield values exceed DNDC-derived values (by between 15-37 %) in four out-of six fertilizer management scenario's considered. DNDC model demonstrated potential, with further refinement of input-model parameters, for supplementing the often repetitive and resource demanding field experimentation at estimating cereal grain yields under fertilizer management practices. A soil information user needs assessment surveyed within Nairobi, its environs and western Kenya revealed that accessing soil information was difficult among the end users and the information accessed was scanty; and thus setting up an up-to date soil information source is urgently required. A baseline study to diagnose and characterize the farming systems in western Kenya preliminary results indicated that the main crop grown was maize which recorded low yields and the farmers associated low yields with low soil fertility. The key indicators of low soil fertility used by farmers were low crop yields, presence of indicator weeds and soil colour. Lack of crop rotation due to small farm sizes was the most frequently cited cause of soil fertility depletion followed by inadequate cash to buy mineral fertilizer. A biophysical survey on food security conducted in central Kenya revealed that the soil fertility was generally low across the farms. A study on the analysis of communication and dissemination channels influencing the adoption of integrated soil fertility management in western Kenya



revealed that community-based and mass media channels were significantly advantageous to farmers. A survey on the adoption of integrated soil fertility management practices in western Kenya showed that information access, particularly from farmer groups played a significant ( $p < 0.1$ ) role in determining the intensity of ISFM. Age of the household head, rented tenure and farmers' perception on soil erosion had a negative influence on the adoption intensity.

#### EFFECT OF TYPES OF FERTILIZERS ON SOIL CHEMICAL PROPERTIES AND YIELD OF TOMATO (*LYCOPERSICUM LYCOPERSICON*) IN ALFISOL, SOUTHWESTERN NIGERIA

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Field experiments were conducted between 2010 and 2012 to determine the effect of organic, organomineral and NPK fertilizers on soil chemical properties and yield of tomato in Ondo south western Nigeria. Organic (OG) and Organomineral Fertilizers (OMF) were each applied at the same rate of 2.5, 5 and 10 t ha<sup>-1</sup> while NPK 15:15:15 fertilizer was applied at 300 kg ha<sup>-1</sup>. The treatments were arranged on a Randomized Complete Block Design with three replicates. Relative to control, OG and OMF significantly increased ( $p < 0.05$ ) soil pH, OM, N, P, K, Ca, Mg, Fe, Cu, Zn and Mn. Compared with control, OM applied at 5 t ha<sup>-1</sup> most increased soil total N (143%), 10 t ha<sup>-1</sup> OG had the highest percentage increase in Ca (98%), K (114%) and ECEC (221%), Organic fertilizer applied at 2.5 t ha<sup>-1</sup> recorded the highest available P (695%), Zn (887%) and Cu (110%). Organomineral fertilizer applied at 10 t ha<sup>-1</sup> had the highest increase in Fe (232%). Relative to control, OG, OMF and NPKF significantly increased ( $p > 0.05$ ) tomato fruit yield. Organomineral fertilizer applied at 5 t ha<sup>-1</sup> had the highest increase in fruit weight of tomato.

#### EFFECTS OF FARMYARD MANURE AND MINERAL FERTILIZERS ON MAIZE YIELD AND SOIL PROPERTIES IN TWO DISTRICTS OF RWANDA

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The Rwanda agriculture is today characterized by low agricultural productivity due to soil fertility decline. This is mainly attributed to the mining of nutrients due to continuous cropping without external addition of adequate nutrients coupled with small land sizes which promotes limited scope for crop rotation and inadequate land productivity. The adoption of ISFM technologies such as the combination of organic manure and mineral fertilizers is being taken as one of solutions to the situation. The objective of this study is to investigate the effect of farmyard manure and mineral fertilizers on maize yield, determine the crop nutrient uptake and nutrient use efficiency and evaluate changes due to treatments on bio-chemical soil properties. The study is being conducted in Huye and Bugesera Districts in Southern and Eastern Rwanda. The experiments is being conducted in the field where maize crop



has been planted in plots measuring 4.5x4.5 m with spacing of 75 x 30 cm. Treatments have been in a factorial design arranged in a randomized complete block design (RCBD) with three factors (nitrogen, phosphorus fertilizers and manure) at three levels for nitrogen (0; 50 and 100 kg/ha), three levels for phosphorus ( 0; 25 and 50 kg/ha) and two levels for manure (0 and 10 tons/ha). Soil samples will be analyzed for aggregate stability, soil  $P^H$ , soil organic carbon, available N, total N, Phosphorus, available Potassium, CEC and ECEC. Maize grains will be dried after harvest and be weighed at 12.5% moisture content. The experiment has been replicated three times. The data will be subjected to analysis of variance using the general linear model of the SAS software. Treatment differences will be examined using Least Significant Differences (LSD) test. Regression and correlation analyses between various variables will be done to draw key relationship.

### **ENHANCING SOYBEAN YIELDS BY INCREASING PLANT-AVAILABLE PHOSPHORUS THROUGH USE OF ORGANIC AND INORGANIC SOURCES**

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A research study to increase plant-available phosphorus to soy bean using organic and inorganic phosphorus (P) resources is being conducted in Isingiro District, Southwestern Uganda; and at Makerere University Agricultural Research Institute-Kabanyolo (MUARIK). Isingiro (00°46.044'S, 030°42.593'E, altitude 1378m above sea level) is generally hilly with severe soil nutrient loss mainly due to soil erosion as a result of rain water washing away the nutrients; and nutrient mining without replacement due to over cropping. Generally, there is a steady decline in soil fertility leading to low crop yields, less food and low household incomes. Among the nutrients depleted, phosphorus is the main outstanding one and consequently its levels in Isingiro are low. Besides, Isingiro soils are oxisols which are high phosphorus fixers, thus making P more unavailable to crops. These high P fixing soils are a big problem to soybean farmers! In fact during 2009, the Alliance for a Green Revolution in Africa (AGRA) worked with the Ruhira Millennium Villages project (MVP) to promote use of P mineral fertilizers but in some areas soybean yields were not substantial due to phosphorus unavailability as a result of soil P fixation. The main objective of the study is to evaluate the potential of organic and inorganic P resources to increase soybean yields and plant-available phosphorus in a P-fixing soil. The specific objectives are: To determine the optimum combination of organic and inorganic P resources for soybean yield; To evaluate the interactive effect of organic and inorganic P resources on plant-available phosphorus; and, To find out the effect of joint application of organic and inorganic P resources on soybean apparent phosphorus recovery (APR) efficiency. The hypotheses are: There is a specific combination of organic and inorganic P resources that gives an optimum soybean yield; The interactive effect of organic and inorganic P resources promotes plant-available phosphorus; and, Joint application of organic and inorganic P resources increases soybean APR efficiency. At the beginning of the on-going experiment, the soil was analyzed for pH, total P, soil organic matter, nitrogen and available P. The treatments were various combinations of different cattle manure

and phosphorus levels. Cattle manure levels were:  $M_0 = 0 \text{ tons ha}^{-1}$ ,  $M_1 = 2.5 \text{ tons ha}^{-1}$ ,  $M_2 = 5.0 \text{ tons ha}^{-1}$  and  $M_3 = 7.5 \text{ tons ha}^{-1}$ . P levels were  $P_0 = 0 \text{ Kg P ha}^{-1}$ ,  $P_1 = 15 \text{ Kg P ha}^{-1}$ ,  $P_2 = 30 \text{ Kg P ha}^{-1}$  and  $P_3 = 45 \text{ Kg P ha}^{-1}$ . The treatments were replicated three times in a randomized complete block design (RCBD). The treatment plots each measured 2m by 5m. The test crop was a soybean variety, Maksoy 1N planted at 50cm by 25cm. The source of inorganic P was triple superphosphate (TSP) applied in planting holes. A rate of  $40 \text{ Kg N ha}^{-1}$  was used in all plots in form of urea to ensure that N was not limiting. For the screen house pot experiment at MUARIK, soil and cattle manure were collected and transported from Isingiro. They were analyzed for total P, organic matter, pH, N, potassium and available P (Bray 1). The P fixation capacity of the soil was also determined and was found to be around 60%. The same treatments as for the field experiment were used for the pot experiment but were adjusted per pot which contained 4 Kg of soil. Data collected from the field experiment which awaits analysis includes: Average number of leaves per plant; average plant height (cm); average number of pods per plant, grain yield; 100-seed weight and above-ground plant dry matter. Data will be statistically analyzed by way of analysis of variance (ANOVA) using GENSTAT statistical package (version 14).

#### **AFRICAN TRADITIONAL VEGETABLES AS AGENTS OF ISFM-CLOTALARIA AND AMARANTH FARMING**

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The knowledge and understanding of African leafy vegetables had become minimised over time but in the recent past there is more interest in their research for their nutritive and medicinal values. Of value are those that have the potential to ameliorate soil nutrient levels. This is with the background that despite inorganic fertilizers having had a dramatic impact of agriculture in the world, the economic situation in sub-Saharan Africa calls for alternative methods of reducing soil fertility degradation. The use of leguminous vegetables may be a solution. The study looks at the potential contribution of a leguminous traditional vegetable, *Crotalaria ochroleuca* to soil nitrogen and its response to various nutrient additions. The crop was chosen for its vigorous growth and adaptability to many regions of Kenya. During the study which was conducted over three seasons, *C. ochroleuca* was grown under two treatments of inorganic fertilizer (IF) and organic fertilizer (OF) with a control in which there was no fertilizer applied (NF). Two other non-leguminous vegetables, *Amaranthus dubius* (Amaranth) and *Corchorus olitorius* (Jew's mallow) were grown under the same treatments for comparison purposes. Soil analysis was done before planting on a composite sample collected from 9 sites in the experimental plot and soil nutrients were again measured after harvest in the NF subplots. Growth parameters were measured every fortnight and these included leaf number, shoot length, dry weight and nodule number for *Crotalaria*. Results indicated that while the leguminous vegetable was not affected by external inputs with no significant differences between treatments and control. The non-leguminous vegetables responded well to both IF and OF treatments in all the measured



parameters. This underlines the potential for improvements in soil nitrogen levels using leguminous vegetables especially as intercrops with the non-leguminous types.

## **POTENTIAL OF MANURE, LIME AND MINERAL P FERTILIZER FOR IMPROVE SOIL FERTILITY AND SOYBEAN YIELDS ON SMALLHOLDER FARMERS IN CENTRAL HIGHLANDS OF KENYA**

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In Kenyan central highlands, the declining soil fertility continues to be the major cause of low food production due to its effects on crop productivity. Soybean (*Glycine max* (L.) Merrill) as one of the most important legumes crop is being introduced in the region with expectance of increasing yields. However, P fixation, depletion of other nutrients and soil acidity are seen as the major causes impairing goal achievement. To evaluate the influence of manure, lime, P fertilizer and their combination on the soil fertility and soybean performance an experiment was conducted in Embu-ATC comprising 9 treatments. The study included manure (0, 5 and 10 t ha<sup>-1</sup>), Lime (0 and 2 t ha<sup>-1</sup>) and P fertilizer (0, 30 and 60 kg P ha<sup>-1</sup>). The experiment was laid out as RCBD with 4 replicates in plots of 4x4.5m. The results revealed that manure and lime significantly reduced exchangeable acidity and increased soil pH. Application of manure alone or combined with lime or P fertilizer increased Mg and K. Lime sole, combined to manure and both manure and TSP gave a significant increase in exchangeable Ca. Soybean yields responded well to application of manure either alone or combined to lime, TSP and both. These results shows the potential role of organic and inorganic resources in improving soil fertility which can be applied for increasing crop and food production and soil fertility management in Central Highlands of Kenya.

## **RESPONSE AND PHOSPHORUS UTILISAION EFFICIENCY BY GROUDNUT GENOTYPES ON FIELDS OF VARYING SOIL FERTILITY IN NORTHERN UGANDA**

**Othieno A., Ebanyat P. and Olupot G.**

Groundnut is an important legume in Uganda but yield remains low and variable on smallholder fields. This is attributed to heterogeneity in soil fertility and poor fertility particularly limited supply of phosphorus which is essential in increased productivity of grain legumes like groundnut. Addition of external phosphorus fertilizer is key in improving yields of groundnut but various sources of phosphorus fertilizer exist and variety response to them is not clear. Approaches that enhances resource use efficiencies like use of varieties with high phosphorus utilization efficiency can help increase yields of groundnut. On-farm trials are being conducted in Northern Moist Farmlands (NMF) agro-ecological zones where groundnut is mostly produced in Uganda for two season of 2012b and 2013a to determine yield response of groundnut genotypes to P-sources and rhizobia as affected by heterogeneity, assess the efficacy of nutrient management practices (P and rhizobia)



in increasing Nitrogen fixation by the groundnut genotypes and to identify genotype(s) that efficiently utilizes P. The treatments are P at levels of 0 and 15 kg P ha<sup>-1</sup> from two different sources (TSP and SSP) with and without rhizobia applied in four fields each of good, medium and poor fertility. Three groundnut genotypes Serenut 2, Serenut 5R and 6T were planted in 2012b season at spacing of 45cm x 10cm. At flowering, biomass was determined and grain yield at maturity. Preliminary results indicate a significant ( $P < 0.001$ ) difference in genotype grain yield response to phosphorus sources and the best responsive genotypes were Serenut 6T (47%) in good fields and, Serenut 2 (52%) and 82% in medium and poor fields respectively. More data is being collected to validate this preliminary findings and answer other objectives.

### **RESPONSE OF RICE TO DIFFERENT LEVELS OF NITROGEN FROM UREA AND LABLAB IN A SANDY CLAY LOAM SOIL IN MOROGORO .**

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Inadequate supply of N by tropical soils is an important constraint to productivity of lowland rice. Limited information is available on the use of green manure especial lablab on increasing nitrogen in rice fields. A study was conducted to investigate the response of rice to different levels of nitrogen from urea and lablab in a sandy clay loam soil in Morogoro. Two experiments, one field and one pot were conducted. Treatments evaluated were absolute control, three levels of N from urea or lablab and the same levels of N from combination of lablab and urea at equal levels of N plus a treatment supplying N from lablab roots arranged in a randomized complete block design and replicated three times. Phosphorus (30 kg/ha) was applied. The results showed that treatments maximum Urea N, led to highest crop performance and rice yield than the control. Highest rice yield (4.1 t/ha) was obtained at 120 kg N/ha from urea followed by a combination of lablab (60 kg N/ha) and urea (60 kg N/ha) which gave 3.7 t /ha. Incorporation of lablab resulted in a rapid build-up in total N suggesting an improvement in soil N status. It is concluded that, urea at the rate of 120 kg N/ha produced the highest rice grain followed with a combination of 60 kg N/ha from urea and 60 kg N/ha from lablab. It is recommended to use 120 kg N/ha from urea or a combination of 60 kg N/ha from urea and 60 kg N/ha from lablab.

### **AMELIORATING ALUMINIUM TOXICITY IN SOYBEAN (*GLYCINE MAX (L.) MERRIL*) PRODUCTION WITH COMBINATIONS OF FERTILIZER MATERIALS ON AN ALFISOL IN SOUTH - WESTERN NIGERIA.**

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Aluminium (Al) toxicity is a major limitation to leguminous crop production in acidic soils and fertilizer treatment could ameliorate the condition. In this



investigation, direct and residual effects of different fertilizer materials on the growth and yield of soybean grown with or without Al treatment were evaluated on an Alfisol. The investigation involved a greenhouse (5kg soil/pot) experiment conducted at the Agronomy Department, University of Ibadan, Nigeria, with two factors: fertilizer types - control, organic fertilizer (OF), inorganic fertilizer (IF) and OF + IF mixture at ratio 1:1 and Al treatment (0, 50, 100 and 150 $\mu$ M AlCl<sub>3</sub>). Sunshine organic fertilizer and single superphosphate (SSP) were used as OF and IF respectively. Treatment combinations were replicated three times in a completely randomized design, giving a total of 48 experimental units. Data on growth parameters (plant height, number of leaves and stem girth) as well as yield parameters (biomass and pod weights) were analysed using ANOVA ( $p=0.05$ ) while treatment means were separated by Duncan's Multiple Range Test. High Al rate (150 $\mu$ M) reduced the growth and yield of soybean while moderate Al application rates (50 and 100 $\mu$ M) enhanced the performance of crop. Combination of OF +IF enhanced crop growth and yield even when 100 $\mu$ M Al was applied. However, it was only sole application of organic fertilizer that was able to promote crop performance at 150 $\mu$ M Al concentration. Organic fertilizer had the highest residual effects among the various fertilizer treatments confirming that organic based fertilizers could be used to minimize the deleterious influence of aluminium toxicity on the production of soybean in acid soils.

#### **EFFECT OF MAVUNO AND FARM YARD MANURE FERTILIZER APPLICATION ON SOIL PROPERTIES IN WESTERN KENYA**

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The study was undertaken to evaluate the effect of organic and inorganic fertilizer application on soil chemical and biological properties in Siaya and Vihiga districts of Kenya. The experiment was set up in a completely randomized block design with a split plot arrangement with the fertility gradients (high and low) as the main plots and the treatments (IR maize control, manure only and mavuno + manure) as the sub plots. IR maize was the test crop. Soil pH, organic C, P and total N were analyzed at initial, flowering and at maturity maize growth stages. Organic carbon respiration was recorded at 3, 7 and 14 days of incubation. There were significant differences in P levels between treatment means with mavuno + manure treatment recording the highest mean P levels (11.78) at crop maturity. Soil organic C and total N showed significant differences across sites and treatments prior to planting and at harvest ( $P<0.001$ ). There were significant differences in soil pH across sites prior to planting. Soil respiration showed significant differences across fertility gradients after 7 and 14 days of incubation. A combination of both organic and inorganic fertilizers potentially enhanced both soil biological and chemical properties. Further studies are recommended on dynamics of soil microbial biomass across fertility gradients in smallholder farms.



## **EXPLORING THE EFFECTS OF APPLICATION OF INTEGRATED SOIL FERTILITY MANAGEMENT TECHNOLOGIES (ISFM) ON YIELDS AND BENEFITS OF IMPROVED CASSAVA AND SWEET POTATO VARIETY IN KAGERA REGION, TANZANIA**

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Eighty five per cent of the people in Kagera region depend on agriculture as the main source of livelihood. Although the region is endowed with high rainfall (above 1500 mm) with short and long rain cropping seasons yet it is one of the most food-insecure in the country. The baseline survey conducted in 2011 showed that the average yields of cassava root and sweet potato tubers were 7.1  $\text{tha}^{-1}$  and 5.2  $\text{tha}^{-1}$ , respectively compared to 26-30  $\text{tha}^{-1}$  and 15-20  $\text{tha}^{-1}$  for cassava and sweetpotato, respectively from on station trials. These low yields are due to complex interaction of frequent outbreaks of cassava and sweet potato pests and diseases, aggravated by use of poor cassava and sweetpotato germplasm, declining soil fertility and use of poor agronomic practices by farmers. A study was conducted in 2011 in Bukoba, Muleba and Biharamulo districts of Kagera region to explore the effect of application of ISFM technologies on cassava and sweetpotato yields and profit. A total of five cassava and eight sweetpotato mother demonstration fields were established during 2010-11 season. Triple superphosphate (TSP) and muriate of potash (MOP) both at the rate of 50 kg P and K  $\text{kg ha}^{-1}$ , respectively and farmyard manure at the rate of 6  $\text{tha}^{-1}$  were tested against the control (no fertilizer applied). Demonstration fields were laid out using randomized complete block design (RCBD). Treatments were applied in three replications. Plot size was 10 m x 10 m. Before planting soil samples were collected and analyzed for particle size distribution (soil texture), pH, organic carbon (O.C), total nitrogen (N), available phosphorus (P) and cation exchange capacity (CEC), exchangeable cations (calcium, magnesium, potassium and sodium). Agronomic and socio-economic data collected, were processed and analyzed using Gen-stat and excel programs, respectively. The laboratory soil results showed that the soils in all sites were acidic to moderate acidic, with very low to low organic carbon, low to medium total N, low to medium extractable P, low to medium exchangeable K, low to medium exchangeable Ca, and low to high exchangeable Mg. The results showed significance ( $P \leq 0.001$ ) response to the application of fertilizers within the treatments and districts but not across the districts. Application of fertilizers increased cassava root and sweet potato tuber yields from 11.36  $\text{tha}^{-1}$  and 7.75  $\text{tha}^{-1}$  to 26.09  $\text{tha}^{-1}$  and 22.44  $\text{tha}^{-1}$  for cassava and sweetpotato, respectively and cassava and sweetpotato biomass from 19.02  $\text{tha}^{-1}$  and 4.51  $\text{tha}^{-1}$  to 33.34  $\text{tha}^{-1}$  and 9.81  $\text{tha}^{-1}$  for cassava and sweetpotato, respectively. Likewise, the application of fertilizers gave net profit ranging from 2,732-3,676 USD for cassava and 1,932.7-2,191.33 USD for sweet potato compared to 1,523.3 USD and 536 USD for cassava and sweetpotato, respectively when fertilizers were not applied. The research suggested more investigation on the rate(s) of fertilizers to be applied for optimum cassava root and sweetpotato tuber yields and benefits.



## MAIZE GROWTH RESPONSE AND PHOSPHORUS AVAILABILITY FOLLOWING BUSUMBU PHOSPHATE ROCK APPLICATION IN A DESMODIUM- MAIZE ROTATION SYSTEM

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Phosphorus (P) is a limiting macronutrient after nitrogen (N) for plant growth in western Kenya. It has been demonstrated that in soils deficient in plant available P, legumes supplied with phosphate rocks (PR), increase P availability and uptake by the succeeding crop. The aim of this study was to assess the extent to which *Desmodium* spp fertilized with Busumbu phosphate rock (BPR) can increase soil available P, P uptake and biomass yield of maize (*Zea Mays*) planted after *Desmodium* spp in a greenhouse experiment conducted in two phases. In the same pots, sole maize and two *Desmodium* spp: (*D. intortum*-(Mill.) Urb. cv Greenleaf and *D. uncinatum*-(Jacq). DC., cv Silverleaf) with and without BPR were grown separately in the first phase of the experiment followed by sole maize with no P application in the second phase of the experiment. Pots were arranged in a completely randomized design replicated four times. Reference treatments with soluble P (KH<sub>2</sub>PO<sub>4</sub>) were included. Results showed that in the first phase of the experiment, application of BPR significantly increased above ground dry matter yield (DMY) of *Desmodium* spp but not of maize, suggesting enhanced BPR solubilization in *Desmodium* grown soils. When BPR was not applied, soil available P was higher in soils with *D. intortum* compared to either *D. uncinatum* or sole maize. In the second phase of the experiment, above ground maize DMY, P concentration and available P were higher in maize following *Desmodium* spp compared to maize following maize whether BPR had been applied or not. *D. intortum* previously fertilized with BPR gave the highest and significant above ground maize DMY (6.05 g container<sup>-1</sup>) and P concentration (16.15 g P container<sup>-1</sup>). This study demonstrated that *Desmodium* spp receiving BPR enhances yield and P availability of the following maize crop compared to sole maize systems.

## COMPARATIVE EFFECTS OF ORGANIC AND INORGANIC PHOSPHORUS SOURCES ON MAIZE YIELDS AT TWO ACIDIC SITES IN WESTERN KENYA

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We evaluated the effects of FYM and tithonia, when applied alone or in combination with Minjingu phosphate rock (MPR), Busumbu phosphate rock (BPR) or triple superphosphate (TSP), on maize yields and financial benefits in acid soils at Bukura



and Kakamega in western Kenya. The response of maize to the nutrient inputs was site specific. At Bukura maize did not respond to inorganic P sources applied in combination urea but responded when the inorganic P sources were applied in combination with FYM or tithonia while at Kakamega maize responded to TSP but not MPR or BPR when applied with urea. Tithonia combined with TSP gave the highest yields and net financial benefits at both sites but this did not translate to economic attractiveness since the benefit cost ratio was lower than 2, which is considered the threshold below which farmers will not adopt a technology. Only FYM when applied alone seemed to meet this criterion at Bukura and therefore the most likely of the tested practices to be adopted at this site while at Kakamega none of the tested technologies was economically attractive.

### HOW 50 YEARS OF ORGANIC AND MINERAL FERTILIZATION REGIMES ON LIXISOL AFFECT SOIL P AVAILABILITY AND SYMBIOTIC N<sub>2</sub> FIXATION IN SORGHUM-COWPEA ROTATION?

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The lixisols from semi-arid West Africa, given their fragile structure and their low nutrient contents are difficult to manage to reach good crop yields. Organic and mineral inputs are essential for reaching good crop yields in those soils. Whereas the long-term effects of organic inputs on soil N and P dynamics were largely investigated on temperate soils, little information are available for tropical soils mostly the lixisols from West Africa. This study was conducted in the long-term field trial of Saria implemented since 50 years in the Centre West area of Burkina Faso. In the plots where sorghum and cowpea are grown in rotation, we evaluated in 2009 and 2010, the effects of organic and mineral fertilizers on soil P availability from the upper layers to 100 cm and symbiotic N<sub>2</sub> fixation. Soil chemical characteristics namely total C, N, P and pH were assessed as well as sorghum and cowpea yields. We calculated available P stocks for the horizons 40-60, 60-80 and 80-100 cm and N and P balances for two cropping seasons, taking into account the N<sub>2</sub> fixed by cowpea in 2009. Cowpea does not respond to the fertilization rates as much as sorghum. With an application rate of 40 t ha<sup>-1</sup> of manure every second year, sorghum yield potential is reached (about 5 tha<sup>-1</sup> of grain) and soil carbon stocks maintained but the risk of P losses is high (about 50 kg ha<sup>-1</sup> of available P found in the horizon 80-100 cm). In the contrast, 5 tha<sup>-1</sup> of manure every second year does not maintain soil carbon stock and crop yield potentials are not reached but lower amount of P is found in the horizon 80-100 cm (<10 kg ha<sup>-1</sup>). About 35% of cowpea N is derived from the atmosphere. The high rates of fertilizers lead to limited quantities of N derived from the atmosphere but to high amounts of N fixed because of yields increase. When water soluble mineral fertilizers are applied solely, cowpea exports



more P and K than sorghum leading to a negative K balance. On the contrary when manure is added, sorghum exports more P and K than cowpea and balances are positives.

## **PERFORMANCE TESTING FOR SOIL LABORATORIES AS A CONTRIBUTION TO SOIL FERTILITY CHARACTERISATION IN SOUTHERN HIGHLANDS**

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This study was carried out by three major soil laboratories in Tanzania. These laboratories were in Agricultural Research Institute Uyole, Sokoine University of Agriculture and Agricultural Research Institute Mlingano. Top soil composite samples (from 0-25cm depth) were sampled from two different locations. Samples were air-dried ground uniformly then sieved and three labelled subsamples were taken to each laboratory for analyses of parameter of interest. Similar analytical methods were applied in each laboratory in order to allow results from each laboratory to be compared. Calculations and computations of results were carried out to obtain means, standard deviations and coefficient of variations (CV) in the excel 2007 program. Outcomes of the computed results were used for discussion. Generally, results have shown a great degree of comparability. Within-laboratory standard deviations were relatively small for most of parameters analysed, and standard deviations were less than 10. However, CV values were high in parameters such N (CV 25-39%), P (CV 38%) and CEC (CV 13-25%). For inter-laboratories precision, standard deviation values and CV were larger than within laboratory values a good example was for exchangeable-base cations. This to greater extent shows the need to emphasise inter-laboratory precision. Analytical instruments used for the measurement, procedures for extraction of exchangeable-base cations varied from 4 to 10 years old for AAS. The effect of electricity fluctuations and surges did in fact contribute to most of the within laboratory observed minor variations. It is recommendations that firstly to improve inter-laboratories precision, standard operating procedures should be elaborated for all laboratories. Secondly, to counter unstable power supplies and surges which affect analytical results in laboratories must be installed with stable power supply systems to maintain the longevity and the functionality of the laboratory working instruments. Regular quality control needs to be promoted, not only in the laboratories that participated but also in others that serve the farming community; this will encourage the production of credible and reliable results on consistent basis. Further, efforts should be made to improve precisions by promoting standardization of the procedures. Disparities in methodologies in use should be avoided this will allow our results to be compared with minimum discrepancies.



## THE EFFECTS OF APPLICATION OF INTEGRATED SOIL FERTILITY MANAGEMENT TECHNOLOGIES (ISFM) ON YIELDS AND BENEFITS OF MAIZE IN KAGERA REGION, TANZANIA

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The production of maize in many parts of Kagera region is increasing rapidly due to declining production and yields of banana, the only food crop widely grown in the region 20 years before. However, the baseline survey conducted in 2011 in Biharamulo, Bukoba, Muleba and Misenyi districts showed the average maize yields under farmers fields to be 1.1 t/ha as compared to 3 tha<sup>-1</sup> from on station trials. The low maize yields is due to declining soil fertility aggravated by extensive weathering of the soils, low organic matter content in the soils and continuous crop removal of the nutrients from the soils without replenishment (Baijukya and Folmer, 1999), use of poor germplasm and poor agronomic practices by farmers. A study was conducted in Biharamulo, Bukoba and Muleba districts of Kagera region to explore the impact of ISFM technologies on maize yields. The study took a mother-baby demonstration approach to identify the best bet ISFM technologies among the candidate technologies including Urea alone, Urea and Minjingu granular, Urea and Minjingu powder, Urea and Minjingu mazao and Urea and triple superphosphate. All fertilizers were tested against the control (no application of fertilizer). Urea was applied at the rate of 60 kg Nha<sup>-1</sup> while TSP and Minjingu fertilizers were applied at the rate of 20 kg Pha<sup>-1</sup>. Demonstration fields were laid out using randomized complete block design (RCBD). Treatments were applied in three replications. Plot size was 10 m x 10 m and the net plot area was 43.2 m<sup>2</sup>. Improved maize seeds (*Situka variety*) were planted in a flat land at a spacing of 0.9 m x 0.6 m. Before planting soil samples were collected and analyzed for particle size distribution (soil texture), pH, organic carbon (O.C), total nitrogen (N), available phosphorus (P) and cation exchange capacity (CEC), exchangeable cations (calcium, magnesium, potassium and sodium) using standard methods outlined by National Soil Service, 1990 and Moberg, 2000. Agronomic and socio-economic data collected, were processed and analyzed using Gen-stat and excel programs, respectively. The laboratory soil results showed that the soils in all sites were acidic to moderate acidic, with very low to low organic carbon, low to medium total N, low to medium extractable P, low to medium exchangeable K, low to medium exchangeable Ca, and low to high exchangeable Mg (Landon 1999). The results showed significance (P≤0.001) maize response to fertilizers application within the treatments and districts but not across the districts. Application of fertilizers increased maize grain and biomass yields ranging from 2.28-3.25 tha<sup>-1</sup> and 1.15-1.45 tha<sup>-1</sup>, respectively, compared to 0.86 tha<sup>-1</sup> from the control. Likewise, application of fertilizers gave net profit ranging from 116.7-378.7 USD compared to net loss of 278 USD when fertilizers were not applied (control). The research showed that it is uneconomical to plant maize without application of fertilizers.



### THEME III: ORGANIC FERTILIZERS

#### ENHANCING DECOMPOSITION AND IMPROVING THE QUALITY OF RICE STRAW COMPOST AND ITS RESPONSE ON LOWLAND RICE IN RWANDA

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Rice (*Oryza Sativa*) is one of the major staple crops in Rwanda cultivated twice a year mainly in the marshlands. The local average production is 5.8t/ha. The majority of the soils under which rice is grown are inherently infertile. This calls upon to initiate ways of providing appropriate and inexpensive agricultural techniques to improve soil fertility. Rice straw as an important agricultural waste available in huge quantities to rice farmers imposes its proper use instead of being inadequately disposed off. The aim of this work is to improve the quality of rice straw compost by enhancing the decomposition process using locally available nitrogen rich materials namely *tithonia diversifolia* and cattle manure with respect to adequate combinations. The nutrient content of raw materials: rice straw, *tithonia diversifolia* and cattle manure has allowed to determine the adequate combinations of this materials prior to making compost. This was done in such way that the C/N ratio in each treatment could lie between 25-30. Four treatments with three replications were under study. These were control (rice straw only) with a C/N ratio of 46.56:1, a combination of rice straw with cowdung (C/N of 30.27:1), a combination of rice straw with *tithonia diversifolia* (C/N ratio of 28:1) and a combination of rice straw with cowdung and *tithonia diversifolia* (C/N ratio of 26.6:1). Monitoring of chemical changes during composting has helped to investigate the crucial importance of aeration, moisture content and temperature on the quality of the final product. Changes in total carbon, total nitrogen, in water soluble carbon, in ammonia, in nitrates and pH have been studied at different stages of compost decomposition. Results showed that during the thermophilic phase, the optimum temperature reached 67°C. The quality of final product will be assessed by the level at which the compost will be rich in available nutrient contents: total carbon, total nitrogen, phosphorus, potassium, calcium and, magnesium.

#### IMPROVING SOIL FERTILITY USING ORGANIC FERTILIZERS IN CENTRAL KENYA

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Soil fertility decline is an insidious process that continues with time, there is therefore need to appraise levels of nutrient losses continuously and replenish the lost nutrients. As a result, there is need to integrate different nutrient inputs to the



fertility-depleted soils to increase per capita food production, particularly maize the staple food in most African countries. Organic soil amendment technologies have shown to provide the soil with not only the macro and micronutrient elements but also found to improve soil texture and structure enhancing soil aeration through bacterial activities and increased water holding capacity. To demonstrate the potential of organic soil fertility inputs, different organic fertilizers were tested in two districts of central Kenya; Kirinyaga and Maragua. The results showed that *Tithonia diversifolia* (tithonia 5 t ha<sup>-1</sup> application) (fresh weight) gave the highest yield in Kirinyaga (4 t ha<sup>-1</sup>) but in Maragua although high yields were observed in tithonia 5 t ha<sup>-1</sup> (4.5 t ha<sup>-1</sup>), the highest yield was recorded under manure 10 t ha<sup>-1</sup> (5.6 t ha<sup>-1</sup>). Green manure cover crops suppressed maize grain yields during vegetative growth and some incorporation performed poorly particularly dolichos incorporation, but mucuna and *crotalaria ochroleuca* (crotalaria) had promising yields. This is an indication that there is potential to create food security to many rural Kenyan households, who have tithonia naturally growing along their fences and can regularly prune and use it to increase food production in their farms. Although during the growing period green manure cover crops compete with the intercropped crop for light, water and nutrients, after incorporation, the benefits are evident, but the greatest challenge is to convince the farmers to sacrifice their food crop legume (mainly beans) and grow green manure to improve soil fertility. There is potential in both the green manure cover crops, biomass transfer and manure application technologies to improve soil fertility and food production.

#### **INFLUENCE OF COMPOST USE ON SOIL NUTRIENTS AND MAIZE YIELD IN SOILS OF WESTERN KENYA**

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A study was conducted in Buyangu and Ivakale villages in Kakamega County from March 2010 to August 2011 to evaluate six locally available organic biomasses namely; cow manure, maize stover, *Tithonia diversifolia*, sugarcane straw, bagasse and filtermud for their potential in compost production and its effects on soil chemical properties and maize growth. The treatments comprised of the six composts, inorganic fertilizer and a no-input control, and the experiment was laid out in a randomized complete block design (RCBD) with four replicates. Soil samples were taken randomly from the plots using steel core samplers. Yield data was obtained at the end of the season when the crop was dry. Data obtained was subjected to analysis of variance using GENSTAT statistical software while treatment differences were evaluated using least significant difference (LSD) at 5% level of significance.



## INTERACTIVE EFFECTS OF SOIL AMMENDMENTS ON SOIL EXCHANGEABLE ALUMINIUM AND pH OF AN ACID MOLLIC ANDOSOL

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The current study investigated the interactive effects of Lime (L), minjingu phosphate rock (RP) and manure (FYM) on soil exchangeable Al and pH of an acid soil (pH < 5.0). The field experiment, conducted in 2009 and 2010 at the Kenya Agricultural Research Institute (KARI), Molo, Kenya, was laid out in a randomized complete block design with 2<sup>3</sup> factorial arrangement. The factors each at two levels were L (0 and 3 t ha<sup>-1</sup>), RP (0 and 60 kg P ha<sup>-1</sup>) and manure (0 and 5 t ha<sup>-1</sup>) giving a total of eight treatments; control, L, RP, FYM, L\*RP, L\*FYM, RP\*FYM and L\*RP\*FYM. The L\*RP interaction had significantly higher soil pH at end of the experiment followed by L\*MRP\*FYM interaction. All treatments, except control, had lower levels of exchangeable Al at termination of the experiment. Since the application of RP and L may have strong carry over effect on soil pH, the L\*RP\*FYM may be preferable due to the acidifying effect of FYM.

## DECOMPOSITION RATES AND NUTRIENT RELEASE PATTERNS OF TEPHROSIA VOGELII AND TEPHROSIA CANDIDA RESIDUES IN MALAWI

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The main input of nutrients in agroforestry systems is achieved through biomass decomposition. A study was carried out to determine the rates of decomposition and N and P release pattern from *T. vogelii* and *T. candida* plant residues using litterbag experiments in Malawi. The plant residue treatments included *Tephrosia* biomass alone or in combination with maize stover. For each treatment, sixteen replicates of litter bags were buried in the soil at the depth of 20cm and Samples were drawn from each litter bag at 1, 2, 3, 4, 5, 6, 7 and 8 week intervals and were analyzed to determine remaining dry matter weight (DMW), N and P. The fastest decomposition rates (k) recorded when *T. vogelii* or *T. candida* leaves + twigs + stover were combined, while the slowest was when twigs alone or maize stover alone were used. The *Tephrosia* residues were high in N (>3.5%) and P (critical value of >2.0%). The N release rates were fastest from twigs of *T. vogelii* or *T. candida* followed by maize stover alone, while the slowest release was when *T. vogelii* leaves were combined with twigs. P release pattern from residues was the same as N release. No N and P immobilization was observed throughout the study period. The results have clearly demonstrated that that the *Tephrosia* fallow biomass alone decompose considerably



faster attaining their half-life within 2–3 weeks and over 95% within 8–25 weeks but when mixed with maize stover (a low quality farm residues) decomposition was slowed down. Therefore, *Tephrosia* fallow biomass can be used for short-term correction of soil fertility.

## THEME IV: SOIL BIOLOGY

### IMPROVING SHELF LIFE OF LEGUME INOCULANTS IN EAST AFRICA

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Adoption of legume inoculation with rhizobia by small-scale farmers in East Africa, and the resultant increase in biological nitrogen fixation requires that quality inoculants meet minimum standards. In the case of BIOFIX, the only commercially-available inoculant in East Africa, that standard is at least  $10^9$  rhizobia  $g^{-1}$ . We examined the effects of carrier material and storage conditions on the populations of two industry standard rhizobia, *Bradyrhizobium japonicum* USDA 110 for soybean (*Glycine max*) and *Rhizobium tropici* CIAT 899 for common bean (*Phaseolus vulgaris*) over 165 days using the drop plate method on Congo Red Yeast Extract Mannitol Agar. Viable populations of *rhizobia* differed significantly between carriers ( $P < 0.001$ ) and rhizobia strain ( $P < 0.05$ ). *R. tropici* CIAT899 prepared with filter mud carrier achieved a shelf life of 135 days and *B. japonicum* USDA110 contained over  $10^9$  cells  $g^{-1}$  for 105 days. Both of these results fall below the stated six month expiry period of BIOFIX. Replacing filter mud carrier with vermiculite resulted in an inferior product however both more thorough sterilization and refrigerated storage after a 14 day curing stage improved it. While BIOFIX meets reasonable standards in terms of its rhizobia, it must not be carried over between seasons. Even under refrigeration, its expiry period should be shortened and opportunity exists to improve its quality.

### SOIL EFFECTIVE MICROORGANISMS AS FOUL ODOR ELIMINATOR IN PIG PRODUCTION IN UGANDA

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Soil under our feet contains all the treasures that man needs for his development. There are non-living things like precious minerals like gold, diamond, silver and gas oil like petroleum and natural gases together with living organisms. The living part of soil consists of microorganisms like bacteria and fungi that are only seen by an aided eye and macro organisms exemplified by earthworms, termites and ants. Due to its direct economic and market attraction the nonliving portion of soil



has been greatly attended to and explored by man. On the contrary little is known yet of the living soil. Nevertheless, recent increased man's needs in terms of improved food production and environment to cater for increasing population have educated man to put more efforts in discovering the potential of soil organisms in enabling farming communities to excellently produce their own foods. Some nations like India, China, France, Switzerland Japan and U.S.A to mention but a few have benefited from use of soil organisms in improving food production and environment management. Usually use of such soil organisms begins with isolation and characterization of the indigenous ones. Therefore, this work aimed at initial isolation and characterization of indigenous soil microorganisms (IMOs) that eliminate foul odor from a piggery. This is very important to man because pork in time memorial, has played a major global role as an easily accessible source of animal protein for a big percentage of human kind. Samples of cultures containing soil organisms to improve sanitary of piggery, were collected from 5 farms in three districts namely Mukono, Kayunga and Wakiso. The isolation and characterization focused on comparison of organisms in stirred slurry, un - stirred slurry and piggery litter / floor where slurry had been applied. Standard methods of viable microbial counts were employed in the laboratory at Makerere University. Indigenous soil organisms used to give good sanitary piggery consist of actinomycetes, bacteria and fungi (ABF) in varying proportions. Bacteria with 45% registered highest mean population followed by actinomycetes (29%) and fungi (26%) registered the least population. Among the farms studied significant variations were mostly obtained in fungi populations, followed by actinomycetes and bacteria varied less. In addition, ABF populations were highest in stirred cultures, followed by un - stirred cultures and litter had the least. It was concluded that Uganda soils have beneficial indigenous microorganisms that have potential use in eliminating foul odor from piggery but their culturing conditions practices should be suitable to promote ABFs' growth in their proportional ratio and their cultures must be thoroughly stirred up before application to the litter. Authors recommend an in-depth research to avail more understanding of the species of ABF for exploitation to ensuring good sanitation and improved and environment in pigs production industry.

#### **EFFECT OF LAND USE INTENSIFICATION ON EARTHWORM ABUNDANCE, BIOMASS AND SOIL IMPACT INDEX IN MABIRA TROPICAL FOREST AND ADJACENT FARMLANDS, UGANDA**

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Land use intensification is on an increase in developing countries. It may have effects on soil organisms like earthworms (Oligochaeta). Such organisms play a big role in sustenance of soil quality and improvement of crop production. However, in Uganda little is known of earthworms and how they respond to land use changes. Hence, this study aimed at identifying earthworm species, evaluating their



responses to land use changes along an intensification gradient in Mabira Tropical Forest and the adjacent agro-based ecosystems of Uganda. Six Windows each being 1 Km, <sup>2</sup> were set in areas capturing most dominant land use mosaics. A Window stretched from least disturbed forest to most intense farms giving a land use intensification gradient. Considered six land use types were: Forestry, Fallow, Mixed cropping, Tea plantation, Grassland and Sugar cane plantation arranged in their order on the gradient. Land use types and their numbers varied among Windows. Sampling points were 16 for each Window, a minimum of 7 for each land use type and a total of 96. Known methods of sampling of earthworms from soil were employed. Taxonomic methods were used to identify earthworm species. Species were separately counted and weighed for each sampling point. Data obtained on diversity, density, biomass and soil impact index (SIINDEX) of the earthworms were statistically analyzed using computer programs like Estimates and PAST. Fourteen (14) terrestrial earthworm species were identified. One was exotic, while the rest were of African origin and one was endemic to Uganda. Two morpho-species were found to be new to science. Dominating species by density were *Gordiodrilus wemanus* (Michaelsen, 1937) by 50% and *Eminoscolex kisantuanus* (Michaelsen, 1935) by 27%. Forestry was significant ( $P < 0.005$ ) different from the rest land use types in terms of both density biomass of earthworms. Mixed cropping was significantly different from Sugar cane, Grassland, Tea. Also Fallow was significantly different from Sugar cane and Grassland. The observed trend from Forest through mixed cropping, fallow systems, and grazing systems to plantations shows the increased detrimental effects of land use intensification on earthworm communities. It is noted that though mixed cropping is a land use type of high disturbance, it was consistently found to have high diversity and density of earthworms similar to and in some cases better than strict nature forest. It was suggested that such results are attributed to how the management practices of this land use type provide ecological conditions such as continuous supply and quality of organic materials as food and refuge niches against climatic stresses that are required for multiplication and growth of earthworm population. Therefore more in-depth research should be done to understand the ecology of the various land use types especially that of mixed cropping aim at better conservation of earthworms in agro-systems.

#### **DIVERSITY OF SOIL INVERTEBRATE MACRO- FAUNA AND THEIR RELATIONSHIPS WITH SOIL PHYSIOCHEMICAL PROPERTIES IN OIL PALM PLANTATIONS IN BUGALA ISLAND KALANGALA**

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Oil palm management practices in particular such as application of fertilizer, influences the status and abundance of soil macro fauna in Kalangala district. On the other hand, this could lead to emergence of key groups and species of fauna and on the other elimination or reduction of the same. A study was conducted to investigate the relationship of soil macro fauna composition with soil physiochemical properties



in oil palm plantations. The macro fauna populations were monitored in soil monoliths 25cm x25cmx 30cm. Significant differences were recorded across oil palm plantations. Seven ecological categories were used as basis for functional groupings with Ants constituting the highest number of the total organisms observed. (Epigeic/Anecic ecological category) ranked highest among the macro fauna with 28.2%. Hymenoptera (ants) ranked highest in this study with 33.6% followed by Isoptera (Termites) with 23.6 % and Others which were not identified were of 15.4%. Soil analysis indicated that pH was generally low for all fields. The study demonstrated the role of soil invertebrates macro fauna in regulating soil chemical properties and vice versa and contributes a great deal towards filling the knowledge gap on the role soil macro fauna play within oil palm growing. The study therefore suggests that soil macro fauna can be used as indicators of chemical status of the soil there by forming a basis for the management of soil resource for increased productivity. The challenge in future calls for creation of biophysical tools capable of promoting successful and sustainable biota conservation within oil palm plantations.

#### **ENHANCING NITROGEN FIXATION AND PRODUCTIVITY OF DRY BEAN GENOTYPES IN PHOSPHORUS & NITROGEN LIMITED AREAS OF CENTRAL KENYA HIGHLANDS THROUGH *RHIZOBIUM*, *AZOSPIRILLUM* RHIZOBACTERIA-RHIZOBIUM CO-INOCULATION**

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Bean productivity in the highlands of Kenya is on the decline due to low soil fertility with respect to N and P. The low bean productivity should be addressed by technologies that are based on locally available resources, conserve the environment and are sustainable. Co-inoculation of dry bean with *Azospirillum* and *Rhizobium* has the potential to enhance nitrogen fixation of bean genotypes in N and P limited conditions. The objective of the study was to determine growth and yield response of two bush bean varieties inoculated with *Azospirillum*, *Rhizobium* and a mixture of *Azospirillum* rhizobacteria and *Rhizobium* under high and low Phosphorus levels at KARI-Embu. The treatments were laid out in a randomized complete block design with a factorial arrangement and replicated four times. Results of four seasons' trials show that P application improved nodulation, grain and biomass production. Inoculation with *Azospirillum* increased the grain yield of bean line Embean 14 in high P soil by 11 kg ha<sup>-1</sup> compared to 97 kg ha<sup>-1</sup> in low soil P, and bean line Nguaku nguaku in high P soil by 83 kg ha<sup>-1</sup> compared to 335 kg ha<sup>-1</sup> in low P. Higher yield increases due to *Azospirillum* inoculation were realized in low P soils probably due to improved P uptake. Inoculation with *Rhizobium* increased the grain yield of line Embean 14 by 228 kg ha<sup>-1</sup> in high P soil compared to 27 kg ha<sup>-1</sup> in low P soil, and line Nguaku nguaku grown in high P soil by 253 kg ha<sup>-1</sup> compared to 83 kg ha<sup>-1</sup> when grown in low P soil. *Rhizobium* inoculation resulted higher increase in grain yields in high P soils. Co-inoculation with both *Azospirillum* and *Rhizobium* increased the grain yield of line Embean 14 by 307 kg ha<sup>-1</sup> in high P soil compared with 146 kg ha<sup>-1</sup> in low P soil. Line Nguaku nguaku increased grain yield by 200 kg ha<sup>-1</sup> in high P soil and 146 kg ha<sup>-1</sup> in low P soil. *Rhizobium* CIAT 899 strain was superior in grain yield



improvement than the native *Rhizobium* and that that co-inoculation with *Rhizobium* and *Azospirillum* improved grain yields of beans in high and low P soils.

## CONSERVATION AGRICULTURE EFFECTS ON EARTHWORM POPULATIONS IN WESTERN KENYA AND EASTERN UGANDA SOILS

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High population pressure and poverty levels in Western Kenya and Eastern Uganda have led to continuous cultivation of land aimed at achieving a stable food supply for the ever growing population resulting in a decline in food crop production and decline in soil quality over the years. Studies have underlined the advantages of Conservation Agriculture towards improving crop production and replenishment of soil fertility; increase in crop yields, increase in soil organic matter content and decrease in runoff and hence aid in controlling soil erosion. However, the mechanisms responsible for these improvements have not been fully explored. Studying soil biodiversity can help in understanding the dynamics of soil structure and the replenishment of nutrients. The population of soil invertebrates and soil pH in relation to Nitrogen application (+N and -N) were therefore studied under maize, beans and mucuna crops: 3 tillage systems; 1) No-Till (NT), 2) Conventional Tillage (CT), 3) Minimum Tillage (MT), and 3 cropping systems; 1) Strip cropping, 2) Intercropping with Mucuna riley, and 3) Maize-Beans intercropping as done by the locals. A total of 20g of soil from a depth of 0-20cm was used at vegetative stage and before harvest, all sampled on a rainy day. From management perspective, tillage systems affected macroorganisms population densities differently with the order of highest to lowest; MT < NT < CT. There was a strong correlation between macrofauna numbers, and the amount and quality of residue returned to the soil as it was evident in the experimental plots with mucuna cover crop. The different Nitrogen fertilization regimes of +N and -N had strongest positive effect on earthworm population and density in a strip cropping system combined with MT, with Mucuna strip and +N recording the highest number of macrofauna (especially termites, earthworms, millipedes, centipedes) followed by beans plots (+N) and maize plots(+N). A negative correlation was realized between soil pH and earthworm population, with the population significantly reducing with soil pH below 5.00 (P<0.001). Residue returned to the soil under MT was decomposed by the increased number of soil macrofauna under mucuna cover crop plots and hence resulted to improved soil quality.



## EFFECT OF RHIZOBIA INOCULATION AND PHOSPHORUS ON NODULATION AND YIELD OF SOYBEAN (*GLYCINE MAX* L MERRIL) IN CENTRAL HIGHLANDS OF KENYA.

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Grain legumes replenish and improve soil fertility by fixing nitrogen, provide protein for nutrition, and generate income. Methods that improve nitrogen fixation in legumes therefore need to be evaluated as a means to increase food production per unit input. Field experiments were conducted in Central Highlands of Kenya (CHK) to investigate the response of Soybean (*Glycine Max.* L.Merril.) to *Bradyrhizobium japonicum* inoculation and phosphorus in the 2012 October/November long rains (LR). Three P rates of 0, 30, and 60 kg P Ha<sup>-1</sup> were evaluated with *rhizobia* inoculation and non-inoculation. The experimental design was a randomized complete block design with eleven replicates. Number of nodules and activity, plant dry and root dry weights, total biomass and grain yield were determined. *Rhizobia* inoculation significantly increased nodule numbers of soybean, giving mean nodules per plant as follows; P0; 0.3, P0+inoculation; 24.2, P30; 0.7, P30+inoculation; 25.5, P60; 1.3, and P60+inoculation; 24. The treatment with the highest number of nodules was 30Kg P Ha<sup>-1</sup> with *rhizobia* inoculation. Inoculation also affected the presence of leghaemoglobin in nodules with inoculated plants having more active nodules than non-inoculated ones. It also significantly increased plant total biomass yield Ha<sup>-1</sup> at harvest with P0; 1866.7Kg, P0+Inoc; 4745.5kg, P30; 3297kg, P30+Inoc; 5169.7kg P60; 5024.2Kg, P60+Inoc; 6254.5kg, and grain yield Ha<sup>-1</sup> of P0; 842.3kg, P0+Inoc; 2467kg, P30; 1506.3kg, P30+Inoc; 2678.3kg, P60; 2285.4kg and P60+Inoc; 3396.5kg. Phosphorus fertilizer application significantly increased root dry weight of soybean, with P0 recording a mean root dry weight per plant of 1g, P30 1.9g, and P60, 2.5g. Phosphorus rate, however, did not significantly affect the nodule numbers of Soybean neither did it affect leghaemoglobin in nodules. Nitrogen fixation was evident in all inoculated and nodulated plants due to the presence of leghaemoglobin. Nodulation was negatively affected by soil acidity with more acidic soils (pH 4.8-5.3) recording low nodulation despite inoculation. P affected soybean yield in the LR season with higher yield in the higher rate application of 60Kg per ha. This indicated the need to raise soil pH values as a way of improving soybean yield. The highest agronomic efficiency was however realized in the application rate of 60Kg P per ha, as 1 kg of Phosphorus gave 22.13kg soybean in yield {(yield of P30-Control)/30=Yield contribution per kg of Phosphorus} while the additional 30kg in P60 gave 25.97kg soybean per 1kg of P {(Yield of P60-yield of P30)/30=Yield contribution per additional kg of Phosphorus} It would therefore be recommended to apply 60Kg of phosphorus per ha for soybean production since it gave higher yield per unit application by a factor of 3.84kg.



## ENHANCING BIOLOGICAL NITROGEN FIXATION IN CLIMBING BEANS GROWING ON ACIDIC SOILS OF RWANDA

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Soil fertility is a key holder of agriculture production in Africa where the farmers spend a lot of money and force in order to get a solid roof in Agro-economy sector. Climbing bean production in Rwanda is constrained by soil nitrogen, which is mainly due to integrally low nitrogen content, soil erosion, and Aluminium in acidic soils. A study was conducted in order to increase yield of climbing beans in the smallholder production systems using low cost inputs under soil management practices. Assessment of Biological Nitrogen Fixation parameters was done using four different rhizobium isolates: two native isolates (SMP10<sub>(4)</sub> and SMP6<sub>(3)</sub>) and two isolates from Makerere University (Mak-Bio-fixer) and Rwanda Agriculture Board (RAB) and three level of lime (0t ha<sup>-1</sup>), (2.5t ha<sup>-1</sup>) and (4t ha<sup>-1</sup>) arranged in Complete Randomized structure in Greenhouse. Dry Matter Yield as well as N uptake increased significantly with increase in lime levels. There was varying response of native isolates SMP (10<sub>4</sub>) and SMP (6<sub>3</sub>) in performance of climbing beans varieties in terms of Dry Matter Yield, nodulation and effectiveness compared to other treatments without rhizobium and lime. Increasing of lime rate at 4t ha<sup>-1</sup> was not significant in terms of pH level reduction but was wonderful in terms of dry matter yield, total N, nodulation and its effectiveness, the height and biomass. Therefore, those native isolates and using of 2.5t ha<sup>-1</sup> of lime can be recommended for use in low-nitrogen environment as well as procreation materials.

## EVALUATION OF FOUR INOCULANTS TO ASSESS BIOLOGICAL NITROGEN FIXATION ON SOYBEAN VARIETIES IN ACID SOIL OF RWANDA

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As farming systems are changing and farmers are adopting intensive agriculture aimed at high yield per unit area, demand for more nutrient nitrogen is high to replenish the exhausted soil. In the developed world, there is high application of inorganic fertilizer especially for nitrogen, phosphorus and potassium. In such cases, the challenge is soil overload with nutrient. On the other hand, in developing countries where Rwanda belongs, there is limited application of inorganic fertilizer and the challenge is nutrient deficiency. The trials had been established in a green house, at Rubona RAB station, southern province of Rwanda. The experimental trial was made up of 19 treatments; Four different inoculants (Biofix, Legufix, USDA110 and Local) provided with tree different soybean varieties (PK6, SB24 and Sc Saga); and also tree different mineral fertilizer (TSP, KCL and Urea). Beyond the specificity of good resistance bradyrhizobium strains, inoculation cannot respond due to many



factors of which the poor quality of inoculants prevails. The quality of inoculants depends on the population number of rhizobia and their effectiveness in fixing nitrogen. The results has shown differences on N-fixing, whereby inoculants can withstand at the pH of 4.1 and N uptake went to 3.9 %,and SB24 as a promiscuous fixed up to 2.7 without inoculum. However, different strains of rhizobia form effective (N<sub>2</sub>-fixing) symbioses with their host legumes under salt, heat, and acid stresses, can sometimes do so under abiotic conditions.

## **INFLUENCE OF CROP ROTATION, FERTILIZATION AND TILLAGE ON INFESTATION OF ROOTS OF SORGHUM (*SORGHUM BICOLOR*) BY *PRATYLENCHUS BRACHYURUS***

**Mamoudou T.**

The sorghum's roots infestation (*Sorghum bicolor*) by nematode *Pratylenchus brachyurus* was studied in 03 agricultural trials in Western of Burkina Faso during 2010. These trials are representative of sorghum production by using different agricultural practices: crop rotation, the contribution of various sources of exogenous organic matter and two modes of tillage. The objective was to determine the effect of these practices on the rate of infection by *P. brachyurus*. The root lesion nematode, *P. brachyurus* was extracted according to the method of the sprinkler of Seinhorst. The infestation was 0-46 nematodes per gram of fresh roots depending on the type of agricultural practice. Our results show that crop rotations associated with mineral fertilizers can lower the pressure of nematodes on crops. Monoculture of sorghum is the most infested by nematodes compared to the rotations, sorghum-cowpea and sorghum-cotton. The sorghum-cowpea rotation was the most effective for the control of infestation by *P. brachyurus*. An average rate of infestation of 03 types of rotation (sorghum sorghum-sorghum, sorghum-cotton and sorgho-cowpea) was respectively 12, 5.5 and 3.5 nematodes per gram of fresh roots. Treatments with addition of various exogenous sources of organic matter induce low levels of *P. brachyurus* in the roots compared to control treatments without addition of organic matter. Average rates of infestation treatments with anaerobic compost, aerobic compost, manure and straw were respectively 8.5, 15.5, 7.5 and 21.5 nematodes per gram of fresh roots against 36.5 nematodes per gram of fresh roots for the control treatments. Oxen plowing affected more nematodes of sorghum compared to hand plowing. Deep oxen plowing recorded a lower rate of infection by *P. brachyurus* compared to superficial hand plowing. Treatments with oxen plowing had an average infestation of 10.5 nematodes per gram of fresh root against 19 nematodes per gram of fresh roots for hand plowing.



## EFFECTIVENESS OF PROMISING COMMERCIAL BIO-FERTILIZERS ON SOYBEAN PRODUCTION IN BUNGOMA COUNTY, WESTERN KENYA

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The study was conducted to compare the performance of promising commercial bio-fertilizers that have been evaluated under the green-house conditions at TSBF-CIAT, in farmers' conditions through the use of promiscuous soybean variety (SB19). The trials were laid out on small scale farms in Bungoma County, situated in Western Kenya. The experiment was established in March 2010 during the long rains (LR) and repeated during the short rains (SR) of 2010; laid out in multi-locational one farmer field one replicate design. Treatments were not replicated within each field. During LR 2010, 50 farms were researched on and 100 farms in the second season (SR 2010). A promiscuous medium-maturity soybean variety TGx1740-2E (SB 19) was inoculated with Legumefix (Rhizobia) or/and Rhizatech (mycorrhizae) inoculants. The mycorrhizae inoculum was applied to the soil in the seed furrows at the recommended rate of 30 kg ha<sup>-1</sup>. Nodulation was examined at mid-podding (50% podding) by carefully uprooting all plants with their entire root system from a 1 m<sup>2</sup> section in each plot. Nodules were counted and weighed; the root and shoot parts separated, and fresh and dry weights assessed. Analysis of variance was conducted to determine the effects of (and interactions between) the two inoculants on plant parameters using a mixed linear model (MIXED procedure, SAS). Rhizobial inoculation resulted in significantly ( $p < 0.001$ ) higher nodule biomass (0.93 g plant<sup>-1</sup>) compared to the control (0.27 g plant<sup>-1</sup>) across many farms. Mycorrhizal inoculation had no significant effect on nodulation when applied solely (0.38 g plant<sup>-1</sup>), but co-inoculation of Rhizobia and mycorrhizae increased nodule biomass further by 0.09 g plant<sup>-1</sup>. There was a significant difference ( $p < 0.001$ ) in terms of biomass yield between treatments. Rhizobial inoculated plants had the highest biomass production of 2086 kg/ha. Rhizobial inoculation resulted in higher grain yields of 1116 kg/ha above the control. Soybean inoculation increased both nitrogen and phosphorus uptake in the biomass. Rhizobial inoculant had the highest soybean N uptake of 48.6 N kg/ha which was significantly different ( $p < 0.05$ ) from control and sole application of mycorrhizae. Statistical analysis showed that soil factors (pH, P, C, N) significantly ( $p < 0.001$ ) affected soybean grain yields during both seasons. It is concluded from this study that rhizobial inoculants have a high potential as commercial bio-fertilizers. However, there is need to target these inputs to the most responsive fields. Further studies are needed to elucidate the conditions under which synergism between both inoculants may occur, with specific focus towards soil P availability and management of P inputs.



## **PERFORMANCE OF POTATO (*SOLANUM TUBEROSUM*) INOCULATED WITH RHIZOBACTERIA AND ARBUSCULAR MYCORRHIZA FUNGI (AMF) DUAL INOCULANTS IN CONTROL OF BACTERIAL WILT (*RALSTONIA SOLANACEARUM*)**

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Bacterial wilt is a soil borne disease caused by *Ralstonia solanacearum* is a major constraint to potato production in Kenya resulting to losses of up to 100% under favourable conditions. Biological control practices such as use of *Trichoderma*, Arbuscular Mycorrhiza Fungi (AMF) and Rhizobacteria have gained interest due to the significant role they play in nutrient uptake and suppressing pathogenic microorganisms. This study evaluated effects of three commercial strains of AMF combined with rhizobacteria on two potato cultivars; Tigoni and clone (387164.4). Potatoes were planted in a complete randomized block design four plants per crate. The experiment had 14 treatments: three strains of AMF; *Glomus intraradices*, *G. mosseae*, and *G. etunicatum* individually, nine combinations of AMF and Rhizobacteria and control. The parameters evaluated include disease severity, latent infection, tuber number and weight. For each treatment disease severity was more pronounced in Tigoni than in 387164.4 with or without microbial inoculation. There was 0% disease severity where dual inoculants containing *G. intraradices* and *Pseudomonas*, *G. etunicatum* and *Bacillus* on variety 387164.4. Similarly, *G. etunicatum* and *Bacillus* had the highest tuber yield of 40% and 74% above the controls. There is potential for microbial based bio-inoculants either as biocontrols or biofertilizers and for them to be available farmers test these microorganisms in the field to determine their efficiency and effectiveness.

## **DELIVERING BNF TECHNOLOGIES TO KENYAN SMALL-SCALE FARMERS**

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Kenya is literally "Putting Nitrogen Fixation to Work for Smallholder Farmers". It is part of a large-scale program (N2Africa) focused upon increasing grain legume production and its symbiotic N<sub>2</sub>-fixation in smallholder farming systems of sub-Saharan Africa. The program conducts strategic research in legume agronomy and rhizobiology that backstops BNF technology dissemination activities targeting 225,000 poor households over four years. As this effort is quite diverse, this abstract focuses upon activities in Kenya as an example of its mechanisms and achievements. Rhizobiology studies are conducted at the University of Nairobi MIRCEN Laboratory and through the field activities of 26 grassroot groups in west Kenya. These actions include bio-prospecting native rhizobia, greenhouse and field evaluation of these isolates, working with the MEA Fertilizer Company the



producers of BIOFIX® inoculants to assure product quality and assisting the Ministry of Agriculture to frame bio-fertilizer legislation. To date, 387 isolates were collected from 20 legume genera in 14 different ecological zones, 85% belonging to the tribe *Phaseoleae*. Isolates were tested against inoculant industry standard for bean (CIAT 899) and soybean (USDA 110) and six consistently outperform them. Collaborative efforts with inoculant production include testing the effects of carrier material selection, storage condition and different quality assessment approaches. Peat and sugar cane factory filter mud carriers perform well while vermiculite, coconut coir and charcoal do not. Refrigeration extends soybean inoculant shelf life by 30%. Recent tests of BIOFIX® ranged between 1.1 and 6.2 x 10<sup>9</sup> rhizobia g<sup>-1</sup> using the YMA drop plate technique. Evaluation using MPN procedures in the greenhouse yield lower, and more variable results. Under fertilized conditions (Sympal 0-23-16+ at 222 kg ha<sup>-1</sup>), climbing bean cv. Tamu and soybean (SB 19) responded to inoculation with BIOFIX® during the 2013 long-rains with yields increasing by +286 and +530 kg ha<sup>-1</sup>, respectively. Recommended practice (BIOFIX inoculant and Sympal fertilizer) resulted in economic returns of 4.3:1 for bean and 3.1:1 for soybean. Inoculation of soybean the previous short rains increased yield by +260 kg ha<sup>-1</sup>, nodulation by +11 plant<sup>-1</sup>, crown nodulation by +44% and red interior pigmentation by +58%. To date, improved grain legume and inoculation technologies were introduced to 37,464 Kenyan households with an adoption ratio of approximately 70%, average household benefits of \$350 per year (KSh. 30,117) and increased symbiotic N-fixation of 46 kg ha<sup>-1</sup> season<sup>-1</sup>. On another front, inoculant standards of only >10<sup>7</sup> rhizobia and <10<sup>5</sup> contaminants g<sup>-1</sup> were included within Kenya's draft Biofertilizer Act, will likely be adopted into law and N2Africa plans to assist producers to monitor and exceed these modest thresholds. The activities in Kenya are representative of the program's larger impact on BNF technologies across Africa with its main advantage being levels of commercialization in farm input manufacture and distribution, well organized farmer associations and strong demand for grain legumes by top-end buyers and food processors. For more information on our approaches and achievements, visit the program's website at [www.n2africa.org](http://www.n2africa.org).

## **ENHANCING THE STATUS OF HUMAN NUTRITION AND FOOD SECURITY IN AFRICA THROUGH INTEGRATED SOIL FERTILITY MANAGEMENT (ISFM) AND SMALL SCALE IRRIGATION: THE CASE OF N2AFRICA PROJECT**

This paper has been developed through the inputs of a large number of N2Africa milestones reports that can be accessed through the official website - [www.N2Africa.org](http://www.N2Africa.org). In addition to these inputs, special thanks go to the N2Africa project team leader - Dr Ken Giller, the current project coordinator - Dr Jeroen Huising, the capacity building coordinator - Dr Saidou Koala, the Kenya country coordinator - Dr Paul Woomeer and the former N2Africa project coordinator - Dr Ken Dashiell for using materials attributed to them personally directly in this paper. Their excellent presentation of the project work at similar conferences and workshops is enviable. Gratitude is also expressed to other N2Africa project staff members who have participated directly or indirectly in putting together the various





reports referred to in this paper. Finally, we acknowledge the ongoing support of farmers, other partners and the donors - BMGF and the Howard G. Buffet Foundation, which has led to the progress and success of the N2Africa project.

## RESPONSE OF COMMON BEAN GRAIN YIELD TO *RHIZOBIUM* INOCULATION IN MBEYA REGION, TANZANIA

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Mbeya region is among big producers of common beans (*Phaseolus vulgaris*) in Tanzania, producing about 13.5% of national annual bean production. However, yields are low averaging at 0.5t ha<sup>-1</sup> against the potential of over 1.5t ha<sup>-1</sup>. Among major reasons for low production is low soil fertility and low use of fertilizers, caused mainly by high prices of inorganic fertilizers. This study aimed to test effectiveness of bean *Rhizobium* inoculation on grain yield. The study was conducted during dry season of 2012 in two research stations, Uyole and Mbimba in Mbeya Municipal and Mbozi district respectively. Soil characterization was done in the two sites by taking one composite sample from each site and one sample from each plot (0-20cm) in both site to quickly appraise soil fertility status. Results indicated slightly acidic soils in Uyole and medium acidic in Mbimba. These soils were also poor in N, P, Ca and S. Three strains of inoculants (CIAT 899, USDA 2667 and WSM 171) were tested against two improved varieties of common beans (Uyole 96 and Njano Uyole). A control and TSP&CAN (30Kg P ha<sup>-1</sup> and 25Kg N ha<sup>-1</sup>) were included as checks, making a total of 10 treatments laid in a split plot design. Plot sizes were 5x5m and spacing of 30x10cm. 20g of inoculants was mixed with 10Kg of seeds two Hours before planting. TSP&CAN were applied basally. There was no interaction between varieties and fertilizers. TSP&CAN had the highest yields of above 1.5 t ha<sup>-1</sup> and differed significantly (P=0.05) from other treatments. The three inoculants did not differ significantly among themselves, yielding between 1.0 and 1.2t ha<sup>-1</sup>, but significantly differed from the control (0.6t ha<sup>-1</sup>). It is recommended that the three inoculants be subjected to further experimentation in combination with P source fertilizers as well as performing economic analysis of using inoculants versus N source fertilizers.



## RESPONSE OF ORANGE FLESHED SWEETPOTATO TO ARBUSCULAR MYCORRHIZAL FUNGI INOCULATION AND FERTILIZER APPLICATION IN WESTERN KENYA

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Arbuscular mycorrhizal fungi (AMF) represent a functionally important component of soil microbial community, particularly plant mineral nutrition in agro-ecosystems. A pot experiment was conducted under greenhouse conditions to evaluate the effects of different *Glomale* mycorrhizal fungal inoculants with varying chemical phosphate fertilizer rates on biomass production and root colonization of two orange fleshed sweetpotato (OFSP) varieties SPK004 and Kabode. The inocula were tested as separate single species of *Glomus mosseae*, *G. etunicatum*, *G. intraradices* and *G. aggregatum* and as mixtures in granular formulation containing spores, root fragments and other propagules. These were tested in combination of varying rates of phosphorus (P) fertilizers. Phosphorus (P) fertilizers at three rates (0kgP/ha, 20kgP/ha and 40kgP/ha) was tested. Mixed species inoculation recorded the highest root colonization compared to the separate single species. Singly, *G. intraradices* outperformed (give figures to quantify this) the other single species in terms of root colonization while *G. aggregatum* recorded the lowest root colonization. Application of chemical fertilizer at 40kgP/ha increased sweetpotato biomass production but reduced AMF root colonization. It is concluded that there is a functional complementarity among species within the AMF community and that varieties may respond differently to AMF. Soil P status also affects AMF effectiveness. Optimal condition for AMF functioning in Western Kenya therefore needs to be established.

## THE USE OF PHOSPHATE SOLUBILISING RHIZOBIA AS ISFM TECHNOLOGY TOOLS IN THE AGRO ECOLOGICAL ZONE IV OF CAMEROON

Fankem H., Ngo Nkot L., and Bahiha Ba Makon P.C.

A study that aimed at evaluating different rhizobia strains in improving local species of peanut (*Arachis hypogaea* L.) growth under stress conditions was conducted in Douala and Buea of the agro ecological zone IV of Cameroon. Sixteen isolates were obtained from peanut nodules and the analysis of their morphological and cultural characteristics as well as their growth in media with different pH and different salt concentrations allowed highlighting a physiological diversity within population of rhizobia nodulating peanut. The phosphate solubilising activity of strains was assessed on Petri plates and in liquid media amended with different sparingly soluble rock phosphates, either of Mali, Morocco or Mexico. Five of the sixteen isolates were able to dissolve the three phosphate types and the phosphate solubilising activity of strains was accompanied with the pH decrease of media. The



activity of those strains was confirmed under peanut pot grown conditions where 15-42 % yield increase was obtained.

### **INFLUENCE OF PHOSPHORUS FERTILIZED DESMODIUM SPECIES ON *S.HERMONTHICA* (DEL.) BENTH SEED GERMINATION AND VIABILITY**

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Root exudates of some desmodium species are known to not only stimulate germination of *Striga* seeds but also suppress its emergence. In a pot experiment at KARI - CIMMYT *Striga* Research Station, we tested the hypothesis that phosphorus affects production of exudates by enhancing root proliferation and consequently influencing *Striga* germination as well as seed longevity in the soil. Desmodium plants were established in pots that were treated with phosphorus at 0, 15, 30, 45, 60, 75, 90 and 105 kg P ha<sup>-1</sup>. *Striga* seeds were packed in Eplee bags and buried in separate maize potted plants that were continuously irrigated with aqueous root exudates from established potted *D. intortum* and *D. uncinatum* plants. Germinated and non-germinated but viable *S. hermonthica* seeds were determined after exposing the seeds to the root exudates treatments for 21 and 42 days. Results showed that exposing *Striga* seeds to root exudates for 42 days significantly ( $p \leq 0.05$ ) increased seed germination in both *D.intortum* and *D.uncinatum* treatments. However, fertilizing desmodium plants significantly ( $p \leq 0.05$ ) decreased *Striga* seed germination compared to the control treatment. Whereas *D.uncinatum* exudates reduced significantly seed germination at 60 kg P ha<sup>-1</sup>, *D.intortum* registered significant decrease at a slightly lower P rate (45 kg P ha<sup>-1</sup>). Seed viability was reduced, though non-significantly at 21 days of continuous exposure to the exudates. But at 42 days of seed exposure to the exudates, desmodium plants significantly ( $p \leq 0.05$ ) reverted seeds to dormancy status.

### **TILLAGE EFFECTS ON BIOLOGICAL NITROGEN FIXATION AND SOYBEAN GRAIN YIELDS IN WESTERN KENYA**

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Low soil fertility has become a major impediment to crop production in most parts of sub-Saharan Africa. Over the years, technologies have been generated to combat this problem and the most used is application of organic and inorganic fertilizers. However, inorganic fertilizers are not always available to most small holder farmers due to their high costs and poor accessibility. Although use of legumes is a viable



option, biological nitrogen fixation is influenced by soil moisture availability which is in turn influenced by the type of tillage used. The objective of this study was to determine the effect of tillage methods on biological nitrogen fixation and grain yields of three soybean varieties. The study was conducted in four sites representing four agro-ecological zones of Western Kenya. The treatments were laid in a randomized complete block design in a split plot arrangement. Tillage methods (No tillage and conventional tillage) were main plots and soybean varieties (Nyala, SB19 and SB20) were subplots. Determination of N fixed was conducted using  $^{15}\text{N}$  abundance method. The results showed that Nyala fixed higher amount of nitrogen under no till at Alupe ( $28.7 \text{ kg ha}^{-1}$ ) and Bungoma ( $11.3 \text{ kg ha}^{-1}$ ). At Ugunja and Rarieda the interactions between variety and tillage were not significant. Overall amounts of N fixed in no till plots were higher than till plots for all the sites combined. Soybean grain yield between the tillage methods was not different in all the sites and also between varieties. Alupe site had the highest grain yield ( $1543.0 \text{ kg ha}^{-1}$ ) and Nyala fixed higher nitrogen amounts across the four sites. No till has potential to increase biological nitrogen fixation in some agroecological zones which may translate to higher grain yields over time.

## **TRANSFORMING RURAL LIVELIHOODS IN AFRICA: HOW CAN LAND AND WATER MANAGEMENT CONTRIBUTE TO ENHANCED FOOD SECURITY AND ADDRESS CLIMATE CHANGE ADAPTATION AND MITIGATION?**

**Musyoka J.M.**

### **N2 Africa Project poster presentation**

This poster presentation focuses on N2Africa Project which is working in eight African countries (Ghana, DRC, Kenya, Malawi, Mozambique, Nigeria, Rwanda, and Zimbabwe) using a partnership approach with the aim of deploying legume and inoculants technologies to triple the inputs of free atmospheric nitrogen by biological nitrogen fixation, thereby improving crop and livestock productivity, human nutrition and farm income for smallholder farmers of Africa, while enhancing soil health. N2Africa project, a partnership between CIAT, Wageningen University in the Netherlands and IITA was started in 2010. It has five objectives; (1) Establish a baseline of the current status of N<sub>2</sub> fixation, identify niches for targeting N<sub>2</sub> fixing legumes in the impact zones, monitoring, evaluation and impact assessment; (2) Select multipurpose legumes (food, fodder, stakes, and soil fertility management) for enhanced BNF and integrate these into the farming systems; (3) Select superior Rhizobia strains for enhanced BNF and develop inoculums production capacity in sub-Saharan Africa, including private sector partners; (4) Deliver legume and inoculants technologies to farmers throughout sub-Saharan Africa; and (5) Develop and strengthen capacity for BNF research, technology development and application. N2Africa uses a step-wise approach to deployment of legume and inoculant technologies with strong BNF capacity, focusing initially on 'quick-wins' – employing existing proven technologies based on the success feedback from researchers, farmers, extensionists and other partners. This allows for acceleration of the process of engaging with farmers and extending technologies from the very start



of the project. The research component uses an adaptive and applied research approach, focusing on screening legume genotypes (both grain and forage) with improved BNF potential and on selecting better Rhizobium strains for use in inoculants. In this way N2Africa project critically analyses technologies, products and land management strategies to benefit small-holders in Africa in line with sub-theme (b) of the conference.

## **BACTERIAL DIVERSITY IN LAKE NAKURU AND THEIR POTENTIAL UTILIZATION IN AGRICULTURE AND ENVIRONMENT MANAGEMENT**

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Albeit their known importance in decomposition which is an important function in environmental health and soil's nutrient replenishment, bacteria have been largely omitted from ecosystem studies of saline lakes. An inventory was taken in Lake Nakuru to determine the biodiversity and load of bacteria of the alkaline waters and potential utilization of microorganism in agriculture and environment restoration through decomposition. Samples were collected in three different depths at five points of the lake selected based on their locations, proximity to fresh water inlets and depth of the lake. The samples were collected once a month for a year in 2011. Bacterial load was determined by counting the number of colonies formed (CFU) for each of the sample that had components of time, depth and location. Pure cultures were isolated, identified and introduced to different pollutants and materials to elucidate their decomposition potential. Decomposition potentials of the isolated bacteria were observed for various materials including farm and domestic organic wastes and fossil fuel spills at different levels of aeration. Observations were routinely done weekly for 60 days by performing a "greasy spot" test. Differences in bacterial load, species and diversity were observed over time, location and depth. Sixty-six different types of bacteria were identified. Some bacteria found to be effective in decomposition of materials and hence important in agriculture and environment waste handling. Some of the bacteria that were identified as having high potential in utilization in agriculture and environment management include *Sphingomonas paucimobilis*, *Streptococcus pyogenes*, *Tatumelaptyseas*, *Bacillus anthracoides*, *Chryseobacterium indologenes*, *Chryseobacterium meningosepticum*, *Pseudomonas cepacia*, *proteus perineri*, *Morganella morganii*, *Moraxela* sp., *Alcaligena* sp., *Providencia stuarti*, and *Providencia rettgeri*.



## INTEGRATION OF COMMERCIAL MICROBIOLOGICAL PRODUCTS INTO SOIL FERTILITY PRACTICES AS A POTENTIAL OPTION FOR ACCLIMATIZATION AND GROWTH OF TC BANANA IN KENYA

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Tissue culture (TC) banana plantlets at the *in vitro* stage are delicate and devoid of microbes and nutrients that are essential for establishment and subsequent growth. Some microbes are known to function best under certain soil threshold levels of macro and micronutrients and have been associated with growth and performance of TC banana. A green house and field study was conducted to evaluate the effect of combining two commercial biological products [Rhizatech and ECO-T (mycorrhiza and *Trichoderma* based products, respectively) with various sources of nitrogen and phosphorous including Mavuno, Minjingu phosphate rock, CAN, manure and diammonium phosphate (DAP) on growth and performance of TC banana in Vertisol and Rhodic Ferralsol soil conditions. Tissue culture plants were initially inoculated with Rhizatech (mycorrhizal product) and ECO-T at the acclimatization stage and subsequently at the beginning of the potting stage and field establishment. Addition of macro and micro nutrient sources was also done at the same stages of plant growth by mixing with the soil substrates prior to planting. The performance of plants was significantly (at  $P \leq 0.05$ ) affected by the combinations of macro and micro nutrient sources depending on the soil type and stage of plant development. The growth of plants in the Vertisol increased with *Trichoderma* combined with either organic manure inorganic phosphate diammonium phosphate) or combined with a macro and micro nutrient source (Mavuno) as compared to the sole application of *Trichoderma*. Performance of plants treated with combination of mycorrhiza and either mavuno (macro and micro nutrients) and minjigu rock phosphate was consistently higher in the Rhodic Ferralsol than either mycorrhiza alone or fertilizer alone. This indicates that tissue culture plants could highly benefit from combined application of microbiological products and inorganic and organic fertilizers. However, a prior knowledge of the product's microbial formulation and prevailing soil conditions is essential for optimizing the potential benefits of integrating microbe-based product with inorganic and organic fertilizers.



## THEME V: AGRONOMY AND CROP MANAGEMENT

### RESPONSE OF MICRO-DENSE BEAN VARIETIES TO FERTILITY AND WATER HARVESTING TECHNOLOGIES IN THE SEMI-ARID AREAS OF EASTERN KENYA

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Beans (*Phaseolus vulgaris* L.) are the most important legumes in the semi-arid areas of Eastern Kenya. But their production is constrained by water stress within the season and between seasons. A field trial was conducted in the short rains 2011 (October to December) and long rains 2012 (March to June) at KARI-Katumani (1° 35'S and 37° 14' E) to determine the effect of water harvesting techniques and organic amendments on grain yield of three market preferred bean genotypes; namely: Katumani bean 1, NUA 1 and NUA 4. Results showed that bean grain yields grown on tied ridges with manure application at 5 tons ha<sup>-1</sup> produced significantly ( $P < 0.05$ ) higher yields than furrow or flat planted beans without manure in the short rains 2011. In the long rains 2012, tied ridges without manure had significantly higher grain yields than beans grown on flat ground with (FM) or without manure (F) but did not differ significantly ( $P < 0.05$ ) with treatments that had open furrows with or without manure. Notably, grain yields were higher in the LR than in the SR season. Katumani bean 1 produced significantly higher grain yields than NUA 4 during the short rains 2011 but out yielded all the other genotypes in the long rains 2012 season.

### SCREENING SOME PROMISING RICE CULTIVARS FOR ROOTING ABILITY IN LOW MANAGEMENT CONDITION

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Rainfall reduction in West Africa adversely affects water supply for rainfed rice production. There is a need to improve water use efficiency by rice varietal rooting ability in order to mitigate water stress. Therefore, the rooting ability of some interspecific (*O. sativa* (V11) × *O. Glaberrima* (V12)) rice cultivars named NERICAs (V1, V2, V3, V4, V5, V6, V7, V8, V9 and V10) was assessed compared to their parents under two rates (0 kg ha<sup>-1</sup> (N0) and 30 kg ha<sup>-1</sup> (N1)) of nitrogen-N in a split-plot design. Profile method of root study was used. Highest root densities (1700/m<sup>2</sup>) were observed for cultivars V1-NERICA 1 and V2-NERICA 2 with 0 kg Nha<sup>-1</sup> compared to that of 30 kg Nha<sup>-1</sup>, meanwhile, the highest overall mean value of root density (4000/m<sup>2</sup>) was observed for N1 (30 kg Nha<sup>-1</sup>) especially in the top soil (0 – 20



cm). The cultivar-V11 (*O. sativa*) has the highest root density in the topsoil indifferently to N-rates while NERICA 2 (V2), 4 (V4) and 8 (V8) have similar characters in subsoil 20 – 40 cm and 40 – 60 cm likewise for the parent *O. Glaberrima* (V12) in 40 – 60 cm depth. Varietal difference of rooting ability was under different management options and NERICA 1 and 2 was recommended for drought mitigation under limited N-supplying condition while NERICA 4 and 8 are for low-N supplying condition.

### CONSTRAINTS IN IRRIGATED LOWLAND RICE CULTIVATION AS AFFECTED BY THE HARMATTAN

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The *harmattan* is a cold and dusty wind period during the dry season under bimodal rainfall area in Guinea savanna zone of West Africa. Due to the adverse effects of this particular climate on rice production, the farmers stop rice cultivation in this period even in irrigable perimeters. However, there is limited diagnostic study of the constraints involved in such cropping condition. Assuming that, the reduction of temperature can affect rice mineral nutrition during this period, two agronomic trials were conducted in irrigable valley of M'be II (8°06 N, 6°00 W, 180 m) in a Guinea savanna zone of Centre Côte d'Ivoire. The first study was an omission trial (Fc-N, Fc-P, Fc-K, Fc-Ca, Fc-Mg and Fc-Zn) with a complete fertilizer (Fc) composed of 30 kg N ha<sup>-1</sup>, 60 kg P ha<sup>-1</sup>, 50 kg K ha<sup>-1</sup>, 50 kg Ca ha<sup>-1</sup>, 50 kg Mg ha<sup>-1</sup> and 10 kg Zn ha<sup>-1</sup>. No fertilizer treatment was the control. All the treatments were composed of NPK applied at the same rates and Ca (0, 50, 100 and 150 kg ha<sup>-1</sup>), Mg (0, 50, 100 and 150 kg ha<sup>-1</sup>) as well as Zn (0, 10, 20 and 30 kg ha<sup>-1</sup>) were added in respective treatments. Soil test and rice grain yield showed N- and K-deficiencies for rice cultivation in the studied agro-ecology. In spite of sufficient Mg (2.26 cmol kg<sup>-1</sup>) in the soil, significant low yield was also observed in Fc-Mg as a consequence of the synergism depletion in Mg- and N-nutritions. Poor land management has also induced submersion increase dead plant number whereas, increasing the rate of Ca<sup>++</sup> about 50 – 100 kg ha<sup>-1</sup> has improved N-nutrition. Applying NKMg in improved land management condition was recommended for a target rice grain yield of 2 tha<sup>-1</sup> in *harmattan* period. Further improvement can be observed by combining 90 kg Ca ha<sup>-1</sup> to the basal fertilizer.



## EXPLORING THE EFFECTS OF APPLICATION OF INTEGRATED SOIL FERTILITY MANAGEMENT TECHNOLOGIES (ISFM) ON YIELDS AND BENEFITS OF SOYBEAN IN BUKOBA DISTRICT, KAGERA REGION, TANZANIA.

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Soybean is one of the major crops recently grown in Bukoba, Misenyi Bihramulo and Muleba districts of Kagera region. Current yields of soybean in Sub-Sahara Africa (SSA) average  $830 \text{ kg ha}^{-1}$  with potential yields as greater as  $5000 \text{ kg ha}^{-1}$ . The baseline survey conducted in Bukoba, Biharamulo, Muleba and Misenyi districts in 2011 showed that the average soy bean yields from farmers' fields were  $700 \text{ kg ha}^{-1}$  as compared to  $1800 \text{ kg ha}^{-1}$  from on station trials. This is the result of a complex interaction of many factors including declining soil fertility and use of poor soybean germplasm and agronomic practices by farmers. A study was conducted in Maruku and Kaibanja villages in Bukoba district during 2010-11 season to explore the effect of application of ISFM technologies on soy bean yields and benefits. We planted improved soybean variety (*Uyole soya 1*) at a spacing of  $0.5 \text{ m} \times 0.2 \text{ m}$  by applying soybean inoculants alone at the rate of  $100\text{g}$  per  $10\text{kg}$  seeds, TSP fertilizer alone at the rate of  $20 \text{ kg Pha}^{-1}$  and the combination of inoculants and TSP. Mother demonstration fields were established using RCBD and treatments were applied in three replication. Before planting soil samples were collected and analyzed for particle size distribution (soil texture), pH, organic carbon (O.C), total nitrogen (N), available phosphorus (P) exchangeable cations (calcium, magnesium, potassium and sodium) and cation exchange capacity (CEC). Agronomic and socio-economic data were collected, processed and analyzed using Gen-stat and excel programs. The laboratory soil results showed that the soils were acidic to moderate acidic with very low to low organic carbon, low to medium total N, low to medium extractable P, low to medium exchangeable K, low to medium exchangeable Ca, and low to high exchangeable Mg. The results showed significant difference ( $P \leq 0.001$ ) in soybean response to the application of inoculants and TSP. There was significant different in soybean grain and biomass yields among the applied treatments. The lower grain ( $0.67 \text{ t ha}^{-1}$ ) and biomass ( $0.30 \text{ t ha}^{-1}$ ) yields and net profit ( $110.67 \text{ USD}$ ) were recorded from the control treatment. Combined application of inoculants and TSP gave significantly ( $P < 0.001$ ) higher grain yield ( $2.05 \text{ t ha}^{-1}$ ), biomass yield ( $0.58 \text{ t ha}^{-1}$ ) and net profit ( $1,474.67 \text{ USD}$ ) as compared to TSP and inoculants alone which gave almost equal yields of  $1.84$  and  $1.89 \text{ t ha}^{-1}$ , respectively and net profit of  $1,276.67$  and  $1,413.3 \text{ USD}$ , respectively. The research suggests more investigation on the rate(s) TSP fertilizer to be applied with inoculants for optimum soybean yields and profit.



## **MINERAL FERTILIZERS FOR IMPROVED PRODUCTIVITY OF CLIMBING BEAN (*PHASEOLUS VULGARIS L.*) IN THE SOUTH-EASTERN RWANDA**

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The objectives of this study were to assess the response of MACC 44 variety of climbing bean to single or combined applications of N, P, and K nutrients in the south-eastern Rwanda, and to calculate the probable value to cost ratios of treatments in south-eastern Rwanda. Rates applied were 30 kg N, 30 kg P, 30 kg K ha<sup>-1</sup>. N, P, NP, NK, PK, and NPK significantly improved grain yields by 13.3% up to 98% across the study zone and cropping seasons and had benefit to cost ratios greater than two ( $P < 0.001$ ). NPK combination provided highest yields, highest gross benefit, and highest net benefit with BCR greater than five. Farmers from south-eastern Rwanda are encouraged to apply NPK compound fertilizer in their climbing bean production systems to improve the system productivity.

## **AGRONOMIC AND ECONOMIC POTENTIAL OF SOYBEAN RESIDUE TO IMPROVE MAIZE PRODUCTION IN EASTERN UGANDA**

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Crop yields in Uganda have continued to decline over the years due to low soil fertility and little or no soil input application. An on-farm study was conducted for two seasons (2011B - short rains and 2012A - long rains) in Namayingo and Tororo districts eastern Uganda, located in Lake Victoria crescent agro-ecological zone to evaluate the agronomic and economic potential of soybean residues in improving maize production. Nitrogen fertilizer was also tested for comparison purpose. The rates of soybean residue were 0, 2, and 4t ha<sup>-1</sup> and N fertilizer rates were 0, 30, 60 and 120kg ha<sup>-1</sup>. The experimental design was a RCBD with 12 treatments replicated four and three times for each of the study sites respectively. Fertilizer equivalence value of soybean residues, maize yield response, agronomic nitrogen use efficiency and financial benefits of combined use of N fertilizer and soybean residue were determined. Significant differences were recorded between the two sites ( $p < 0.05$ ) and treatments ( $p < 0.05$ ). Average maize grain yield increases ranged from 0.49 to 0.8t ha<sup>-1</sup>, 0.49 to 0.73t ha<sup>-1</sup>, 0.75 to 1.28t ha<sup>-1</sup> and 0.62 to 1.15t ha<sup>-1</sup> above control for sole N fertilizer, sole soybean residue, a combination of 2t ha<sup>-1</sup> soybean residue with varying rates of N fertilizer and a combination of 4t ha<sup>-1</sup> with varying rates of N fertilizer respectively in Namayingo district. and in Tororo district, average maize grain yield increases ranged from 0.39 to 1.02t ha<sup>-1</sup>, 0.50 to 0.45t ha<sup>-1</sup>, 0.74 to 1.17t ha<sup>-1</sup> and 0.80 to 1.44t ha<sup>-1</sup> above control for sole N, sole soybean residue, a combination of 2t ha<sup>-1</sup> soybean residue with varying rates of N fertilizer and a combination of 4t ha<sup>-1</sup> with varying rates of N fertilizer respectively. Agronomic nitrogen use efficiency differed significantly ( $p < 0.05$ ) in sites, with higher agronomic nitrogen use

efficiencies in Namayingo district than in Tororo district. Agronomic nitrogen use efficiencies were higher in both sites with combined application of N fertilizer than sole application of residue and sole N fertilizer. Fertilizer equivalent value of soybean residue at 2t ha<sup>-1</sup> of residue gave a yield comparable to sole application of 30kgN/ha urea. The financial analyses indicated that sole application of N fertilizer at a rate of 30kgN ha<sup>-1</sup> is profitable (VCR=2.0) but 2t ha<sup>-1</sup> sole soybean residue was the most profitable (VCR=3.3) in Namayingo district. In Tororo district, sole N fertilizer application was unprofitable (VCR<2) though sole soybean residue was profitable. The results of this study showed that the decline in crop yields can be reversed if readily available resources that are within the reach of smallholder farmers are used in combination with N fertilizers. Soybean residues that approximate to 1.32t ha<sup>-1</sup> could potentially improve crop yields in a legume-cereal rotation system of eastern Uganda if popularized among smallholder farmers. Smallholder farmers in Namayingo district can reduce the current maize yield gap of 5.5t ha<sup>-1</sup> in Uganda by 31.6% using the most economically optimum input rate (2R+30N), but for Tororo district, use of N fertilizer combined with soybean residue is not remunerative. Smallholder farmers may have to apply sole soybean residue for building up soil organic carbon stocks so as to reap better remunerations in the future. The technology was found appropriate for smallholder farmers cultivating moderately fertile fields.

#### **EFFECTS OF DIFFERENT MAIZE (*ZEA MAYS* L.) - SOYBEAN (*GLYCINE MAX* (L.) MERRILL) INTERCROPPING PATTERNS ON YIELDS AND GROWTH PARAMETERS**

**Matusso J.M.M., Mugwe J.N. and Mucheru-Muna M.**

The production of maize in many parts of Kagera region is increasing rapidly due to declining production and yields of banana, the only food crop widely grown in the region 20 years before. However, the baseline survey conducted in 2011 in Biharamulo, Bukoba, Muleba and Misenyi districts showed the average maize yields under farmers fields to be 1.1 t/ha as compared to 3 tha<sup>-1</sup> from on station trials. The low maize yields is due to declining soil fertility aggravated by extensive weathering of the soils, low organic matter content in the soils and continuous crop removal of the nutrients from the soils without replenishment (Baijukya and Folmer, 1999), use of poor germplasm and poor agronomic practices by farmers. A study was conducted in Biharamulo, Bukoba and Muleba districts of Kagera region to explore the impact of ISFM technologies on maize yields. The study took a mother-baby demonstration approach to identify the best bet ISFM technologies among the candidate technologies including Urea alone, Urea and Minjingu granular, Urea and Minjingu powder, Urea and Minjingu mazao and Urea and triple superphosphate. All fertilizers were tested against the control (no application of fertilizer). Urea was applied at the rate of 60 kg Nha<sup>-1</sup> while TSP and Minjingu fertilizers were applied at the rate of 20 kg Pha<sup>-1</sup>. Demonstration fields were laid out using randomized complete block design (RCBD). Treatments were applied in three replications. Plot size was 10 m x 10 m and the net plot area was 43.2 m<sup>2</sup>. Improved maize seeds



(*Situka* variety) were planted in a flat land at a spacing of 0.9 m x 0.6 m. Before planting soil samples were collected and analyzed for particle size distribution (soil texture), pH, organic carbon (O.C), total nitrogen (N), available phosphorus (P) and cation exchange capacity (CEC), exchangeable cations (calcium, magnesium, potassium and sodium) using standard methods outlined by National Soil Service, 1990 and Moberg, 2000. Agronomic and socio-economic data collected, were processed and analyzed using Gen-stat and excel programs, respectively. The laboratory soil results showed that the soils in all sites were acidic to moderate acidic, with very low to low organic carbon, low to medium total N, low to medium extractable P, low to medium exchangeable K, low to medium exchangeable Ca, and low to high exchangeable Mg (Landon 1999). The results showed significance ( $P \leq 0.001$ ) maize response to fertilizers application within the treatments and districts but not across the districts. Application of fertilizers increased maize grain and biomass yields ranging from 2.28 - 3.25  $\text{tha}^{-1}$  and 1.15-1.45  $\text{tha}^{-1}$ , respectively, compared to 0.86  $\text{t ha}^{-1}$  from the control. Likewise, application of fertilizers gave net profit ranging from 116.7 - 378.7 USD compared to net loss of 278 USD when fertilizers were not applied (control). The research showed that it is uneconomical to plant maize without application of fertilizers.

#### **IMPROVING LAND PRODUCTIVITY AND COMBATING DESERTIFICATION THROUGH PIGEON PEA-BASED CROPPING SYSTEMS IN SEMI-ARID LANDS OF KENYA**

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Use of inappropriate land and soil management technologies accompanied by lack of specific land use policies have led to widespread land degradation which is likely to worsen with the on-going climate change and may hasten desertification. There is therefore need to develop sustainable pro-poor technologies that will improve land productivity and reduce and reverse the effects of land degradation. A pilot on-station study was conducted at Katumani, Machakos district, in eastern Kenya. The main objective of the project was to develop and pilot-test the adoption of improved soil, water and nutrient management technologies to enhance food security and contribute to combating desertification in arid and semi-arid areas. Pigeon pea is a well-known food security and drought tolerant multi-purpose food legume that is well adapted to dryland conditions. It has a high nitrogen fixation capacity, solubilizes soil-bound phosphorus and accumulates a substantial amount of litter fall thereby building up soil organic matter. Pigeon peas alone, pigeon peas intercropped with maize and maize alone cropping patterns were cropped for 4 seasons between November 2006 and November 2011. Pigeon peas, "short" variety and maize variety "Katumani" were used. Phosphorus was applied at a basal rate of 40 kg/ha at planting. Amount of N fixed by pigeon pea alone or intercropped, soil organic matter and water dynamics were assessed for 4 seasons using nuclear techniques. Cotton was used as the reference crop. Combined analysis of variance

showed that monocropped maize gave significantly (0.05%) higher yields (3,017 kg/ha) than the maize-pigeon pea intercrop (2,597 kg/ha). No significant yield difference was noted between pigeon peas monocrop and maize-pigeon pea intercrop, thus giving intercropping an economic advantage. Pigeon peas further contributed about 50 - 65% of nitrogen to the cropping system through biological nitrogen fixation while the seasonal litter contained about 38 - 56 kg N/ha, which denoted a potential capacity to enhance soil organic matter and carbon sequestration.

## INFLUENCE OF ZINC ON TISSUE ZINC, PROTEIN CONTENT AND PERFORMANCE IN TERMS OF NODULE ACTIVITY AND DRY BIOMASS YIELD OF BUSH BEAN GENOTYPES

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Bush beans (*Phaseolus vulgaris* L.) are among the staple legumes in most developing countries, especially in Sub-Saharan Africa. Beans are particularly recognised for provision of vital micronutrients such as Zinc, especially through consumption of young leaves, green pods and grain. Bean genotypes with unique capacity to biofortify (accumulate) Zn exist in different germplasm, even in East Africa, but the relative accumulation of this mineral in the different consumable parts remains to be ascertained. In addition, the effect of Zn on other important nutritional components such as protein remains to be investigated. Additionally, the performance of beans in terms nodule activity as well as dry biomass yield a result of Zn accumulation needs to be evaluated. A study was conducted at National Crops Resources Research Institute (NaCRRI) to investigate the influence of zinc on the content of Zn and protein in the leaves and the grain; nodule activity and dry biomass yield of Zn dense bean genotypes. Treatments included Zn at 0, 2, 3 and 5 kg ha<sup>-1</sup> applied as zinc sulphate; and bush bean genotypes, namely KaboF6-2.8-27, NUA69, NUA99 and RWR2154(37). There was a significant interaction between Zn rates and genotypes in terms of tissue Zn, protein content, nodule activity; and dry leaf and grain weight (p<0.05). Zinc application caused a slight effect on leaf zinc in KaboF2.8-27 and RWR2154(37), but had no significant effect (p>0.05) in NUA69 and NUA99 genotypes. However, the genotypes responded similarly within each Zn rate, with KaboF2.8-27 outperforming the rest, with a peak of 0.04403 mg kg<sup>-1</sup> of dry leaf tissue. NUA99 accumulated the least leaf Zn. KaboF2.8-27 superseded the other genotypes in seed Zinc with the highest of 0.2 mg kg<sup>-1</sup> in the Zn rate of 3 kg ha<sup>-1</sup>; while RWR2154(37) trailed in this respect. There was a slight but significant (P<0.05) increase in leaf protein resulting from application of Zn; with the highest level occurring in KaboF2.8-27 genotype at the Zn rate of 3 kg ha<sup>-1</sup>. Apart from KaboF2.8-27, the performance of the other three genotypes was not significantly different. The distribution pattern of leaf protein within the different Zn rates was similar among the genotypes. Seed protein was slightly but positively influenced (P<0.05) by Zn application, though KaboF2.8-27 responded most, especially at the Zn rate of 3 kg ha<sup>-1</sup>.

1. Zn rate had a significant effect ( $P < 0.004$ ) on leaf dry weight across genotypes as well as dry seed weight ( $P < 0.001$ ). Leaf Zn had a strong and positive correlation ( $r = 0.84$ ) with leaf protein in KaboF2.8-27 genotype. Similarly seed Zinc was strongly and positively correlated ( $r = 0.95$ ) with seed protein. Also, nodule activity was strongly enhanced ( $P < 0.041$ ) by Zn application, reaching a climax at the Zn rate of 3 kg ha<sup>-1</sup> for all genotypes. After the climax level, nodule activity declined drastically at levels similar to the control. There was also a positive but weak correlation ( $r = 0.52$ ) between leaf Zinc and nodule activity in KaboF2.8-27 genotype. Additionally, there was a strong and positive correlation ( $r = 0.91$ ) between leaf Zn and leaf dry biomass in NUA 99 genotype.

## INFLUENCE OF CEREAL-LEGUME CROPPING SYSTEM ON STRIGA HERMONTICA CONTROL AND MAIZE GRAIN YIELD IN EASTERN UGANDA.

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The purple flowered parasitic weed *striga hermonthica* has been ranked the number one constraint to maize production, a staple food for the people in Eastern Uganda. The cereal-legume cropping systems is one of the control measures suggested for poor resource farmers in striga infested areas. In this study the main focus was on the effectiveness of intercropping in reducing striga infestation and hence overall land productivity. The major objective was to identify suitable legumes in the control of striga. In order to achieve this, on farm experiments were conducted in Tororo and Busia districts of Eastern Uganda where the effect of the legumes on the striga prevalence was evaluated. Maize was intercropped with Common beans, Soybean and Desmodium with sole maize as the control. Laboratory experiments were also carried to screen the different legumes on their ability to stimulate suicidal germination by quantifying the amount of germination stimulant produced. Intercropping was found to control striga and improve overall productivity of the land. Desmodium was found to be the most effective of the legumes while common beans produced the highest amount of germination stimulant for striga. Based on the economic analysis conducted maize and common bean intercrop was the most profitable combination. There is need to screen more legumes and their different varieties to increase the potential of using legumes in the control of striga.



## EFFECT OF MAIZE VARIETY AND NITROGEN FERTILIZER ON STRIGA PARASITISM AND MAIZE YIELD IN WESTERN KENYA

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Parasitism by *Striga* weed is the major cause of maize yield losses in the Lake Victoria Basin. Severity of attack is generally greater in soils with poor fertility. This study evaluated the effects of two different maize varieties and inorganic nitrogen sources on striga weed parasitism and maize yield in Kisumu West, Busia and Teso South districts of western Kenya. A randomized complete block design (RCBD) with a split-split plot arrangement replicated six times was used. The districts formed blocks. The main plots were fertility gradients (high and low fertility) and the sub-plots comprised of maize variety (WS 303 and DH 04) while nitrogen levels (0 and 60 kgNha<sup>-1</sup>) was the sub-sub plot. The parameters measured in the field included: maize germination count, striga weed population count and maize yield. A combination of a *Striga* tolerant variety- WS 303 maize- nitrogen applied at the rate of 60kgN/ha, in high fertility plots was superior to other treatments. The lowest striga count at 6, 8 and 10 week after planting (WAP) and the highest maize grain yield were achieved in the WS 303 maize variety in Kisumu West, Busia and Teso South districts. Teso South district realized the least striga emergence in the plots with WS 303 maize variety and thus resulted to high yield. To facilitate proper choice of striga control options and their uptake by most farmers, this calls for the use of integrated *Striga* control technologies that give high yield, increase soil fertility and reduce striga seed bank in farmers' led field experiments.

## EFFECTS OF DIFFERENT MAIZE (*ZEA MAYS* L.) - SOYBEAN (*GLYCINE MAX* (L.) MERRILL) INTERCROPPING PATTERNS ON YIELDS AND ITS ECONOMICS

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In central highlands of Kenya, the low soil fertility and inability to replenish it are amongst the major constraints affecting the productivity of maize and cash crops, leading to hunger and poverty. The adoption of ISFM technologies such as maize-soybean intercropping system is being promoted as one of the options to address low crop productivity among the farmers. This study intended to determine the effects of maize-soybean intercropping patterns on yields and to assess the economics of different maize-soybean intercropping patterns in two the contrasting



sites. The experiment was arranged in a randomized complete block design (RCBD) with four replications. The treatments were four maize (M) – soybean (S) intercropping patterns (conventional=1M:1S; MBILI-MBILI=2M:2S; 2M:4S; 2M:6S) and two sole crops of maize and soybean, respectively. The results showed that in both sites during the both seasons maize stover and grain yields were significantly affected by the intercropping pattern. During 2012 LR at Embu site the MBILI treatment produced significantly higher stover and grain yields (13.12 t ha<sup>-1</sup>,  $p=0.0001$  and 6.11 t ha<sup>-1</sup>,  $p<0.0001$ , respectively) than all other treatments. During 2012 SR, still the MBILI treatment had recorded significantly the highest stover and grain yield (7.62 t ha<sup>-1</sup>,  $p<0.0001$  and 5.62 t ha<sup>-1</sup>  $p=0.0467$ , respectively) than all other treatments. During 2012 LR at Kamujine site the conventional treatment produced significantly the highest stover yield (3.87 t ha<sup>-1</sup>,  $p=0.0461$ ) than only the 2M:6S treatment. During 2012 SR at Kamujine site, the MBILI treatment had recorded significantly the highest stover and grain yield (6.55 t ha<sup>-1</sup>,  $p=0.0005$  and 3.55 t ha<sup>-1</sup>  $p=0.0006$ , respectively) than all other treatments. During both seasons in both sites, the soybean yield was significantly affected by the intercropping pattern. During the 2012 LR, the yields were reduced by 60 and 81% due to the intercropping with maize, at Embu and Kamujine, respectively; whereas, during the 2012 SR, the yields were reduced by 52 and 78% as effect of intercropping with maize, at Embu and Kamujine, respectively. At Embu site during the both seasons, the MBILI treatment was more profitable. At Kamujine site during the 2012 LR maize sole crop was the most profitable; whereas during 2012 SR the MBILI treatment was the most profitable.

## CONTRIBUTION OF PHOSPHORUS LEVELS TO INOCULATED SOYBEAN IN SOIL AMENDED WITH FERTISOIL

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An experiment consisting of four levels of phosphorus (0, 30, 60 and 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>), two levels of inoculation and two levels of fertisoil was conducted under field condition in Cheshegu northern region of Ghana, to determine optimum phosphorus level for soybean production. The different levels of phosphorus combined with inoculation and fertisoil (3 ton ha<sup>-1</sup>) were arranged in split-split plot design. Soybean was assessed for nodule number plant<sup>-1</sup>, nodule dry weight (mg plant<sup>-1</sup>), biomass yield (kg ha<sup>-1</sup>), pod number plant<sup>-1</sup>, pod dry weight (g plant<sup>-1</sup>) and grain yield (kg ha<sup>-1</sup>). The results showed that the use of inoculation significantly ( $p<0.05$ ) influenced nodulation and resulted in about 10% grain yield increase compared to the control. Plots amended with fertisoil had no significant effect on nodulation, but gave 3713 kg ha<sup>-1</sup> biomass yield and 15% grain yield increase over the control. The different phosphorus levels i.e. P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub> recorded nodule numbers and nodule dry weights which were not significantly higher than the control (P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>), However grain yields of the various phosphorus levels recorded values greater than 17% over the control. Soybean responded well to inoculation on amended soil (fertisoil + Inoculation) whereby resulted to significant nodule number, highest nodule dry weight (400 mg plant<sup>-1</sup>), biomass yield, pod dry weight and grain yield

(142%, 70%, and 32% increments) than the control plots respectively. The combination of phosphorus levels + inoculation indeed had significant effect on nodule number, however the dry weights were not significantly different as compare to the control, produced biomass yield was lowest with P<sub>3</sub> + I, while P<sub>2</sub> and P<sub>1</sub> (+ inoculation) were not significantly different from one another and were all different and higher than the control significantly. Significant discrepancies were not observed in pod dry weight even with the control plots, but the soybean grain yield from P<sub>1</sub> + I was significantly superior to the control (27%), though was at par with the other levels of phosphorus, however the other levels (P<sub>2</sub> and P<sub>3</sub>) of phosphorus were not significantly superior to the control plot performance, yet had 24% and 17% increment in grain yield than the control respectively. The soil amendment with fertisoil + phosphorus was not responded to by soybean with regards to nodulation and that resulted to non significant nodule number and nodule dry weight as compare to the control, the response of soybean to these combination did not result in significantly different biomass yield within the phosphorus levels but were significantly superior to the control. The P<sub>2</sub> + FS > P<sub>3</sub> + FS > P<sub>1</sub> + FS > control (6903, 5438, 5323 kg ha<sup>-1</sup>) respectively. The higher the phosphorus level + fertisoil the more the grain yield, P<sub>3</sub> + FS had 40%, P<sub>2</sub> + FS (39%) and P<sub>1</sub> + FS had (29%) grain increment as compare to control, infact the highest yield was gotten from this treatment combinations (P<sub>3</sub> + FS ) with 3783 kg ha<sup>-1</sup>. Soybean responded to the three treatment combinations in the same trend (not minding the phosphorus levels) and were significantly higher than the control. The combination with P<sub>2</sub> gave the highest number of nodules, while the nodule weight ranked as P<sub>1</sub> > P<sub>2</sub> > P<sub>3</sub> > 0, the biomass yield was influenced by the treatment in that the P<sub>3</sub> had the highest value, which was 214% more than the control though not superior to that obtained from the other phosphorus levels. The biomass yield translated into high pod weight for P<sub>3</sub> which had the highest pod dry weight (40.9 g) and also not significant to other levels of phosphorus combination, finally it was observed that the lower the phosphorus + inoculation in an amended soil the more the yield and that ranked as P<sub>1</sub> > P<sub>2</sub> > P<sub>3</sub> and were 32%, 27% and 26% significantly (p<0.05) superior to the control plot grain yield.

#### **NITROGEN AND PHOSPHORUS COMBINATIONS AND MAIZE (*ZEA MAYS* L) VARIETY EFFECT ON *STRIGA* INFESTATION AND MAIZE YIELD IN EASTERN UGANDA**

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*Striga* species a parasitic angiosperm weed is a major problem in cereal production causing huge losses in grain yields, greater than fungal diseases and insect pests combined. On farm studies were conducted in season b (2012) and season a (2013) to evaluate nitrogen and phosphorus combinations and maize variety effect on *striga* emergency and maize yield in Eastern Uganda. The study specifically sought to



determine N and P fertilizer combination levels that can suppress *striga* germination in maize fields, determine the effect of different maize varieties on *striga* infestation and determine the economically optimum N and P combination that can suppress *striga* infestation. The experiment was laid using a criss-cross (strip plot) experimental design and replicated 5 times on farms with high *striga* weed pressure and 5 times on farms with low or no *striga* weed pressure. The different *striga* weed pressure levels were the blocks. Two maize varieties, MM3 open pollinated and Longe10 hybrid varieties were tested. Fertilizer was applied through band application, with N applied at 0kg $ha^{-1}$ , 25kg $ha^{-1}$ , 50kg $ha^{-1}$  and 100kg $ha^{-1}$ ; P at 0kg  $ha^{-1}$ , 15kg $ha^{-1}$  and 30kg $ha^{-1}$ . Potassium (K) was blanket applied at a rate of 60kg $ha^{-1}$  to ensure that it does not constitute a constraint. Data collection included taking; striga counts in the 6<sup>th</sup> week, 8<sup>th</sup> week after crop emergence and at harvesting, number of plants at harvesting, total biomass, number of cobs, total weight of cobs and dry weight of the grains for each treatment. Statistical analysis is yet to be performed using Genstat 14<sup>th</sup> edition software for Bio-Sciences and the procedures will be used for Analysis Of Variance (ANOVA). The agronomic efficiencies of N and P use for the maize varieties will be calculated using methods described in Baligar *et al.* (2001). The significant differences between treatment effects will be compared using Fisher's Least Significant Difference (LSD) test at  $p \leq 0.05$ . Economic feasibility analysis of the different fertilizer rates use in *striga* control will be carried out using the procedures described in CYMMYT (1988).

#### **EFFECTS OF DIFFERENT MAIZE (ZEA MAYS L.) - SOYBEAN (GLYCINE MAX (L.) MERRILL) INTERCROPPING PATTERNS ON SOIL MINERAL-N, N- UPTAKE AND SOIL PROPERTIES**

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The adoption of ISFM technologies such as maize-soybean intercropping system is being promoted as one of the options to address low soil fertility and crop productivity among the farmers of the central highland of Kenya. The purpose of this study was therefore to determine the effects of maize-soybean intercropping patterns on soil inorganic N, N uptake and soil chemical properties. The experiment conducted during 2012 LR and 2012 SR and it was arranged in a randomized complete block design (RCBD) with four replications. The treatments were four maize (M) - soybean (S) intercropping patterns (conventional=1M:1S; MBILI-MBILI=2M:2S; 2M:4S; 2M:6S) and two sole crops of maize and soybean, respectively. The results showed that at Embu during 2012 LR, at harvest the MBILI and 2M:4S treatments observed significantly ( $p=0.0525$ ) the lowest  $NO_3^-$ -N content (8.24 mg  $kg^{-1}$  and 9.15 mg  $kg^{-1}$ , respectively); and at Kamujine during the same 2012 LR, at harvest the sole soybean treatment recorded statistically ( $p = 0.0301$ ) the highest  $NO_3^-$ -N content (8.24 mg  $kg^{-1}$ ). At Embu site the soil mineral N was not significantly affected by the intercropping patterns. Whereas, at Kamujine the sole soybean treatment recorded statistically ( $p=0.0131$ ) the highest (12.84 mg  $kg^{-1}$ ) soil mineral N. The N uptake by maize and soybean was significantly affected by the



intercropping patterns and it was positively correlated with soil mineral N, at both sites during the sampling period. During 2012 SR at Embu site, the MBILI treatment observed significantly the highest soil total N value of 0.05% ( $p=0.0530$ ). The soil SOC was not significantly affected by the intercropping patterns at this location. At Kamujine site, the soil total N was not affected by the intercropping patterns. The SOC was significantly affected by the intercropping and the conventional treatment recorded the highest value of 2.46%,  $p=0.0020$ .

## **SOIL PROPERTIES AND YAM PERFORMANCE AS INFLUENCED BY POULTRY MANURE AND TILLAGE ON AN ALFISOL IN SOUTHWESTERN NIGERIA**

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Field experiments were conducted to investigate the effect of soil tillage techniques and poultry manure application on the soil properties and yam (*Dioscorea rotundata*) performance in Ondo, southwestern Nigeria for two farming seasons. Five soil tillage techniques, namely ploughing (P), ploughing plus harrowing (PH), manual ridging (MR), manual heaping (MH) and zero-tillage (ZT) each combined with and without poultry manure at the rate of  $10\text{t ha}^{-1}$  were investigated. Data were obtained on soil properties, nutrient uptake, growth and yield of yam. Soil moisture content, bulk density, total porosity and post harvest soil chemical characteristics were significantly ( $p>0.05$ ) influenced by soil tillage-manure treatments. Addition of poultry manure to the tillage techniques in the study increased soil total porosity, soil moisture content and reduced soil bulk density. Poultry manure improved soil organic matter, total nitrogen, available phosphorous, exchangeable Ca, k, leaf nutrients content of yam, yam growth and tuber yield relative to tillage techniques plots without poultry manure application. It is concluded that the possible deleterious effect of tillage on soil properties, growth and yield of yam on an alfisol in southwestern Nigeria can be reduced by combining tillage with poultry manure.



## THEME VI

### SOIL AND WATER MANAGEMENT (CA, WATER HARVESTING, TILLAGE)

#### UNDERGROUND WATER MANAGEMENT AND POLLUTION THREATS IN DRY SEASON VEGETABLE GROWING IN TABORA, TANZANIA

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Small scale vegetable growing is an important economic and the climate change adaptive activity during the dry season in Tanzania. Open shallow underground water wells are used by farmers for vegetable growing. Sustainable use of open shallow water wells is threatened by various factors such water depletion in response to prolonged droughts. However, the human caused factor of polluting scarce water resources has not adequately studied. This study was conducted in 2009-2012 to assess pathways of underground water resources pollution in vegetable growing. The objective of this study was to identify causes of underground water pollution and the role of human activities in causing water pollution. The methodology used was onsite inspection of underground water wells, identification of invasive plants growing in water wells. Laboratory analysis was carried out Kitete hospital in Tabora for testing *Escheria coli* a gram positive bacterium in water samples. Results show that, decomposition of aquatic plants, frogs and organic manure in water as well as the concentration of livestock urine significantly contribute to water pollution. Poor handling of pesticides allow pesticide residues to flow into water. Water management in semi-arid environment in Tanzania is needed for protecting the scarce water resources

#### STATUS REVIEW OF THE ADOPTED SOIL AND WATER MANAGEMENT TECHNOLOGIES IN KENYA AS A CRITICAL COMPONENT OF THE ENVIRONMENT

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Land degradation processes are evident on Kenyan landscape, more serious signs being realized in cultivated and pastoral areas as productivity continue to decline. Unsustainable land use practices are leading to low food production in comparison to demand of the growing population. There is need to promote adoption of appropriate natural resource management technologies that will protect the marginal lands and forest areas from overgrazing and unsustainable cultivation practices. There are enough studies to show that combination of soil and water conservation and soil fertility amendment technologies can improve crop yields and



improve other ecosystem services. However performance and adoption of these technologies may vary depending on agro-climatic regions. This paper examines status of soil and water management practices that have been practiced/tested in Arid and Semi-arid lands (ASALs), sub-humid and humid agro-climatic areas of Kenya using published and gray literature but also through discussions with extension experts/agents in sub-districts representing the three major agro-climatic regions of Kenya. The study shows that across each region physical soil and water measures (Fanya Juu/chini, water harvesting, etc), biological structures (grass strips, mulching, agroforestry, etc), organic and inorganic soil fertility, conservation agriculture/farming and pasture management are been tested and adopted across the agro-climatic regions despite variation in extent and magnitude. The paper provides the researchers and extension agents a better view of the gaps in promotion of the soil and water management practices. Particular areas that needs redress is in promotion of minimum tillage and combining organic-inorganic fertilizer amendments for improved food production while reducing soil and water losses in the watersheds.

#### SOIL PHYSICAL AND HYDROLOGICAL PROPERTIES MODIFICATIONS UNDER ARACHIS SPECIES IN IBADAN SOUTHWESTERN NIGERIA

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Conservation of soil moisture is one of the major limiting factors to crop production. Improvement of soil physical properties could enhance soil moisture conservation, improve crop productivity and reduce food insecurity in sub Saharan Africa. A field study was carried out to determine the effects of 3 plant densities (33333, 66667 and 83333 plants/ha) on soil properties and water loss through evaporation from soils under 2 cultivars of *Arachis hypogaea* L. (SAMNUT 10 and SAMNUT 21) and *Arachis pintoi* (PINTOI) in Ibadan, south western Nigeria. The experiment was a split plot in randomized complete block design with *Arachis* varieties as the main plot and plant densities as subplot with three replications. Data were collected on daily soil water evaporation, bulk density, saturated hydraulic conductivity, particle size, total porosity and permeability. The Soil was loamy-sand and marked reductions in soil water evaporation were observed in surfaces under *Arachis* varieties compared to bare soil. Reductions in soil water evaporation were 44.5%, 41.1% and 34.7% under SAMNUT 21, PINTOI and SAMNUT 10 respectively. Significant ( $p= 0.05$ ) improvement on soil structure and hydraulic conductivity were observed under *Arachis* varieties. Plant density of 66667 plants/ha showed the best positive effect on the improvement of soil physical structures. The cultivation of SAMNUT 21 at 66667 plants/ha and PINTOI at 83333 plants/ha along with other measures of sustainable soil water conservation are recommended.



## SCREENING OF DIOSCOREA ALATA GENOTYPES FOR DROUGHT TOLERANCE

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Amongst the most important factors affecting yield of tropical tubers, soil moisture is considered as a vital factor that could impose a significant impact of tuber yield. Screening of thirty-two genotypes of *Dioscorea alata* was carried out for their varied responses to moisture stress at the International Institute of Tropical Agriculture (IITA), Ibadan. Perforated pots filled with 5kg of sterilized soils were irrigated and left to equilibrate for 24 hours. Thirty setts of 40g were prepared from each genotype. The setts were pre-germinated for 3 weeks in sterile carbonized rice husk medium. After transplanting, each vine was passed through the hollow of short poly vinyl chloride (PCV) pipes, and the pots were tightly wrapped with transparent polyethene bags to prevent moisture loss. The design of the experiment was randomized complete block with three replicates. The experiment was maintained within a glasshouse for three months without further watering. Data collected include: weekly pot weight, number of days to wilting, interval leaf counts, vine length and leaf area, shoot and root weight. The data were subjected to analysis of variance and multivariate cluster analysis. The thirty two genotypes differed significantly ( $P < 0.01$ ) with respect to the seven phenotypic traits. Four clusters emerged from the grouping of the 32 genotypes. Genotypes in cluster 3 had the best performance for biomass yield (37.05g), fresh shoot weight (21.43g) and vine length (127.62 cm) and could be potential materials for selection as drought tolerant genotypes. These genotypes include; 03/00185, Olesunle, Sagbe, 93-36, 00/00060, 03/00090, 00/00104, 98/01166, 00/00045 and 00/00064.

## OPTIMUM CROP ENTERPRISE COMBINATION IN SUGARCANE BASED FARMING SYSTEMS: A CASE OF SUGARCANE AND MAIZE IN BUSEDDE SUB-COUNTY, JINJA DISTRICT, UGANDA

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The present study titled "Optimum crop enterprise combination in sugarcane based farming system: a case of sugarcane and maize in the vicinity of Kakira sugar estate specifically Busedde sub-county, in Jinja District", it was undertaken to find a way how sugar cane and maize enterprises can be combined using the available limited resources in order to maximize profits and solve the problem of food security, as well as ensuring sustainable land management. Simple random sampling was used in selecting sample farmers, were by three parishes were selected, and two villages from each parish were considered for detailed study. From each village, 10 small scale sugarcane famers were selected randomly and all together 60 famers were



considered in the study. The required data was collected using check lists and personal interviews. Linear programming was used in developing optimum plans for maximization of profits. Findings of the study indicated that 83.3% of the people in the study area depend on maize as the main source of food. Also the farmers should use 25% for maize and 74% for sugarcane of the total land utilized for agriculture. In addition sugarcane contributed an average net return of 13,360,354 Uganda shs, and maize 526,960 Uganda shs per hectare to farmer's income with in a period of five years .The net present value analysis indicated that sugarcane growing Project is a profitable enterprise however its not advisable to carry it out as a single project because the out comes can not cater for all requirements for the house hold. In conclusion in order to solve food security issues in the area the small scale sugarcane out grower should produce 1units of sugarcane and 1 unit for maize, for a period of five years using 1.8 ha of land for sugarcane and 0.6 ha for maize and full utilization of the available labor and seeds, of the total resources available , in order to maximize profits that can enable them to avail their families with enough food for a period of five years in the sub county of Busedde in the vicinity of Kakira sugar estate.

### **AEROBIC METHOD OF RICE PRODUCTION: A PROMISING CROPPING SYSTEM FOR IMPROVING WATER QUALITY AND ENVIRONMENT IN WATERSHEDS**

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Availability of freshwater for Agriculture is declining in many parts of India and Asia, thus affecting lowland rice production in watersheds significantly. Though water saving is the main focus, farmers are still growing rice by flooding ground water, with this rice fields face sever deterioration in soil health and ecology by emitting green house gases leading to environmental pollution. Hence, a water-saving technology to grow more rice with less water is essential, besides lowering green house gas emission into the atmosphere. In this context "Aerobic rice" cultivation is a promising new cropping system with suitable varieties is very relevant today. In this system, rice is grown in non-puddled and non-flooded way as in maize or millets by direct seeding like any other rain-fed crops. Irrigations are provided as and when water is required by the crop after examining the moisture content. Case studies have exhibited yields vary from 4.5 to 6.5 ton per ha, which is almost equal to lowland rice system under flooded conditions. However, the water used is about 60 per cent less than that of lowland rice, a total water productivity of 1.6 to 1.9 times higher and net returns to water use was two times higher. Although, aerobic rice production technology is made known to number of farmers, only few farmers have adopted. This calls for applying farmer's participatory methods to refine and validate aerobic method of rice production practices so as to make the farmers aware, upscale and also disseminate the seeds.



## **EFFECT OF TILLAGE PRACTICES ON SOIL MOISTURE AND SELECTED SOIL PHYSICAL PROPERTIES IN MAIZE-BEAN INTERCROPPING SYSTEMS IN MWALA DISTRICT, KENYA**

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Soil moisture conservation through tillage is one of the appropriate ways of addressing soil moisture deficits in changing climates. This study was conducted in the long rains (LR) and short rains (SR) of 2012 to evaluate the effects of tillage practices on soil moisture conservation in Mwala District, Eastern Kenya. Six tillage systems: Mouldboard (MB), Mouldboard and harrowing (MBH), Ox-ploughing (OX), Subsoiling - ripping (SR), Hand hoe and Tied Ridges (HTR) and Hand hoe only (H) and, three cropping systems, namely, sole maize, sole bean and maize-bean intercrop, were investigated in a split-plot design with four replicates. Soil moisture decreased over time ( $p < 0.001$ ), between soil depths ( $p < 0.001$ ) and also varied among the tillage methods ( $p < 0.019$ ) in LR, 2012. The moisture trend was at  $HTR > MBH > H > OX > MB$  while in the SR at  $OX > SR > MB > HTR > H > MBH$ . In the SR, 2012, there was some significant interactions between time  $\times$  cropping systems ( $p = 0.003$ ). Results show that tillage influenced soil surface roughness ( $p < 0.001$ ) and crust strength ( $p < 0.001$ ). High surface roughness observed in HTR is due to the raised ridges and basins created during tied ridging and higher crust strength observed in the SR and OX plots. These results suggest that tillage methods influence soil moisture conservation and soil properties in the semi arid areas of Kenya.

## **EFFECTS OF CONSERVATION AGRICULTURE PRACTICES ON SOIL MOISTURE AND WEED INCIDENCES IN MID-ALTITUDE AGRO ECOLOGIES OF MALAWI.**

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Conservation agriculture (CA) entails the application of wise soil and water management practices that will improve and safeguard the quality of land and rainwater resources so that they continue to meet the needs of agriculture, society and nature. An on-farm research to investigate the effect of Conservation Agriculture on soil moisture and weed incidences was conducted in Kasungu and Lilongwe districts in Malawi. Continuous monocropped maize (*Zea mays*) under conventional tillage practice (CP) was compared with different CA cropping systems in continuous monocropped CA maize, intercropping with pigeon pea (*Cajanus cajan*) and maize-legume rotation. Data gathered for this research was both quantitative and qualitative. Soil moisture content was taken from ten randomly



selected points using Time Domain Reflectometer (TDR) equipment and a mean value was calculated. Across sites mean amount of soil moisture results reviewed higher soil moisture in all the CA plot(2,3,4,5)(28%,29%,27%,27%)respectively and least in the conventional plot (25%). Rainfall pattern results indicated that the rainfall was sparsely distributed throughout the 2011/12 season and this caused the control plot from both study sites experienced abrupt change in soil moisture conservation. Higher weed biomass was obtained in the control plot and lower in soya-maize rotation from both sites. The increase in soil moisture in CA fields will enable crops to overcome seasonal dry spells, mitigate the effects of drought, reduce the risk of crop failure, and secure livelihoods.

### **INTEGRATING SCIENTIFIC AND FARMERS' EVALUATION OF WATER HARVESTING AND INTEGRATED SOIL FERTILITY MANAGEMENT TECHNOLOGIES ON SORGHUM PRODUCTIVITY IN CENTRAL KENYA**

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Soil fertility degradation remains the major biophysical cause of declining per capita crop production on smallholder farms in Central Kenya highlands. A study was conducted to compare farmers' perception and biophysical data on selected water harvesting and integrated soil fertility management technologies on sorghum (*Sorghum bicolor* (L.) Moench) and cowpea (*Vigna unguiculata* L.) production in Central highlands of Kenya. Three seventy one smallholder farmers were invited to evaluate thirty six plots laid out in Partially Balanced Incomplete Block Design (PBIBD) replicated three times. The results show that treatments that ranked top on the scale of 'good' had external soil amendment regardless of water harvesting and cropping systems. The treatment which was ranked best overall rated as 'good' by the farmers was farmers practice with a mean score of (2.78) and yielding (3.5t/ha) under sorghum alone plus external soil amendment of 40 Kg P /ha + 20 Kg N /ha. This was closely followed by tied ridges and contour furrows overall rated as 'good' by the farmers under sorghum alone plus external soil amendment of 40 Kg P /ha + 20 Kg N /ha + manure 2.5 t/ha and 40 Kg P /ha + 40 Kg N /ha + manure 5 t/ha both with a mean score of (2.7) and yielding (3.0 t/ha) and (2.9 t/ha) respectively. However, the treatment which was poorest ranked by farmers overall rated as 'poor' was experiment control under farmers practice with sorghum and cowpea intercrop yielding as low as (0.3 t/ha) with mean score of (1.08). Generally, all experiment controls were overall scored as 'poor' yielding as low as 0.3 t/ha to 0.6 t/ha. The results further showed that there was no significant difference between treatment scoring by gender ( $P \geq 0.05$ ) on the scale of good, fair and poor. Therefore, integration minimal addition of organic and inorganic inputs on highly valued traditional crops



with adequate rainfall under normal farmers practice in semi arid lands could be considered as an alternative option contribution to food security in central Kenya.

## **EFFECTS OF GLYPHOSATE BASED HERBICIDE ON WEED MANAGEMENT AND MAIZE PERFORMANCE UNDER ZERO TILLAGE CONSERVATION AGRICULTURE SYSTEM IN EASTERN KENYA**

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Maize production lags behind the population demand in eastern Kenya regions, and this is attributed to weeds competition with the crop for various growth resources, among other factors. A study was conducted in the region to determine the effects of Glyphosate based herbicides on weeds management and maize performance. The first (LR 2011), second (SR 2011) and third (LR 2012) season's trial results observed that the glyphosate based herbicides are effective means of weed management in maize grown under zero tillage conservation agriculture systems. Roundup Turbo applied at 2.5 lits ha<sup>-1</sup> and the three (1.5, 2.5 and 3.0 lits ha<sup>-1</sup>) tested rates of Roundup Weathermax herbicide performed comparatively well in terms weeds control and therefore improving maize grains and shoot biomass. In addition the product did not have any noticeable phytotoxicity on the crop. Likewise the herbicides treated plots resulted in improved NB compared to results from un-weeded and the conventionally tilled fields. The crop yields significantly ( $p \leq 0.05$ ) differed between un-weeded and weed controlled treatments (both conventional and herbicide methods). Conventionally tilled treatment gave an average grain yield of 3.6 t ha<sup>-1</sup> that was not significantly different from those from zero tillage treatments. The lowest grain yield (0.1 t ha<sup>-1</sup>) was acquired from un-weeded treatment and significantly ( $p \leq 0.05$ ) differed from those of conventional and herbicides treatments. The study concluded that the use of Glyphosate based herbicide is an appropriate and economic approach for weed management in maize grown under zero tillage conservation agriculture systems.

## **ON - STATION EVALUATION OF MAIZE GENOTYPES FOR NUTRIENTS AND WATER USE EFFICIENCY IN THE SEMI ARID LANDS OF COASTAL KENYA**

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About three quarters (75%) of the land in costal Kenya is either arid or semi-arid. Crop failure, especially for maize, is very common in the region. Despite this situation, farmers persistently plant maize every season. Rainfall in arid and semi-arid areas is usually low, erratic and unevenly distributed. Crop yields are extremely low due to not only inadequate soil moisture but also low and declining soil fertility. This therefore calls for integrated technological intervention to address the problem.



In the sub-humid regions of coastal Kenya, 24% of land receives enough rainfall to sustain crop production during the long rains (LR) season. However, during the short rain (SR) season, low amount of rainfall is received, and crop failure is common. In a normal year, two thirds of the total annual rainfall is received during the LR season. Despite the prevailing situation, farmers continue growing maize during the SR season and therefore risk crop failure. Some farmers also plant maize varieties meant for long rain season hence increasing the risk of crop failure. The study was therefore designed to evaluate maize varieties and water harvesting tillage technologies and their effect on the performance of maize in order to come up with a recommendation on the suitable maize varieties for planting under the relatively harsh environments. The results indicate that rainwater harvesting is not critical when the season is wetter than normal in the arid and semi-arid environments. Despite the excellent performance of PH4, CCM and Mdzhiana, these maize varieties cannot be recommended for the semi-arid areas since the high yields were realized under above normal rainfall. There is need for further research to identify the maize varieties that would be appropriate for the areas that normally receive low rainfall.

#### **TILLAGE AND CROP ROTATION EFFECTS ON STRUCTURAL PROPERTIES OF TWO SANDY CLAY LOAM SOILS IN ZANYOKWE IRRIGATION SCHEME, SOUTH AFRICA**

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Intensive tillage and monoculture crop production practices have adversely affected soil structural stability in most of the arable lands in South Africa. Crop production practices that enhance soil organic matter (SOM) contributes to soil structural stability through strengthening the binding of mineral particles by organic bridges and enhancing water repellence of the soil aggregates. Two soils of contrasting mineralogy in Zanyokwe Irrigation Scheme (ZIS) were used to evaluate the impact of tillage and rotational cover cropping on soil aggregate stability and stability index (SI) under irrigated maize (*Zea mays* L) production. A split-plot arrangement of the treatments in a randomized complete block design was used with tillage as the main-plot and crop rotations as subplots. Conventional tillage (CT) was compared to no-till (NT) and crop rotations were maize-fallow-maize (MFM), maize-wheat-maize (MWM) and maize-oat-maize (MOM). The impact of tillage and crop rotations on soil aggregate stability and SI were evaluated after 5 cropping cycles. Across tillage practices, MOM rotation significantly increased soil aggregate mean weight diameter (MWD) as determined by fast wetting (FW) compared to MFM and MWM rotations in Lenye and also resulted in higher SI relative to MFM and MWM rotations at both sites. Scanning electron microscope (SEM) revealed that soils under NT and MOM rotation had dense organo mineral coatings and organic bridges than soils under CT and MFM rotation. No till and rotational cover cropping had positive



impact on soil structural properties reflecting them as more sustainable options than the current intensive-monoculture based crop production practices.

## **ASSESSMENT OF DRY SEASON WATER MANAGEMENT AND SOIL TEMPERATURES IN GREEN MAIZE AND TOMATO PRODUCTION IN TABORA, TANZANIA**

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Dry season vegetable farming is an important economic activity that generates incomes and sustains food security for smallholders in Tabora Region in western Tanzania. But, water scarcity is threatening the sustainability of this enterprise because of annual rainfall variability and low underground recharges. To design more appropriate methods for sustaining dry season vegetable production the current on-farm water management was studied. Participatory studies with farmers were conducted in tomato and green maize growing fields. Farmers' schedule of irrigation is based on access to water resources. Water supply per plant was estimated using the number of plants watered by the bucket of 10 litres water. Soil temperature was recorded using WEKSLER (USA) soil thermometers. Farmers irrigated crops after; 12hrs, 24hrs, 48 hrs and 72 hrs. The increase in air temperatures, evaporation, and the decline of atmospheric humidity in the semi-arid environment increase the water demand for crops at the time when the water resources are decreasing. Soil temperature data are presented qualitatively in graphs. Results show that in tomato plants soil temperature is maintained between 18-27.9°C after 12-72 hours following irrigation. In maize fields soil temperature was maintained between 22-27.9°C after 12-72 hours following irrigation. Soil temperatures for non-irrigated soil range between 23.3-33.9°C between May and September while the mean monthly evaporation for the same period range between 111.1-176.1(mm). Soil temperatures can be used by farmers to regulate irrigation schedules in dry season agriculture in semi-arid environment in Tanzania.

## **THEME VII: EXPLORING OPTIONS FOR SUSTAINABLE INTENSIFICATION AND DIVERSIFICATION OF CROP-SOIL-LIVESTOCK SYSTEMS**

### **NUTRIENT MANAGEMENT PRACTICES FOR VEGETABLE PRODUCTION IN SMALLHOLDER CROP-LIVESTOCK FARMING SYSTEMS IN THE PERI-URBAN AREAS OF SEMI-ARID EASTERN KENYA**

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Declining soil fertility is one of the major factors contributing to the current low productivity of crops in the crop-livestock production systems in the semi-arid areas

of Kenya. This study was conducted in the peri-urban areas of Machakos and Wote towns in semi-arid Eastern Kenya with the aim of identifying nutrient management practices currently used in the smallholder crop-livestock production systems, with a view to developing appropriate nutrient management strategies for enhancing the productivity of vegetables. The target population consisted of smallholder farmers owning at least one dairy cow. In the peri-urban areas of Machakos town, a total of 60 farmers were interviewed while in the peri-urban areas of Wote town, 56 farmers were interviewed using structured questionnaires. An overwhelming majority of the households were male-headed, literacy levels were high and freehold system of land ownership was the most prevalent. The two major vegetables grown in the areas were kale and tomatoes. Farmyard manure was the principal source of nutrients for vegetable production. The use of inorganic fertilizers was low due to high cost. The two main methods of manure application were placement in the furrows and planting pits. Shortage of labour for transporting manure to the fields was the main constraint to its utilization. It was concluded that since farmyard manure is the main source of nutrients for vegetable production, enhancing integration of crop-livestock system has the potential to sustainably increase the productivity of the farms. There is also a need to sensitize farmers on the use of organic sources of nutrients other than farmyard manure and compost in combination with inorganic sources in order to optimize all aspects of nutrient cycling.

#### **SUSTAINABLE INTENSIFICATION IN MIXED CROP-LIVESTOCK AGRO-ECOSYSTEMS: THE CASE FOR THE GUINEA SAVANNAH ZONE OF GHANA IN THE VOLTA BASIN**

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In 2012, on-farm trials were conducted in Tamale and Lawra districts of Ghana. The trials entailed 5 treatments of maize-soybean intercrops each with 3 replications composed of varying fertilizer, manure and soil-water conservation methods that were monitored on a real-time basis to deduce the progression of the soil moisture regime. The three factors that were selected as variables were: manure, inorganic fertilizer and the type of tillage. The soil texture for the Tamale site is a loamy clay soil with a friable structure while the Lawra site is a sandy loam soil with coarse stone aggregates. Soil textural differences revealed varying soil moisture storage regimes and had an impact on the structural durability of the in-situ soil-water conservation interventions. We surmise a facilitative and complementary co-existence between maize and soybean with no evident competition due to differences in crop phenotype and growth stages. Soybean water productivity ranged from 0.12 kg/m<sup>3</sup> in the control treatments to 0.2 kg/m<sup>3</sup> for treatments with no fertilizer but with 40 kg of manure application under tied-ridging (NFM40R). Maize water



productivity estimates from both sites in this study ranged from 0.5 kg/m<sup>3</sup> for treatments with no fertilizer with 40 kg of manure application under contour bunds (NFM40C) to about 1.2 kg/m<sup>3</sup> for treatments with fertilizer and 20 kg of manure with tied ridging (FM20R). Maize revealed a higher seasonal ET average (13%) than soybean. For both sites, soil moisture storage was consistently higher for treatments that had fertilizer with 20 kg manure under tied ridging (FM20R). Maize water productivity and gross value of production trends at both study sites was in the order: FM20R > NFM40R > Control > NFM40C while soybean was: NFM40R > NFM40C > FM20R > Control. These productivity trends are attributed to the combination of captured water, manure-fertilizer dosage supplements and soil conservation. The rain water that was captured within the ridges serves as a “micro-storage basin” thus providing more residence time for the water to infiltrate into the profile. The combination of tillage types with inorganic and organic supplements will yield appreciable dividends for maize and soybean. If both crops exist as an intercrop, we recommend a judicious combination of interventions that improve moisture retention and the nutrient status for optimal crop responses depending on soil textural attributes. This research will be replicated in parts of Western Kenya and the Tana River basin in Eastern Africa.

#### **AGROPASTORAL MUTATION AND POVERTY REDUCTION IN THE NORTH AND SOUTH EASTERN SLOPES OF NKAMBE HIGHLANDS, CAMEROON**

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In the eve of the economic crisis of 1990 that favor the putting in place the structural adjustment program in most African countries in general and in Cameroon in particular, the states disengage themselves from financing the agricultural sector. Considering this brutal transition (sevrage) the farmers were forced to lunch the intensification and diversification of their production to ameliorate their means of livelihoods. In this article, we study this agropastoral transformation in Nkambe highlands in the west of Cameroon, to show how poor farmers multiply their strategies to solve the disequilibrium observe in their food supply. To realize this objective field observation and semi-structured and structured questionnaires were executed to 100 households in the study area. The data collected were treated using the inferential statistical techniques. We also analyze the agricultural statistics from the ministry of agriculture and rural development. The results shows (1) a high agricultural diversification and intensification (2) a net amelioration of the agricultural production and the living standards of the households. However, the evidence also suggest that threats to agricultural production such as climate change, lack of a marketing board, poor land tenure system, inadequate infrastructure and equipment, poor agricultural governance, lack of agricultural insurance policy, high cost of farm inputs must be address to enhance food security and poverty alleviation



## **SOIL FERTILITY IMPROVEMENT USING CROP RESIDUES AND AZOLLA FOR SUSTAINABLE PRODUCTION OF RICE AND FISH IN IRRIGATED RICE-FISH FARMING SYSTEM IN THE LAKE VICTORIA BASIN OF KENYA**

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A balanced, equitable and sustainable food supply to the rural farmer, local market and export can only be achieved, if potential resource productivity is addressed. An experiment set up in Lake Victoria basin, West Kano Irrigation Scheme (WKIS) aimed at increasing both water and land productivity through poly-culture of rice and fish. It also explores un-utilized, cheap and readily available resources into increasing the culture yields from the present. The experiment with six treatment combinations and control was laid in Completely Randomized Design (CRD) replicated four times. The treatments consisted of two levels of commercial Urea, at 48 & 72Kg N/ha in combination with two organic inputs; Nitrogen bio-fixer Azolla at 2 ton/ha and rice straw at 3 ton/ha and that of fish alone. Results showed that application of Azolla at 2 ton/ha + 72Kg N-urea /ha+ Fish and that of 72 Kg N-urea /ha+ Fish gave significant increase in plant height of 25.9% and 15.8% respectively compared to control. The former treatment gave the highest grain yield 4.16 ton/ha. It was also evident that yields from two Azolla containing treatments did not differ significantly ( $P \leq 0.05$ ) from each other despite having different levels of commercial urea. Fish culture (fish droppings) potential as nutrient source in paddy field was also studied in the experiment, there was significant ( $P \leq 0.05$ ) increase in rice grain yield in treatment with fish alone. On the other hand, effects of other applied rice nutrient-sources on fish growth, in the treatment combination were also investigated. Isolation of fish from other rice nutrient sources gave the highest yield 134.7 Kg/ha. There was no significant ( $P \leq 0.05$ ) difference between the latter and that of 2 ton Azolla +48Kg N-urea/ha which yield 131.0Kg/ha.

## **SOYBEAN YIELD RESPONSE TO FERTILIZER, MANURE AND LIME APPLICATION IN WESTERN KENYA**

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Soybean production in Kenya has remained low, with quantities unable to satisfy the increasing demand. Soil nutrient depletion and degradation have been considered serious threats to agricultural productivity. Studies have shown that productivity of soils in western Kenya is hampered by deficiency of nutrients such as N, P and K a problem compounded by low organic matter and soil acidity. Responses of soybean to N and P have been studied and documented but little has been done on micronutrients, and also to establish the scale of macro and micronutrient deficiencies. The objective of the study was to assess nutrient deficiencies and



nutrient induced yield gaps in soybean production in nutrient omission trials. A study that sought to investigate the possibilities of boosting soybean yields through a combination of macronutrients, micronutrients and organic manure. Field experiments were conducted during the 2012 and 2013 cropping seasons in Western Kenya to assess nutrient deficiencies and nutrient induced yield gaps in soybean (*Glycine max* L.). The experiment was laid out in four sites in a randomized complete block design with three replicates. The treatments consisted of: 1) Control-without Biofix inoculant and fertilizer, 2) Inoculation alone, 3) NPK, 4) PK, 5) NP, 6) NK, 7) NPKSCaMgZnMo and 8) NPKSCaMgZnMo+Manure+Lime (treatment 2-8 seed inoculated with Biofix). Fertilizers were applied at rates of 20 kg/ha N, 30 kg/ha P, 60 kg/ha K, 23 kg/ha S, 20 kg/ha Ca, 5 kg/ha Mg, 3 kg/ha Zn, 3 kg/ha Mo, 10 tons/ha Manure and 5 tons/ha Lime. Soybean (SB-132) was planted during the short and long rainy seasons. Treatment effect significantly influenced above ground biomass, nodule mean score, number of nodules per plant, plant height, number of pods per plant, grain yield and total stover yield in both 2012 and 2013 cropping seasons. The highest values were noted in NPKSCaMgZnMo+Manure+Lime hence recommended for achieving high yields in soybean. The findings suggested that the combination of macronutrients, micronutrients, manure and lime can maximize productivity of soybean.

#### **THE EFFECT OF BEEKEEPING ON VEGETATION RESTORATION AND CONSERVATION OF DEGRADED WATER SOURCES AND RIVERBANKS IN THE WEST USAMBARA, LUSHOTO, TANZANIA**

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This paper examines the effect of beekeeping on vegetation restoration and conservation of degraded river banks and water sources as an alternative conservation approach. Data was collected in two sites, Uмба-river bank in Mwangoi village and the water catchment area in Migambo village both of Lushoto District, Tanzania. Methods used for data collection include vegetation assessment through a fine scale survey focusing on the area where beekeeping is carried. Concentric nested circular plots for the larger plot were used with 10% sampling intensity. Data from the forests was summarised and analysed using the excel computer programme, while socio-economic data was subjected to content analysis. The results indicated that over the past three years beekeeping has shown to improve the management of the area and the regeneration of plant species was significantly enhanced. Though the plant diversity of the two pilot areas was relatively low but was better than before the intervention. Moreover, the densities of regenerants are still higher compared to many forests in the Eastern Arc Mountains. Therefore it was recommended that enrichment planting with suitable tree species



suitable for apiculture be introduced to sustain the ongoing beekeeping activity that promotes conservation of these fragile areas.

## SOIL PROPERTIES AND CROP YIELDS UNDER RESIDUES MANAGEMENT OF PLANTED FALLOWS ON ULTISOLS IN CAMEROON.

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In order to evaluate the effect of residues management of *Sesbania sesban* and *Mucuna utilis* planted fallows on soil properties and maize grain yields, an experiment was conducted over three consecutive years at two locations (Minkoameyos in the semi-deciduous forest zone and Ntui in the forest-savannah - transition zone) in Centre Cameroon. The experimental design for each year was made of four replications and eight treatments : Natural fallow with three options, T1 : residue burn (NFB), T2 : residue incorporated in the soil (NFI), T3 : residue retained (mulching) (NFM), - *Mucuna utilis* fallow with two options, T4 : residue incorporated (MFI), T5 : residue retained (mulching) (MFM), - *Sesbania sesban* fallow with two options :T6 : residue incorporated (SFI), T7 : residue retained ( mulching) (SFM) - Maize/groundnut rotation with one option, T8 : residue incorporated (MGR). The analysis of variance and mean separation (Student-Newman-Keuls test) were used to evaluate the effects of treatments on maize grain yields and soil chemical properties at the end of the experiment. The results show that no treatment could produce relatively more than the first year of the experiment where maize yields were based on 3-4 year-old natural fallow in both sites. However, in Minkoameyos, there was a significant difference ( $p=0.048$ ) between treatments in the third year for maize grain yields. In Ntui, all the soil properties tested were significantly ( $p<0.05$ ) affected by the treatments at the end of study; while in Minkoameyos significant differences ( $p<0.05$ ) occurred among treatments only for pH, Ca, K and Al+H. At both sites, *Mucuna utilis* fallow gave the highest productivity index (1.46 in Minkoameyos and 2.65 in Ntui). These results show that *Mucuna utilis* has a potential for improving plant nutrient availability in these soils for the cultivation of maize.



## THEME VIII

### LAND USE PLANNING FOR SUSTAINABLE FOOD SECURITY AND CLIMATE CHANGE ADAPTATION IN AFRICA

#### PREDICTING OCCURRENCE OF SMALL MAMMALS AND FLEAS FROM LANDFORM AND SOIL PROPERTIES IN THE PLAGUE RISK AREA OF LUSHOTO DISTRICT, TANZANIA

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A study was carried out in West Usambara Mountains, Tanzania, to investigate influence of landform and soil properties on the occurrence small mammals and fleas. A conventional landform and soil data collection was done. Small mammals were trapped along randomly selected transects. Results show that small mammals' abundance increases with elevation. In the plateau, small mammals' abundance was at lower and mid slopes of ridges near valley bottoms where water and food are accessible. A landform-soil characteristics' model shows that available phosphorus ( $p=0.001$ ), aspect ( $p=0.01$ ) and elevation ( $p=0.01$ ) are statistically significant predictors explaining abundance of small mammals. Fleas' abundance and spatial distribution were influenced by hill-shade ( $p=0.001$ ), available phosphorus ( $p=0.01$ ) and base saturation ( $p=0.01$ ). This study improved understanding of relationships between landforms, soils and abundance of small mammals and their fleas in a plague focus.

#### PREDICTING SPATIAL DISTRIBUTION OF SMALL MAMMALS AND FLEAS FROM LANDFORM AND SOIL PROPERTIES IN THE PLAGUE RISK AREA, LUSHOTO DISTRICT, TANZANIA

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A study was carried out in Mavumo area, West Usambara Mountains, Tanzania, to analyse the scope of predicting the distribution of small mammals and fleas from



landform and soil characteristics. Aerial photographs and Landsat ETM<sup>+</sup> coupled with standard field survey methods were employed to map and analyse the landforms and soils covering an area of 198 km<sup>2</sup> in a GIS environment. Small mammals were trapped in the ecological niches based on the mapped landform-soil characteristics, and fleas were counted from the small mammals. The results demonstrate that the very steep complex slopes of the escarpment and the lower and mid slopes of the plateaus had higher abundance (> 40%) of small mammals and fleas. The lower and mid slopes of the plateaus are neighboring the valley bottoms where water and food are easily accessible. The landform-soil characteristics model shows that extractable copper, slope gradient, available phosphorus and exchangeable potassium are important factors in explaining the spatial distribution of small mammals. In case of fleas, the model shows that their abundance and spatial distribution was highly correlated with silt content, exchangeable calcium, sodium percentage, total nitrogen and extractable iron. About 99% of the observed variation in the small mammals and fleas occurrence could be explained. The study has demonstrated that the studied small mammals and fleas occurrence seem to prefer certain landform features such as slope characteristics and thrive better in the presence of a high base status of the soils.

#### **SOIL MANAGEMENT REQUIREMENTS FOR SUSTAINING AGRICULTURE DEVELOPMENT OF MOSHI DISTRICT, TANZANIA**

**Mbogoni J.D.J. and Mwangi S.B.**

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A study was conducted to characterise soils of Moshi Rural district and to document their morphological, physical and chemical characteristics. This would culminate in generation of soil fertility characteristics and soil fertility management requirements for sustaining crop yield. Two major physiographic regions and four soil types were identified and described. The study has revealed that soil properties are related primarily to landform and parent materials. Most soils of the Northern Riftzone have low levels of nutrients that require replenishment for optimization of crop yields. Some soils of the Eastern plateaus in the southern part of the district have toxic levels of salts. Crop yields in the district can be optimized by build up of organic matter with improved cropping systems and use of manure and fertilizers. Salt toxicities in the southern part can be mitigated primarily by use of gypsum and adequate drainage provisions.

#### **APPROACH TO TRANSLATE THE EXPECTED GLOBAL SOIL MAP PRODUCT TO SOIL CLASSES ON EXAMPLES OF MAJOR SOILS OF AFRICA**

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The original main objectives of the Global Soil Map (GSM) project is to produce high resolution maps for defined soil properties (soil pH, organic carbon content, texture



and some additional ones according to the project specifications), with new digital soil mapping tools. Deriving soil classes from the Global Soil Map data is not among the original purposes of the project. One of the important purposes of soil classification is to organize our knowledge, understand and define relationships, identify soils and enable communication about them. Soil classes are believed to have similar properties, function similarly and hence require similar management practices for food production or other services and conservation of land quality. Hence classification and extrapolating information is supporting the proper management and food production. Based on the above statements the authors of this paper believe that it is an essential added value to the prospective products if classes are defined. The presented work attempted to generate soil classes by using the suggested parameters of the Global Soil Map project for the most common soils of Africa. The limited set of soil property data of the depth intervals defined by GSM methodology was derived from the ISRIC WISE (v3.1) dataset. The methods to derive the WRB (World Reference base for Soil Resources (WRB) Reference Soil Groups (RSG) included classification algorithm and taxonomic distance calculations and a combination of those. The created tools were validated on soil profiles, subset from legacy datasets. The classification algorithm performed poorly compared to the taxonomic distance calculations, mainly because of the data need of such an approach. Although in general taxonomic distance calculations worked better, for some soil groups the misclassification rate was quite high. The studied pattern in the misclassification table suggested that a minimum criteria filtering on the results could further improve the results. The combination of the two methods resulted more than 80 percent accuracy on the validation profiles.

The promising results and the progress itself can be useful not only for the compilation of a future global soil type maps and also contribute to the development of the next generation of soil classification systems.

#### **SOIL LOSS DUE TO CROP HARVESTING IN WESTERN USAMBARA MOUNTAINS, LUSHOTO DISTRICT, TANZANIA: THE CASE OF CARROT, ONION AND ROUND POTATO**

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A study was conducted in two villages with contrasting agro ecological conditions in Western Usambara Mountains, Tanzania to investigate the amount of soil and nutrients lost and the factors influencing variation of soil loss due to crop harvesting (SLCH) for Carrot (*Daucus carota*), Onion (*Allium cepa* L.) and Round Potato (*Solanum tuberosum* L.) under low input agriculture. Soil particles adhering on roots,

bulbs and tubers were cleaned and the soil suspension oven dried to constant weight at 105 °C to estimate the amount of soil lost after harvesting. Mean soil loss respectively in Majulai and Migambo villages were as follows: onion 3.00 and 5.94 Mg ha<sup>-1</sup> harvest<sup>-1</sup>, carrot 7.44 and 9.30 Mg ha<sup>-1</sup> harvest<sup>-1</sup> and round potato 1.12 and 0.55 Mg ha<sup>-1</sup> harvest<sup>-1</sup>. Soil nutrient losses for onion were N = 6.3, P = 0.04, K = 0.25, OC = 59.83 and N = 14.37, P = 0.06, K = 1.28, OC = 133.9 kg ha<sup>-1</sup> harvest<sup>-1</sup>; carrot were total N = 29.59, P = 0.09, K = 1.50, OC = 362.2 and N = 32.33, P = 0.07, K = 0.82, OC = 422.5 kg ha<sup>-1</sup> harvest<sup>-1</sup>; round potato were total N = 2.79, P = 0.007, K = 0.29, OC = 28.91 and N = 1.83, P = 0.03, K = 0.14, OC = 20.93 kg ha<sup>-1</sup> harvest<sup>-1</sup> for Majulai and Migambo respectively. SLCH was higher in Migambo (humid cold) than in Majulai (dry warm) for all the studied crops. In decreasing order, SLCH trend was carrot > onion > round potato for both villages. Soil water content played a significant role in inducing SLCH for onion and carrot crops whereas round potato crop was not influenced by soil water content. Bulk density and soil texture played only a minor role to SLCH of the studied crops. The observed soil and nutrient losses (except for P) are substantial and pose challenge that calls for immediate attention to the harvesting practices in the study area.

#### EVALUATION OF SOIL FERTILITY GRADIENTS UNDER DIFFERENT SOIL AND WATER CONSERVATION TECHNOLOGIES IN MAJULAI WATERSHED, WEST USAMBARA MOUNTAINS, TANZANIA

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Soil and water Conservation (SWC) technologies like bench terrace, micro ridge and *miraba* have been implemented to reduce the impact of soil erosion and halt land degradation in Western Usambara Mountains, Tanzania. However, some of these technologies in other countries have been criticized for developing soil fertility gradients. This study was conducted in Majulai watershed, Tanzania, to evaluate soil fertility gradients for the aforementioned SWC technologies. Soil samples were collected in three slope categories, in three SWC technologies. Soils of the ridge summits are mainly *Haplic Acrisols (Profondic)*, those of upper and middle slopes are *Cutanic Acrisols (Profondic, Chromic)*, while on the lower slopes the soils are *Cutanic Acrisols (Profondic, Clayic, Chromic)*. *Stagnic Acrisols (Hyperdystric, Profondic)* and *Haplic and Gleyic Fluvisols (Humic, Eutric)* occupy respectively the toe slopes and the valley bottoms. Soil fertility status under bench terraces was higher than under micro ridges, *miraba* and control. In all the SWC technologies fertility was not



affected by slope positions of the terrain for most of the studied soil nutrients except  $Mg^{2+}$  and pH. There were clear trends of fertility gradients indicating that lower parts under *miraba* had relatively higher fertility status for most of the nutrients than the middle and upper parts. Bench terraces and micro ridges had higher fertility status for most of the nutrients at the middle than at the lower and upper parts. These observations imply that there is a need for improvement of the studied SWC technologies and their implementation for sustained crop productivity in Majulai watershed and other areas with similar ecological conditions.

## CHARACTERIZATION AND CLASSIFICATION OF SOILS OF SELECTED AREAS IN BENUE STATE SOUTHERN GUINEA SAVANNA OF NIGERIA

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The soils of some selected areas in Benue state were characterized and classified in 2009 for the purpose of providing information necessary for good land use planning for sustainable Agriculture. Six profile pits were sunk and soil samples were collected for physical and chemical laboratory analysis. The textural composition of the soil ranged from loamy sand to sandy loam to clay loam. The pH ranged from slightly to moderately acidic in reaction in most parts of the areas. The organic matter was very low in all the study areas. Available phosphorus was low in all the locations. Total Nitrogen was predominantly very low to low. CEC also ranged from very low to low. The soils were classified as follows: SIWES Farm *Typic ustochrepts*, Obarike Oju, *Vertic tropaquept* and Otobi *Typic Kandiaqualf*. NYSC farm, *Typic Kandiuustalf*; Adum-Ito, *Typic Kandiuustalf*; and Otukpa, *Oxic Ustropept*. Soil conservation practice and the use of inorganic fertilizer will be necessary for optimum productivity of these soils.

## THE INFLUENCE OF SOME SOIL PROPERTIES ON THE GROWTH PERFORMANCE OF *TECTONA GRANDIS* IN BENUE STATE.

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This study investigated the influence of some soil properties on the growth performance of teak (*Tectona grandis*) in soil samples collected from five locations in Benue state. Bulk composite soil samples were collected at a distance of 500 meters away from teak plantations in five locations in Benue State. These locations include Amilogodo in Oju, Aghan in Makurdi, Mbagba in ushongo, Ihugh in vandekyia, and Ijami in Ohimini local Government Area of Benue state. The soil samples were analyzed in the laboratory and treated seeds were planted and watered in germination boxes for a period of two weeks after which the seedlings were transplanted and watered for a period of three months in polypots. Parameters assessed after the period were, plant height (cm), number of leaves/plants, leaf area index (LAI) and dry matter (g). Analysis of Variance (ANOVA) was used in data



analysis. The results showed that the soil sample E with characteristics pH of 6.10, CEC of 7.10 cmol./kg, organic carbon of 2.28%, total Nitrogen of 0.09% and the available phosphorus of 6.75 ppm collected from Ohimini proved outstanding as shown by the assessed parameters. It was therefore concluded, that *Tectona grandis* should be planted in soil with similar characteristics as those of sample E for optimal performance.

## SPATIAL DISTRIBUTION OF TOPSOIL CARBON CONTENT AND PH CONCENTRATION IN LAKE VICTORIA BASIN.

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Soil is a heterogeneous material even within short distances but it is not possible to take soil measurement at each point due to high cost of soil analysis involved. In this study mid-infrared spectroscopy (MIRS) in combination with spatial analyses is used to show soil nutrient evaluation in a large scale. Geo-statistics provides a set of statistical tools for incorporating spatial and temporal coordinates for observations in data analysis, which allows modeling of spatial patterns, prediction locations not sampled and assessment of uncertainty attached to these predictions. We conducted a study in Nyando, Nzoia and Yala catchment areas. Soil sampling was carried out on the topsoil (0-20 cm) from five sites, of 100 km<sup>2</sup> each, within the Lake Victoria basin. At each point, a composite topsoil sample was taken and analyzed by MIRS. Conventional laboratory analysis was analysis was done on 10% of soil samples for a wide range of soil properties but for our work we evaluated soil pH and organic carbon. MIR- partial least squares regression models were developed for the 10% subset which were then used to obtain predictions for the remaining samples. The calibration models gave acceptable relationship between MIRS and conventional laboratory analysis ( $r \geq 0.8$ ). The approach of using MIRS predicted values increases data points incorporated into kriging model. Geostatistical techniques were used to model and predict the respective surface maps of the pH and carbon, using the kriging method. Comparisons of Spherical and Gaussian variogram models were evaluated. From results Spherical model fitted well with the experimental semivariogram model for pH and soil total carbon. Cross-validation of the kriged maps shows that spatial prediction of the soil properties using semivariogram parameters is better than assuming mean of observed value for any location not sampled. The variance ratio of pH (2.02%) was lower than that of organic Carbon (38.75%). Evaluation of the surface maps for the two soil properties showed reasonable accuracy for use at each of the sentinel site. Therefore, integrating MIRS with spatial analysis increases the sampled points included in kriging models, which improves estimates for both pH and organic Carbon for better land use and management in watershed resources.



## THE POTENTIAL OF CANE CULTIVATION AS A CLEAN DEVELOPMENT MECHANISM: EXPLORING CARBON SEQUESTRATION AT KAKIRA SUGAR ESTATE, UGANDA

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Soils, and managed agricultural soils in particular, represent a potentially significant low cost sink for greenhouse gases (GHGs) with multiple potential co-benefits to farm productivity and profitability. The great majority of agronomists and soil scientists agree that most agricultural soils can store more carbon and even a modest increase in carbon stocks across the large land areas used for agriculture would represent a significant GHG mitigation. In view of the high biomass, the 5 to 6 years the crop occupies land, and accompanied with good farming practices, sugarcane has the potential to sequester considerable amounts of carbon thereby contributing to climate change mitigation. However, little has been done to provide relevant information concerning carbon sequestration in crop lands and sugarcane in particular. Assessment of carbon sequestration for four sugarcane varieties grown at Kakira Sugar Works Limited was done using the RothC-26.3 model. Results show that sugarcane grown at Kakira sugar estate has the potential to sequestering between 589.1 to 591.1Tc/ha/month. This level is high enough to warrant consideration under the clean development mechanism or the climate smart agriculture intervention initiatives

## ORGANIC AND CONVENTIONAL MANAGEMENT FARMING SYSTEMS IMPACTS ON PLANT SPECIES BIODIVERSITY: A CASE STUDY IN KAYUNGA DISTRICT, UGANDA

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Plant biodiversity loss is one of the global challenges. It's attributed to a numbers of issues including deforestation, land degradation, habitat loss, harvesting of plants and climate change etc. Farming management systems contribute to the above issues during land preparation for cultivation. However, farming systems have not been investigated and this formed the rationale of this study. In Uganda, the certified organic farmers as well as convectional farmers are in Nakaseeta and Nsotoka sub-counties, in Kayunga district. The main objective of this study was to compare plant biodiversity abundance under organic and convectional management farming systems. Sixteen farmers under the EU sponsored project- BIOBIO practicing organic and convectional farming were selected for the study, eight practicing organic and eight convectional. A hand held GPS was use to mark the centre of each field under study. Measurements were made using a tape measure; quadrats were positioned using a string and sticks. Data was collected through survey, direct observation and estimations for plant species cover, plant species were identified, classified and their



vegetation cover recorded. The number of plant species recorded present was 256 under 61 families. Conventional farming system had 205 species, organic had 187 species. The data was entered into Microsoft excel and analyzed using one-way ANOVA. Euphorbiaceae and Malvaceae are the families with significant difference under conventional compared to organic farming systems. Descriptive statistics was used to establish the number of species, families and intercropping combinations. The intercropping combinations recorded were 4. Some plant species were only recorded either under conventional or organic farming system. Flora data was statistically related to soil analytical results for conventional and organic farming systems. Plant diversity was significantly correlated to soil quality.

### SCIENTIFIC VALIDATION OF FARMERS' PERCEPTION OF WEED COMMUNITY DISTRIBUTION AS INDICATORS OF SOIL QUALITY IN UGANDA

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Farmers recognize soil quality indicator plants (SQIP) but these are not yet integrated in soil quality monitoring (SQM) due to lack of scientific validation. Yet user-friendly SQM tools are needed to enable such land users to make timely management decisions in averting ever increasing land degradation in sub-Saharan Africa. Good soil quality reveals much of sustainable land use but its measurement is complex thus requiring use of indicators. Technical indicators of soil quality have been developed but knowledge of farmer-perceived indicators is still limited. A cross-sectional community surveys in four agro-ecological zones of Uganda, detailed characterization of weed distribution and soil testing of 150 randomly selected fields in two contrasting soil units; Nitisol and Ferralsol were conducted. This work aimed at relating farmer perceptions and technical knowledge of soil quality indicators as validation efforts. Redundancy and Principal Component Analyses by XLSTAT computer packages were employed to establish the relationships. Results revealed close associations between relative abundance of weed species reported as farmer-perceived SQIP, especially *Commelina benghalensis* and *Amaranthus hybridus* for fertile soils and *Bidens pilosa* and *Imperata cylindrica* for poorer, over cultivated and compacted soils. It was concluded that the scientifically validated weed species- soil characteristics associations are in agreement with indigenous knowledge used by farmers to directly and easily predict the soil quality status for crop performance. The authors recommend further in-depth studies to determine threshold levels.



## **FOCI OF PLAGUE IN WEST USAMBARA MOUNTAINS, TANZANIA: COMMUNITIES AND DIVERSITY OF SMALL MAMMALS IN DIFFERENT LANDSCAPES**

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This study attempts to develop knowledge on the presence and distribution of small mammals at landscape scale in Western Usambara Mountains, Tanzania. The host of the human plague disease, endemic in this region, is since long hypothesised to reside within still unknown rodents or other small mammals. Landsat images and field survey were used to select trapping locations in different landscapes. Forty one trapping units were located, and 188 animals were captured in 4905 trap nights and identified to species level. Thirteen species were identified but *Praomys delectorum* and *Mastomys natalensis* comprised 50% of all the animals trapped. In the study area trap success increased with altitude. The majority of the mammals were trapped in the plateau landscape, which is dominated by cultivation, plantation forest and shrubs. In terms of species diversity, plantation forest ranks first followed by shrub. Spatial distribution of rodents is discussed in relation to the existing knowledge of human plague distribution and to environmental and landscape factors considered being factors of plague distribution.

## **THE EFFECT OF BEEKEEPING ON VEGETATION RESTORATION AND CONSERVATION OF DEGRADED WATER SOURCES AND RIVERBANKS IN WEST USAMBARA MOUNTAINS, TANZANIA**

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This paper examines the effect of beekeeping on vegetation restoration and conservation of degraded river banks and water sources as an alternative conservation approach. Data was collected in two sites, Uмба-river bank in



Mwangoi village and the water catchment area in Migambo village both of Lushoto District, Tanzania. Methods used for data collection include vegetation assessment through a fine scale survey focusing on the area where beekeeping is carried. Concentric nested circular plots for the larger plot were used with 10% sampling intensity. Data from the forests was summarised and analysed using the excel computer programme, while socio-economic data was subjected to content analysis. The results indicated that over the past three years beekeeping has shown to improve the management of the area and the regeneration of plant species was significantly enhanced. Though the plant diversity of the two pilot areas was relatively low but was better than before the intervention. Moreover, the densities of regenerants are still higher compared to many forests in the Eastern Arc Mountains. Therefore it is recommended that enrichment planting with suitable tree species suitable for apiculture be introduced to sustain the ongoing beekeeping activity that promotes conservation of these fragile areas.

#### **EVALUATION OF SELECTED SOIL PARAMETERS CRITICAL FOR SORGHUM PRODUCTION IN SEMI-ARID GHANA.**

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This study aimed at identifying soil parameters that are critical to crop production as to manage them effectively and improve fertilizers use efficiency and crop yield. To achieve this, selected points on an area of about 1.5 km<sup>2</sup> were characterized for their organic carbon, pH, and soil texture. Data collected was used in a pedo-transfer function to estimate wilting point, field capacity, available water and saturation. These were used as input to the crop simulation model (APSIM- Agriculture Productions Systems sIMulator) to simulate sorghum grain yield for each grid cell. Using the factor analysis and linear regression statistical procedures, parameters that contribute to soil structure (soil texture and organic carbon) were identified to have contributed significantly to crop yield. Out of these parameters, only soil organic carbon (SOC) can be significantly manipulated to increase crop yield on poor sandy soils. SOC is therefore a critical soil parameter for sustainable sorghum production in this study.



## **INFLUENCE OF SOIL ORGANIC MATTER ON THE STATUS OF THE ADSORPTION COMPLEX OF TROPICAL ACID SOILS: CASE OF SHIFTING AGRICULTURAL SYSTEM OF SOUTHERN CAMEROON PLATEAU**

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## **SPATIAL DISTRIBUTION OF TOPSOIL CARBON CONTENT AND PH CONCENTRATION IN LAKE VICTORIA BASIN**

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Soil is a heterogeneous material even within short distances but it is not possible to take soil measurement at each point due to high cost of soil analysis involved, but with use of geostatistics methods it is possible to estimate soil properties at the unobserved locations. Geostatistics provides a set of statistical tools for incorporating spatial and temporal coordinates for observations in data analysis, which allows modeling of spatial patterns, prediction at unsampled locations, and assessment of uncertainty attached to these prediction. We conducted a study in Nyando, Nzoia and Yala catchment areas. Soil sampling was carried out on the topsoil (0-20 cm) from five sites, of 100 km<sup>2</sup> each, within the Lake Victoria basin. Soil samples were analyzed for soil pH and organic carbon. Geostatistical techniques were used to predict/model the respective surface maps of the pH and carbon using the kriging method. Comparisons of Spherical and Gaussian variogram models were evaluated. From results Spherical model fitted well with the experimental semivariogram model for pH and soil total carbon. Cross-validation of the kriged maps shows that spatial prediction of the soil properties using semivariogram parameters is better than assuming mean of observed value for any unsampled location. The variance ratio of pH (2.02%) was lower than that of organic Carbon (38.75%). Evaluation of the surface maps for the two soil properties showed reasonable accuracy for use at each of the sentinel site. Therefore Kriging may be a useful technique for delineating distribution of both pH and organic Carbon for better land use and management in watershed resources.



## MINERAL AND GEOCHEMICAL CHARACTERIZATION OF THE WEATHERING MANTLE DERIVED FROM NORITES IN KEKEM (WEST CAMEROON): EVALUATION OF THE RELATED MINERALIZATION

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In West Cameroon, the Kekem weathering mantle exhibited a shallow weathered soil pedon with seven differentiated soil phases. The secondary minerals consist of akaganéite, sepiolite, berthierine and smectite. Phlogopite, feldspar and pyroxene, which are not completely weathered, remain present in specific soil phases. Silica (37.2 - 43.9%), aluminum (16.8 - 23.7%) and iron (9.9 - 15.9%) are the most abundant major elements. Calcium and sodium are almost completely leached, whereas potassium (4.2%) and magnesium contents (6.9%) increase with depth. The most abundant trace elements are Ba (3309.0 ppm), Cr (1133.0 ppm), V (638.0 ppm), Sr (428.1 ppm), Zr (238.0 ppm), Ni (227.9 ppm), Co (174.4 ppm), Zn (139.0 ppm) and Rb (102.7 ppm). Chromium with enrichment factor, EF: 9.1 - 48.1, Cu (EF: 3.0 - 4.9), Hf (EF: 1.9 - 3.5), V (EF: 1.4 - 4.0), Nb (EF: 0.9 - 3.0), Ta (EF: 0.8 - 3.7), Th (EF: 0.9 - 2.3), U (EF: 0.9 - 2.8) and W (EF: 0.6 - 1.8) are enriched in soil phases. The light rare earth elements (LREE) are the most abundant REE in soils, with  $\Sigma$ LREE ranging from 69.5 to 293.4 ppm. The REE in various soil phases are strongly fractionated from La to Dy, with important Eu anomaly. Thus, macroscopic and microscopic organization of various soil phases in this weathering mantle as well as their mineral composition and chemical elements mobilization and redistribution enable us to draw the following conclusion: - This weathering mantle has been subjected to restrained weathering process with minor pedological differentiation; - The major weathering process in this area, referred to as bisiallisation, led to formation of 2:1 clay minerals such as sepiolite and smectite; - The highly confined alkaline conditions prevailing in this area have contributed to the formation of unusual secondary minerals like sepiolite, akaganéite and berthierine in these soils; - Accumulation of rare metals, more specifically Ba, Cr, Sr, Zr, Ni, Co, Zn and Rb, and to some extent Cu, Hf, Sn, Nb, Ta, Th, U and W, in this weathering mantle could have resulted from: (i) relative enrichment during hydrolysis of weatherable primary minerals, (ii) slow dissolution of the neosynthesis secondary minerals or relatively resistant primary minerals, (iii) intense biological activity with recycling of metals by plants at the soil surface; - There is a strong REE fractionation in various soil phases of this weathering mantle from La to Dy, with high Eu anomaly. Overall, the Kekem norites weathering mantle may be compared to a potential deposit with its relatively high accumulation of sepiolite, akaganéite and berthierine, and medium grade concentrations of rare metals (mainly Ba, Cr, Sr and V) in soil phases.



## UPTAKE OF ZINC IN SUGARCANES: AN EXPERIMENT USING SAMPLES FROM NAIROBI RIVER BASIN

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Climate variability and increased demand for arable and productive land from fast growing population has stimulated farming in urban centers, along the riverbanks, wetlands and water catchment areas. For most cities in developing countries, an important part of agricultural production is for self-consumption, with surpluses being traded. The extensive use of river water for irrigation purposes has contributed to the accumulation of heavy metals in the soil through siltation and in food crops grown along the river basin. This is because the water is highly polluted with industrial effluents, raw sewage and effluent from both private and public sewage works. However, food crops grown in these conditions appear 'healthy' and attractive to consumers but are susceptible to accumulation of metals. When consumed they may transfer toxics to human beings and animals. In this study, Energy Dispersive X-ray Fluorescence was used to determine zinc levels in soil and sugarcane samples along Nairobi river basin. In soil, zinc levels were as high as 400 µg/g. Sugarcane samples were found to readily absorb zinc with higher accumulation in the roots than in the stems and leaves. However, zinc levels in the stems were within WHO recommended limits of 45 mg/day, for human consumption.

## TRACE ELEMENTS IN SOILS FROM TANZANIA: APPLICATION OF TXRF ANALYSIS

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A reduction of essential trace elements concentration in soils results in unhealthy low intake to plants, domestic animals and human beings. This could result in an increased risk of mineral deficiency related symptoms, diseases and malnutrition, worsening the current food and economic situation in Africa. Plants essential trace elements (Mn, Fe, Ni, Cu, Zn and Cl) in soils from four sites in Tanzania: Pandambili, Mbinga, Itende and Kidatu were investigated using total X-ray fluorescence spectroscopy. A total of 128 samples were analysed, 32 from each site and the results revealed that Fe and Mn were within the range of world-wide reported values for all the sites. However concentration of Ni, Cu, Zn and Cl were low compared to the values, especially in samples from Kidatu and Itende. The



concentration of the elements compared to world-wide reported values and their variation with depth; top (0-20cm) and sub (20-50cm) in these soils are discussed.

## LAND SUITABILITY ASSESSMENT AND LANDUSE PLANNING: A PREREQUISITE FOR FOOD SECURITY AND CLIMATE CHANGE ADAPTATION

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Though Ghana's crop yield growth rate was at 17%, 5% of every 1.2 million Ghanaians have insufficient and limited access to nutritious food. Climate change and climate variability has enormously affected the state of agricultural productivity and hence could result in food insecurity. As many ongoing projects use Boolean suitability analysis to develop land suitability schemes in landuse planning, management recommendations are still inadequate to provide rural poor resource farmers adequate information and management interventions. This then, is affecting livelihood and agricultural productivity, as such, limited farm input and resources cannot assure improved yield on limited farm resources. In this paper, a geostatistical quantitative method to support a GIS based multi-criteria decision support system (GMCDSS) for an enhanced land suitability assessment (LSA) and landuse planning (LP) was devised. Project findings indicated that, site specific levels of quantities of resources and/or farm inputs could be estimated and application done appropriately. It was estimated that, soil fertility level in the study area was low and serious management efforts were needed. This GMCDSS for LSA aided the quantification of soil amendment indicators (e.g. 1.0 t/ha lime + 1.0 t/ha gypsum was estimated for liming). Additionally, farmers can now save money in their fertility management because, instead of applying 5.0 t/ha poultry manure (PM) or 5 bags of 15-15-15 + 2 bags of sulphate of ammonia (SA), a farmer may instead apply 2.0 t/ha PM + 2 bags 15-15-15 + 1 bag SA. Also, areas where GMCDSS assessment indicated no agricultural benefit, other livelihood alternatives were identified and recommended appropriately. GMCDSS assessment has proved to be fundamental in (1) basing planning and investment decision on, (2) ensuring food security, (3) poverty reduction and interventions to the effects of climate change and climate variability.



## ANDOSOLIZATION OF SOILS ON A STROMBOLIAN CONE AT MOUNT BAMBOUTO, CAMEROON

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Morphology, mineral and geochemical investigations were carried out on two selected soil pedons (ZA and TO) developed on a late Quaternary-aged strombolian cone to better understand andosolization processes in Mount Bambouto, Cameroon. Both pedons have A-BC-C horization. They have thick surface (A) horizon with bulk density less than  $0.7\text{ g cm}^{-3}$ , aluminum oxalate and iron oxalate ( $\text{Al}_0 + 0.5\text{Fe}_0$ ) about 2% and phosphorus (P) retention more than 90%. Mineral association consists predominantly of kaolinite, gibbsite, goethite, organo-metal complexes and trace amount of ferrihydrite and allophane. The  $\text{SiO}_2/\text{Al}_2\text{O}_3$  (Ki) values between 1.1 and 1.6, the low total reserve in bases (TRB: 45 to 67  $\text{mg kg}^{-1}$ ), the important mobility index (IMob: 20% to 24%), the chemical index of alteration (CIA) between 60% and 70% and the enrichment factors (EF) above 1.16 for Al and Fe, and below 0.6 for Si indicate sparingly hydrolysis process in subsoil during which released Al, Fe and Si form allophanic or ferrihydrite minerals undergo crystallization into kaolinite, gibbsite and goethite, respectively. At topsoil, part of released Al (and Fe) is organically bounded with organic acids to form organo-metal complexes. In the late quaternary strombolian deposits from Mount Bambouto, andic soils refer to *aluandic ANDOSOLS (dystric)* according to the World Reference Bases for Soil Resources (WRB-FAO, 2006). They derive from the andosolization process which corresponds to fast and intense release of Si, Al and Fe during rapid hydrolysis of volcanic products under humid conditions. Transient allophanic and ferrihydrite minerals are formed that crystallized into kaolinite, gibbsite and goethite. Part of released Al (and Fe) is bounded at topsoil by organic acids to form stable and less mobile organo-metal complexes. Thus in Mount Bambouto, andosols are non-allophanic which seem to have developed at the same period despite the wide range of rock ages and type.

## MULTI-SCALE ORGANIZATION OF THE DOUMBOUO-FOKOUÉ BAUXITES ORE DEPOSITS (WEST CAMEROON): IMPLICATION TO THE LANDSCAPE LOWERING

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Landscape distribution, macroscopic, microscopic, mineral and geochemical characterizations were conducted on the Doumbouo-Fokoué bauxite ore deposit in



order to estimate bauxites potential and its implication to general lowering of the relief. Fourteen bauxitic plateaus covering a surface area of 5.7 km<sup>2</sup> were identified. Bauxitic pedons show deep weathered profiles (10.0 - 12.0 m) with thick bauxitic mantle (4.0 - 8.0 m). Saprolite and pisolith bauxitic facies own high aluminium (47.5% - 49.5% Al<sub>2</sub>O<sub>3</sub>), relatively low iron (20.0% - 22.0% Fe<sub>2</sub>O<sub>3</sub>) and low silica contents (1.8% - 7.6% SiO<sub>2</sub>). Gibbsite is the dominant mineral (49% - 68% of minerals detected by X-ray); meanwhile hematite, goethite and kaolinite occur in small amounts. Bauxitization corresponds to intense allitization with abundant accumulation of gibbsite and development of lateritic iron bearing ortho-bauxites. Bauxite ores yielded bauxite reserves of 9.2 million tons. They occur as old and residual bauxitic mantles representing remnants of the Miocene residual lateritic deposits in West Cameroon referring to the African surface of Valetton (1999). Its mean altitude (1532 - 1590 m *als*) below the African surface reveals general lowering of the relief. Thus, in Doumbouo-Fokoué, important bauxite ore deposits were developed from basaltic rocks during early to lower Miocene under contrasted climates. They correspond to the iron bearing lateritic ortho-bauxite ore deposits with 9.2 millions tons of bauxite reserves. These lateritic bauxites are differentiated into pisolith bauxitic facies locally overlying saprolite bauxitic facies. They form thick bauxitic mantles at the summit of interfluves which have individualized fourteen bauxitic plateaus (*bowé*). The evolution of the landscape attributed to the bauxitic mantles development in Doumbouo-Fokoué differentiates three major stapes: Development of the old and residual bauxitic surface (African surface) during the early to lower Miocene by intense bauxitization process under contrasted climates; Intense degradation of the African surface favored by regressive erosion, deferruginization and mechanical dismantling of the bauxitic mantle under humid sub-equatorial climate; General lowering of the relief under the control of the above degradation processes and the joining up of this relief with the *Bamiléké* plateau. Thus, bauxitic mantles in Doumbouo-Fokoué, through their landscape distribution, their vertical organization and bauxitic facies evolution, have contributed significantly to the general leveling of the *Bamiléké* plateau in the West Cameroon Highlands.

#### A COMPARATIVE STUDY OF NUTRIENT STOCKS AND CROP PERFORMANCE IN LUVISOLS VERSUS FERRALSOLS OF SEMI ARID THARAKA DISTRICTS OF EASTERN KENYA

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Soils found in Tharaka are from basic igneous rocks with a volcanic origin of the extinct Nyambene ranges which is part of Central highlands of Kenya. A study was conducted in November 2011 to determine the nutrient status of the soils found in this area. Sampling was done in 96 farm fields of 12 different smallholder farms. The study sites were in Nkarini, Ntugi, Nkondi and Thiiti locations of the Tharaka North

and Tharaka South districts of eastern Kenya. In each of the fields sampled, soils were collected from 9 different spots at a depth of 0-15 cm. The soils were analyzed for soil chemical properties that included soil reaction (pH), exchangeable bases (Ca and Mg), extractable phosphorus, organic carbon (OC), total nitrogen and micronutrients (Zn, Cu, Fe and Mn). There were significant statistical differences among soil fertility categories, using parametric techniques (ANOVA) for key soil properties ( $p < 0.05$ ), implying that the soils must have belonged to different populations and that there was a qualitative difference in the soils. The chromic Luvisols which is strongly calcareous, stony clay loam, had comparatively lower soil organic carbon and nitrogen compared to the clayey orthic Ferralsols of Irimba, Kagunda and Kagurini villages of Tharaka. Variability in the nutrient stocks of other macro and micro nutrients was found to be lower between the two soil types. Zinc was found to be uniformly deficient (by falling below the critical levels 5.0 ppm Zn) across all the different locations of Tharaka, irrespective of the soil type - a situation probably attributable to continuous removal through crop products and residues coupled with intensified grazing of the fields.

#### **(147) EFFECTS OF TILLAGE, FALLOW AND BURNING ON SELECTED PROPERTIES AND FERTILITY STATUS OF ANDOSOLS IN THE MOUNTS BAMBOUTO, WEST CAMEROON**

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To assess the impact of land use on the Andosol fertility, changes in chemical and physical properties affecting soil quality were monitored on Andosols from Mount Bambouto submitted to four different land uses and management systems: natural cover, tillage, burning and fallow. In comparison with the natural cover, tillage reduces Andosol organic carbon (OC: 6.5% to 4.8%), total nitrogen (N: 4.51‰ to 2.95‰), cationic exchange capacity (CEC: 22.0 to 20.9 cmol kg<sup>-1</sup>) and the abundance of soil macro-aggregates expressed by the water stable aggregates (WSA) varies from 53.8% to 12.0%; and increases the bulk density ( $da$ : 0.69 to 1.09 g cm<sup>-3</sup>) and the sum of exchangeable cations (S: 3.58 to 4.84 cmol kg<sup>-1</sup>). Burning also reduces Andosol OC (6.5% to 0.8%), total N (4.51‰ to 0.95‰) and CEC (22.0 to 10.2 cmol kg<sup>-1</sup>), but increases soil pH (4.62 to 6.54), the sum of exchangeable cations (3.58 to 5.74 cmol kg<sup>-1</sup>) and the abundance of soil macro-aggregates (WSA: 38.2% to 57.0%). In comparison with tillage, fallow increases Andosol OC (4.8% to 6.5%), total N (2.95‰ to 5.04‰), CEC (18.0 to 21.6 cmol kg<sup>-1</sup>), the sum of exchangeable cations (3.58 to 5.05 cmol kg<sup>-1</sup>) and the abundance of soil macro-aggregates (WSA: 12.0% to 48.8%). Globally, the tillage management deteriorates Andosol chemical and physical properties affecting fertility, whereas the fallow management restores them. The burning management also improves some Andosol chemical and physical properties affecting quality, but it won't last long. So, the tillage management system is a significant driver of the Andosol fertility decline. It reduces significantly the soil organic matter and the CEC content, increases soil acidity and compaction, and



destroys the Andosol macro-aggregates; the chemical and physical properties that affect negatively the Andosol quality. The burning management system has mitigated influences on Andosols quality. The severe reduction of the soil organic matter and the CEC content, and the cations equilibrium imbalance in the burning management system affect negatively the Andosol quality. Inversely, the net increase of the sum of the exchangeable cations and the soil pH above 6, and the fairly high soil macro-aggregates abundance contribute to improve significantly the Andosol quality. The fallow management system globally improves significantly the Andosol quality. It is sustainable in term of the soil organic matter, the CEC and the sum of the exchangeable cations increase, and the soil macro-aggregates regeneration after the tillage management system practice. But, even 10 years of the fallow management system is not enough to regenerate efficiently the soil macro-aggregates and improve the soil acidity.

#### **EVALUATION OF THE MOST APPROPRIATE METHOD IN OROGRAPHIC RAINFALL DATA RECONSTRUCTION OF MBEERE DISTRICT USING GEOGRAPHICAL INFORMATION SYSTEM TOOLS FOR AGRICULTURAL DEVELOPMENT**

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In most water resources management and agricultural production studies in sub-Saharan Africa, the predominant problem in analyzing hydro-meteorological events are occasioned by either lack, inadequate or inconsistent meteorological data. Like in most other places, the rainfall data within Mbeere district and the neighboring stations are scarce and with missing data making their utilization a challenge. Mbeere district represents a semi-arid region with low potential in terms of agricultural production. The objective of the study was to determine the most appropriate geostatistical interpolation approach for spatial and temporal reconstruction of rainfall data in Mbeere based on the gauged data from the neighboring meteorological stations; and to come up with an updated monthly and annual maps. Rainfall data of the neighboring stations were acquired and captured in the Microsoft Excel spreadsheet where missing data gaps were filled through correlation functions derived from elevation versus recorded rainfall amounts. Linear functions were derived and fitted into the GIS environment tool combined with the digital elevation model (DEM) for orographic construction of monthly average maps starting from January 2001 to December 2008 using various interpolation techniques. The performance of the various interpolation methods were assessed using root mean square errors (RMSE), mean absolute errors (MAE) and correlation coefficient (R) statistics and utilizing rainfall data from specific research site for validation. Based on the study results, the Kriging technique was identified as the most appropriate Geostatistical and deterministic interpolation techniques that can be used in spatial and temporal rainfall data reconstruction in the region. Finally, based on the constructed data, updated average monthly and annual rainfall maps of Mbeere district were produced.



## **SOIL AND RAINSTORM SEQUENCE INTERACTIVE EFFECTS ON CRUST STRENGTH, STEADY STATE INFILTRATION RATE AND EROSION IN QUARTZ DOMINATED SOILS IN SOUTH AFRICA**

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The interactive soil and rainstorm sequence effects on surface hydrological processes are not completely understood. The current study investigated the interactive soil and rainstorm sequence effects on crust strength, steady state infiltration (SSIR) and erosion in soils dominated by quartz. Soils were collected from the top 200 mm from 14 sites, air-dried and sieved through a 2 mm mesh, packed into splash cups and pre-wetted, placed in a splash plate and exposed to 360 mm h<sup>-1</sup> simulated rainfall. The rainfall was applied either as a single or four intermittent storms separated by a 48 h drying period. Both site and rainstorm sequence had significant effects on crust strength, SSIR and erosion. Significant interaction effects were only observed for SSIR. Intermittent rainstorms resulted in higher crust strength and more 27% more soil loss compared to the single rainstorm regardless of the site. The effect of rainstorm sequence on SSIR depended on the site. The relationship was most influenced by quartz. Short duration and recurrent storms resulted in higher crust strength and soil loss compared to single storms of equivalent duration.

## **STATE OF SAHELIAN ECOSYSTEM IN TWO VILLAGES IN THE MARADI REGION, NIGER**

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The droughts of 1970 and 1980, bad practices in agriculture and livestock, and population pressure have led to the degradation of natural resources. The lands are degraded, soils are depleted and the tree canopy has disappeared in some areas of the Sahel. Some studies in the region show pockets of re-greening despite the ongoing debate on desertification and land degradation; this re-greening is due to the introduction of new practices in land management. Our study aims to show that some areas in the Sahelian ecosystem are breaking a vicious circle of land degradation. This study consists of an analysis of the dynamics of vegetation in 1975 and 2009 to evaluate the composition and structure of vegetation and assess the impact of this on soil properties in two villages in Niger. Our study shows that Warzou is the most greened of the two sites, especially with respect to small trees, although the level of diversification is lower than at the second site, Maysakoni. The soils at Warzou are also slightly more acidic than those in Maysakoni and the soil structure has been more fully retained. We can therefore say that the Sahelian ecosystems are stable and have capacity for resilience, allowing ecosystems to recover and break a vicious circle of land degradation in order to effectively fight against food security in some Sahel regions.



## **STATUS AND VARIABILITY OF SOIL MICRONUTRIENTS WITH LANDFORMS IN WESTERN USAMBARA MOUNTAINS, TANZANIA**

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A study was carried out in Western Usambara, Tanzania to appraise the status and variability of soil DTPA extractable micronutrients across three geomorphic units. 19 profiles were opened described and 54 samples were collected for laboratory analysis. Standard methods of analyses were used to analyse physical and chemical properties. Micronutrients Fe, Mn, Cu and Zn were extracted by DTPA and quantities estimated spectrophotometrically. Both field data and laboratory data were organized using MS-Excel and imported into Minitab, 2004 for further analysis. Descriptive and stepwise multiple regression analysis was done. 30 percent of the data sets were used for model training and the remaining 70 percent for analysis. Results show that DTPA extractable micronutrients Fe, Mn, Cu and Zn were variable. Fe had a range of 2.13 to 399.4 mg/kg, with a mean of 65.3 mg Fe/kg Mn ranged from 0.59 to 266.28 mg Mn/kg soil. DTPA extractable Cu ranged from 0.25 to 8.19 mg/kg soil with a mean of 2.975 mg Cu/kg soil. DTPA extractable Zn ranged from 0.08 to 19.6 mg/kg soil, with a mean of 1.162 mg Zn/kg soil. Generally, micronutrients decline with soil depth. It is concluded that Fe and Mn values were higher than critical levels. DTPA extractable Cu levels were recommended within critical levels whereas Zn was deficient some soils. There were within soils and between pedons (Plain, Escarpment and Plateau) variability. Physical-chemical properties could be used to estimate soil DTPA extractable micronutrients by 92%, 75% and 51% for iron, copper, zinc and manganese respectively.

## **SUBSOILING AND SOIL SURFACE MANAGEMENT EFFECTS ON MAIZE PRODUCTIVITY IN THE CENTRAL HIGHLANDS OF KENYA**

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Soil management can notably influence crop production under rainfed farming systems in semiarid areas. The central highlands of Kenya, which produce about 20% of the country's maize, cover both areas with high and low potential for crop production because of rainfall amounts and reliability. To increase crop yields, and reduce production risks, better use of available rainfall is required. The objective of the study was to evaluate the effect of soil surface management strategies with or



without subsoiling and their interaction on maize productivity under erratic rainfall conditions. The trial followed a  $2 \times 3$  split-plot design replicated thrice in randomized complete blocks. The main factors were; with or without subsoiling while the sub factors were three soil surface modification methods; i) mulching, ii) cover crop (cowpeas) and iii) bare (control). Seasonal soil-moisture, phenological stages' durations, grain and biomass yields were key parameters. Analysis of Variance was used for analysis and the differences between treatment means were examined using least square difference at 5% level of significance. The trial results showed that, relative to cover crop without subsoiling treatment interaction, subsoiling led to 200 and 228% increase in maize grain yields during the short rains season of 2009 and long rains season of 2010 (LR10) respectively (significance  $p=0.05$ ). The grain performance was inversely related to the soil moisture content at 30 cm depth. Subsoiling in interaction with cover crop treatment showed consistently low soil moisture content throughout the two seasons while mulching irrespective of with or without subsoiling was consistently high throughout the two seasons. The low soil moisture content in the un-subsoiled treatment was probably due to inaccessibility of roots to the deeper horizons of the soil profile. The inverse relationship especially after subsoiling was due to enhanced root penetration and soil water uptake that led to healthier and leafier crops hence higher water uptake through transpiration leading to depressed soil moisture content. The study highlighted the importance of subsoiling and soil surface modification as a key farm management practices that have direct impact on maize productivity under erratic rainfall conditions.

## VARIATION OF NUTRIENT CONTENT IN SOILS OF SOUTH KIVU, DR CONGO

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Quantification of soil nutrients of smallholder's farms is important to understand and design sustainable soil-crop management decisions. To standardize procedures in establishing a regional framework for degradation surveillance and diagnoses of soil health constraints, *Africa Soil Information Service (AfSIS)* approach was used. Two sentinel sites, Burhale (2.700°S, 28.632°E) and Luhihi (2.305°S, 28.858°E) were concerned by this study and each one is extended over 100 km<sup>2</sup> (10km x 10km). Based on the *dorsale du Kivu* soil map, the two sentinel sites are laid on Ferralsols. The aim of this study was to assess the variability of soil nutrient content within two AfSIS sentinel sites in south Kivu. This information will be used in combination with diagnostic trials to design integrated soil fertility management technologies for this area. Each sentinel is divided into 16 equal clusters and each cluster is divided into 10 plots. From these plots 534 composite soil samples were taken at two different depths; top soil (0-20cm) and sub soil (20-40cm) in cultivated and uncultivated land.



All samples were analyzed using NIR spectroscopy, while 10% of samples have been analyzed by traditional chemical methods. Soil chemical properties include pH and soil salinity and sodicity, available phosphorus (P) and potassium (K), exchangeable calcium (Ca) and magnesium (Mg), micronutrients and organic matter. Micronutrients include available Boron (B), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu). Sulfur (S) and aluminum (Al) are considered separately. Organic matter status includes organic carbon (C<sub>org</sub>), inorganic carbon (C<sub>inorg</sub>), and total nitrogen (N). Results show that the whole area is acid. The topsoil pH average was  $4.6 \pm 0,34$  in agricultural land in both sites. Cultivated lands are more depleted in nutrients and seem to be more degraded than uncultivated land. Luhihi sentinel site is richer in most nutrients than Burhale, e.g. nitrogen, phosphorus and potassium. Phosphorus deficiency is acute for Burhale ( $2.43 \pm 3, 47 \text{ mg P kg}^{-1}$ ), but less for Luhihi ( $5.36 \pm 4,6 \text{ mg P kg}^{-1}$ ). In both locations, low levels of exchangeable Ca ( $<4 \text{ cmolc kg}^{-1}$ ) and Mg ( $<2 \text{ cmolc kg}^{-1}$ ) were found. Soil organic matter levels were also higher in cultivated plots in Luhihi ( $3.9 \pm 0.4\% \text{ C}$ ) than in Burhale ( $3.0 \pm 0.4\% \text{ C}$ ). All together this shows that soil fertility has declined more in the Burhale than Luhihi site. This is probably due to, not only farming systems but also, soil forming parent material which is different in the two sites. Finally high soil nutrients variations were found between different clusters in one sentinel site. Nitrogen average in Burhale (mean  $0,24 \pm 0,10\%$ ) was  $0,30 \pm 0,14\%$  in cluster 5 while it was  $0,10 \pm 0,05\%$  in cluster 6.

## SOIL INFORMATION TO SUPPORT SUSTAINABLE FOOD SECURITY IN AFRICA

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Crop performance and response to management are explained through yield gap analysis and codetermined by soil conditions. Agricultural productivity is limited by soil fertility and the response to soil fertility management is limited by soil water availability. Appropriately scaled soil information permits to extrapolate measured soil-specific response to management from a limited range of experimental site conditions to the wide range of environmental conditions that prevail on the agricultural land using models. The necessary information is being compiled at an increasingly fine resolution through various collaborative international frameworks, considering both historic and newly collected primary soil profile data. The Africa Soil Profile database compiles historic soil data for over 16,000 profile records. These represent only a portion of all the soil profile data that have been collected and documented over decades for the continent. Collaborative efforts are needed to develop comprehensive appropriate data and data analysis tools.



## **SOIL ORGANIC CARBON STOCKS AT DIFFERENT ELEVATIONS IN THE MIOMBO WOODLANDS OF KITONGA FOREST RESERVE, TANZANIA**

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This study was thus conducted to assess SOC at different soil depths and elevations in selected sites of the miombo woodlands of Kitonga Forest Reserve (KFR). Ten sampling points located at different elevations were selected, georeferenced and at each point three randomly selected mini-soil pits were excavated for soil sample collection. Samples from different horizons up to 60 cm depth were collected and composited from three replicates. SOC was analyzed using the wet oxidation method. The mean SOC stock increased from 15.2 to 26.7 Mg ha<sup>-1</sup> respectively at 928 and 1548 masl in the case of Fluvisols, and from 11.3 to 44.9 Mg ha<sup>-1</sup> respectively at 1258 and 1598 masl in Cambisols. Conversely, SOC stocks decreased with elevation in Leptosols and the trend was 28.9 to 12.5 Mg ha<sup>-1</sup> at 831 and 1083 masl, respectively. The mean topsoil SOC stock was 26.3±5 Mg ha<sup>-1</sup> in Fluvisols, 19.4±7 Mg ha<sup>-1</sup> in Cambisols and 26.1±7 Mg ha<sup>-1</sup> in Leptosols. SOC stocks at 30 cm depth decreased by 56%, 41%, and 31% when compared to those of top soils in Fluvisols, Leptosols and Cambisols, respectively. The higher amounts of SOC stocks at the surface horizons justify the need for conservation of intact miombo woodlands vegetation.

## **CHARACTERIZATION OF SOME SOILS OF THE MIOMBO WOODLANDS ECOSYSTEM OF KITONGA FOREST RESERVE, IRINGA, TANZANIA: PHYSICOCHEMICAL PROPERTIES AND CLASSIFICATION**

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Understanding the soil types of an area is the basis for sustainable soil use and management. Miombo woodland soils have significant implications in global climate change processes. Few studies have characterized and classified the soils of the miombo woodland ecosystem of Tanzania. The current study was carried out to map and classify soils of the Kitonga Forest Reserve, which is a typical miombo woodland ecosystem, in order to generate relevant information for use and management by stakeholders. The dominant soil types of the miombo woodland ecosystem of



Kitonga Forest Reserve were characterized and classified using standard soil survey methods. Ten soil profiles were excavated and described using standard methods to represent soils of the mapped area. Standard laboratory soil physical and chemical analyses were carried out to enable classification of the soils. According to the World Reference Base (WRB) for Soil Resources system the soils were classified as Cambisols, Leptosol and Fluvisols. In the USDA Soil Taxonomy the soils were classified as Inceptisols and Entisols. Different soil types differed in physicochemical properties, hence exhibit differences in their potentials and constraints for management and use. Topographical features played a very important role in soil formation. Sustainable management of miombo woodlands ecosystem soils requires reduced deforestation and reduced land degradation. The information obtained would be useful in planning management strategies of miombo woodlands ecosystem with similar ecological conditions.

### **RESOURCE USE EFFICIENCY IN RICE BASED FARMING SYSTEMS: A CASE OF UPLAND AND PADDY RICE IN NAMASAGALI SUB-COUNTY KAMULI DISTRICT**

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Rice is one of the most important cereal crop grown in Uganda particularly in the eastern region. This crop is produced throughout the country under diverse environments that include both uplands and wetland areas. Therefore the study focuses on the efficiency of rice growing with concerns on wetlands conservation, ensuring of food security in addition to identifying the factors that determine efficiency of rice production in Namasagali sub-county. Primary data was collected from three parishes in this sub-county; yield surveys were also collected from rice farmers as well as from experiments ran. Secondary data was collected from internet and research centers. Cost benefit analyses were made to estimate the potential of upland rice conserving wetlands. For food security a comparison was made between upland rice yields and the quantity of maize consumed in a year depending on the findings of Isabirye (2005). The study also employed a logistic regression to find the factors determining the technical efficiency of rice growing and the Cobb-Douglas production function model was used to determine the level of technical efficiency of the rice farmers in Namasagali sub-county and it was revealed that out of the 11 factors assessed, 7 of them were found to crucial as regards technical efficiency of rice production and these include; education level, farmers' experience, motive of the farmer, family size, labour, use of ox-plough, land size devoted to rice cultivation were found to be significant at 5% level of significance. However, factors like rice type, fertilizers application, gender, land ownership were discovered to be insignificant in determining technical efficiency in the area. In addition it was found that land size devoted to rice cultivation was the most significant factor determining technical efficiency of rice cultivation in the area. The Cobb-Douglas results exhibit that the farmers in Namasagali sub-county are generally technically inefficient due to decreasing returns to scale of production, implying that key factors of production are over-utilized. It is therefore recommended that farmers should shift to upland



rice cultivation especially NERICA 4 the high yielding one so as to ensure wetlands conservation and food security, in addition to sensitization of farmers about the wetlands values. In addition farmers were called upon to adopt modern farming practices, in addition to intensification of agricultural extension services so as to improve on technical efficiency.

### **LIVESTOCK, BANANA AND LIVELIHOODS: A CASE OF BANANA AND SEDENTARY PASTORALISM IN THE WESTERN SHORELINE OF L. VICTORIA, UGANDA**

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Shrinking of grazing land and the expansion of banana plantations are key land use changes that threaten the sustainability of land resources in the Western shoreline of Lake Victoria. An integrated approach to land evaluation that examines the suitability of selected land utilization types and their impact on soil nutrient budget was used to evaluate the suitability of land resources for rainfed bananas and livestock grazing at low, intermediate and high input levels. Arable soils in the western shoreline are suitable for crop production; however, sustainability is threatened by the low levels of nutrient inputs. Consequently most of the low input land utilization types are associated with negative nutrient balances. Livestock is not profitable and the situation is likely to be worsened by the continued shrinkage of grazing area. As such, land degradation is on the increase due to the above optimal stocking rates. At intermediate input level of banana production, about 5 ha are needed to support a household of 6 that fully depends on farm income for survival.

### **DIAGNOSIS OF SOURCES OF SOIL SALINIZATION IN SELECTED IRRIGATION SCHEMES IN SEMI-ARID LANDS OF TAITA TAVETA COUNTY-KENYA**

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Investigations were carried out in five irrigation schemes in Taita Taveta County to diagnose the extent of soil salinization to develop effective management strategies for enhanced crop productivity and food security in irrigation schemes where crop yields were declining due to soil salinity encroachment. The research involved sampling irrigation waters from the sources, soil from irrigation schemes and testing strategies to minimize soil salinization and increase maize grain yields. Water analysis showed water from Kasokoni (1119.9  $\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 3.92 me/l), Rama springs (1363.75  $\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 5.75 me/l ) and Kimala canal ( 1328.67  $\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 4.59 me/l.), which originates from river Lumi, were significantly ( $p \leq 0.05$ ) saline. Water from Njukini (279.2  $\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 0.66 me/l), Challa (386



$\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 1.16 me/l), Njoro Kubwa (244.4  $\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 0.632 me/l), Grogan springs (377  $\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 0.73 me/l.) and Lumi springs (207  $\mu\text{S}/\text{cm}$  and  $[\text{Na}]$  of 0.387 me/l) before joining Kasokoni springs were not saline. Kamleza-Kimoringo soils irrigated with water from Njoro Kubwa, of low salinity, were found to be significantly ( $p \leq 0.05$ ) more saline (Ece 1.66 mS/cm) than other soils from other schemes whose Eces were generally below 0.56 mS/cm. These soils were at the lowest part of the irrigation schemes near Lake Jipe and had a clay texture and significantly ( $p \leq 0.05$ ) more soluble salts ( $\text{Ca}^{2+}$  20.97 me/100g soil). Soil pH, Ece,  $[\text{Na}^+]$  and  $[\text{Ca}^{2+}]$  did not vary with soil depth. It was concluded that the salts could have been deposited through runoff for most of the irrigation schemes and or left by the retreating nearby Lake Jipe for Kamleza-Kimoringo irrigation scheme soils. However the irrigation water has potential for salinization. Manure application at 20t/ha increased maize grain yield 0.55-4t/ha at Kimala scheme.

### EFFECTS OF AGRICULTURAL LAND USES ON PHOSPHORUS FRACTIONS AND AGGREGATION OF WETLAND SOILS IN EAST AFRICA

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Conversion of natural wetlands to cropped land can have significant impacts on the transformation of soil aggregates and associated nutrients, including soil phosphorus (P). However, little is known about the changes in P fractions in wetland systems, or the fate of aggregate fractions due to conversion of unused wetland areas to cropped systems. We hypothesized that conversion of natural wetland systems will result to changes in the size of P pools and aggregate fractions associated with SOM and that these changes will be determined by the soil type and land use. Our objectives were to evaluate the effects of land use changes on: - (1) the proportions of soil P fractions; (2) the size and proportion of water stable aggregates in two different wetlands in East Africa. The wetlands comprise an inland valley in the highlands-Karatina (1700 masl) and a floodplain in the lowlands-Korogwe (320 masl). Land use treatments included the natural unused sites which were dominated by *Cyperus spp*; the cropped fields under anaerobic and aerobic soil conditions and abandoned sites under fallow vegetation. Results indicated that conversion from natural systems to aerobic, anaerobic or abandoned fallow affected soil P fractions and the stability of soil aggregates. The floodplain soils responded sensitively to intensified land use with pronounced decreases in soil aggregate stability, the availability of labile P-fractions, and the supplying capacity of stable P-fractions. The inland valley showed higher contents of available P and stable P, while the stable P stocks in the floodplain were apparently depleted quickly. This may imply that the conversion of wetland systems to cropped systems could have significant alterations of soil P fractions and the aggregate fractions associated with organic matter unless strategies to increase the organic matter level and hence improved aggregation and mineralizable nutrients are put into consideration.



## SOIL FERTILITY EVALUATION FOR COFFEE (*Coffea arabica*) IN HAI AND LUSHOTO DISTRICTS, NORTHERN TANZANIA

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A study was conducted in Hai and Lushoto districts, Northern Tanzania to assess the soil fertility status against the soil fertility requirements for Arabica coffee. A total of 116 auger sites and 10 pit profiles were described, and soil samples analyzed for the key fertility parameters. Two approaches were used in assessing the fertility of the soils. The qualitative approach assigned fertility scores according to the soil fertility requirement of coffee. In the quantitative approach, the total available forms of N, P and K were calculated using soil pH, organic carbon, total N, available P and exchangeable K, and the total number of soil-available nutrient equivalents per ha used as an indicator of soil fertility. Spatial analysis and interpolation of important fertility attributes was also done. Soil fertility was proved to be considerably low in the study areas. Some interesting similarities and differences were observed among the analytical parameters studied. Most of the observations were explained from either the topography of the area or the farming practices common in the area. Options for improving soil fertility in the two districts are discussed.

## STAKEHOLDERS' DIVERGING INTERESTS AND EMERGING RESOURCE USE CONFLICTS IN APICULTURE IN WEST USAMBARA MOUNTAINS, TANZANIA.

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Over the past decades, increased population and stakeholders' divergent interests have put excessive pressure on natural resources (NRs) leading to over exploitation, degradation and resource use conflicts. Degradation of NRs particularly forests has contributed to progressive decline in resource productivity, reflected in declining forest products, reduced water quantity and quality and crop and livestock yields. Addressing these critical issues has called for an assessment and analysis of stakeholders' divergent interests at local level in order to draw lessons for guiding conservation of NRs efforts in hot spot areas. It is in the context of this thinking a study was conducted in West Usambara Mountains, Tanzania to assess stakeholders diverging interests and emerging resource use conflicts in apiculture with respect to natural resource management (NRM) by local communities. The study aimed at generating knowledge base for effective governance of NRM by farmers from which

lessons could be drawn for guiding appropriate NRM endeavours in the study area and others with similar environmental conditions. Participatory Rural Appraisal (PRA) tools including focused group discussion, questionnaire survey and participant observation were the methods used for data collection from 98 respondents randomly selected. Data collected were analysed using descriptive and inferential statistical analyses. The study identified five major land use types with varying community management practices, largely attributed to community's social economic divergent interests. With regards to apiculture, majority of individual small scale farmers (73%) were driven by social economic interests than NRM. On the hand, farmers' groups (10%) showed high interest in both economic and conservation of natural resources followed by faith based organisations (FBOs) (7%). Stakeholders' diverging interests in apiculture were significantly influenced by educational level ( $p=0.010$ ); household size ( $p=0.006$ ); marital status ( $p=0.011$ ) and major economic activities ( $p=0.029$ ). The most prevalent conflicts in the study area were between farmers practising apiculture and fellow farmers (74%) followed by neighbours (16%). The identified resource use conflicts in apiculture were significantly influenced by the level of interest ( $p = 0.025$ ) and age ( $p = 0.032$ ) of the respondents at  $p<0.05$ . The study demonstrated that for small scale farmers to engage in NRM, economic interest is vital. The study recommends that efforts should be directed towards promotion of apiculture as an economic incentive for sustainable NRM. A stepped up and focused approach for mobilization of small scale farmers as beekeepers coupled with establishment of a coordinated framework for NRM is strongly recommended.

## ECONOMICS OF MAIZE-LEGUME PRODUCTION IN WESTERN KENYA

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Maize and grain legumes are the dominating enterprises in western Kenya. Whilst maize provides the backbone to food security, grain legumes are multi-functionally sources of household protein, fix atmospheric nitrogen to the soil and provide livestock feed. The yield of maize on smallholder farms is typically  $0.5 \text{ t ha}^{-1}$  compared to about  $7 \text{ t ha}^{-1}$  obtainable under research, mainly due to low soil fertility and *Striga* weed. Against this backdrop, during long rain seasons in the years 2010 and 2011, a total of 24 on-farm demonstrations were set up to disseminate Integrated Soil Fertility Management (ISFM) in four districts in western Kenya. The demonstrations were designed in a Randomised Complete Block Design (RCBD) involving four treatments: 1. Maize-bean; 2. Maize-soybean, 3. Sole maize (control) and 4. Maize-groundnut intercrops. The objectives of this study were twofold: to evaluate effect different maize-legume intercrops on maize and legume grain yields; and to analyse costs and benefits of the maize-legume intercrops. Data were collected on maize and legume yields, quantities of inputs applied and prices of both inputs and outputs. The data were evaluated by Analysis of Variance (ANOVA) and cost-benefit analysis. Results showed that the highest maize grain yields ( $4.8 \text{ t ha}^{-1}$ ) were obtained from maize-bean, followed by maize-groundnut ( $4.7 \text{ t ha}^{-1}$ ). Amongst



the legumes, soybean gave highest grain yield ( $0.5 \text{ t ha}^{-1}$ ). The highest benefit-cost ratio of 2.5 was obtained from maize-bean intercrop and the lowest (1.9) was from sole-maize mainly because beans had the highest demand and market price per unit. The findings of this study point to the need to develop policies that promote smallholder farmers' access to efficient input and output markets.

## **THEME IX: SCALING SOCIO-ECONOMIC AND POLICY OPTIONS IN LAND AND WATER MANAGEMENT**

### **COMMON BEAN VALUE CHAIN ANALYSIS AND DEVELOPMENT FOR IMPROVED LIVELIHOODS IN THE CENTRAL HIGHLANDS OF KENYA**

**Bett E.K., Mugwe J.N., Ayieko D.M and Macharia J.**

Majority of the rural population in Sub-Saharan Africa (SSA) and Kenya in particular derive their livelihoods from agriculture. Common beans are the most important legume crop in Kenya. It's a major source of protein, fibre, complex carbohydrates and micronutrients (Iron and Zinc), natural soil replenishment and good income potential. Consequently, it presents a potential rural poverty exit strategy. However, several constraints curtail this potential. Key among the constraints facing this sub-sector are disorganized markets characterized by limited opportunities due to inexistent or poorly developed market infrastructure, geographical remoteness and lack of effective farmer-based marketing groups. Additionally, unlike other high value cash crops like coffee, there is much less private sector-led investment in the beans value chain. The objective of this study was to carry out value chain analysis of dry beans sub sector in order to determine an upgrading strategy. The study focused on mapping the key value chain actors, market opportunities, constraints, opportunities, relationships and linkages and the findings used to develop an intervention strategy. Data was collected using semi structured interview schedules and checklists from stakeholders who included farmers, wholesalers, retailers, assemblers, agro input dealers and producers. Results showed that the cost of input and transportation were some of the factors limiting beans production. The most commonly used inputs for beans production were seeds and fertilizers. Farmers did minimal processing before marketing. These included threshing, drying, sorting, grading, dusting, and packing. Most farmers did not sell beans due to low production. A few farmers sold to national market, while some sold individually to the wholesalers in bulk and at a high price. A major recommendation emanating from this study is that there is need to build more capacity for all the actors in the beans value chain so as to stimulate the flow of the commodity along the value chain.



## **FARMERS PERCEPTION ON CHANGES IN NATURAL RESOURCE BASE AT KATHEKAKAI SETTLEMENT SCHEME, MACHAKOS DISTRICT, KENYA**

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This study analyzed changes in natural resources in Kathakakai settlement scheme, Machakos District using participatory resource mapping and attempted to discuss possible effects. The area, which was a ranching enterprise for nearly a hundred years, was sub divided in 1995 into individual farm holdings with average farm size of 2.5 hectares per household. Individual farmers opened-up the land for agricultural activities and other land developments. The results show that natural resources have decreased since the ranch became a settlement scheme in 1995. Farmers indicated that the natural forests have decreased and have been replaced by exotic trees, vast land was cleared for cultivation, rivers, and dams have since dried-up while soil erosion has increased. A majority of farmers (98%) said they had observed a general change in the climate of the area. They cited declining crop production (29%), increased drought (15%), and increased temperatures (10%) as some of the major pointers to climate change. However, farmers adopted various adapting and coping strategies. Drought tolerant crops (25%), early maturing crops (17%), and water harvesting (14%) were some of the strategies adopted by farmers in response to cope with the emerging changes. The results also show that resource base management at the community level is still a challenge and a lot of investment needs to be done in this field for sustainable management.

## **RHIZOBIUM INOCULANT (BIOFIX®) PRODUCTION TECHNOLOGY - A SUCCESS STORY**

**<sup>1</sup>Muriuki E.M., <sup>2</sup>Wafullah T.N., <sup>2</sup>Karanja N.K., <sup>2</sup>Gachene C.K.K. and <sup>3</sup>Ndegwa D.M.**

MEA Limited is a private company involved in fertilizer production and distribution. MEA Limited has soil testing and BIOFIX® production facilities.

University of Nairobi (UoN) is the oldest centre of excellence and research in Kenya and developed Rhizobium inoculant technology in 1977 but unfortunately the technology had not reached most of the farmers due to inadequate production capacity and marketing channels.

The British Council (BC), under the African Knowledge Transfer Partnership (AKTP), was able to link UoN and MEA where the former agreed to transfer the technology to the latter in order to enhance production and improve accessibility by farmers.

Due to growing global demand for organically grown food and conservation of land and water resources, BIOFIX® aims to promote soil conservation through increased Biological Nitrogen Fixation (BNF) and at the same time enable small holder peasant farmers acquire affordable and quality biofertilizer for their cereal legume crops such as soybean, common bean, groundnuts, green grams and fodder crops such as Lucerne and desmodium. This will result to an increase in soil nitrogen (N) and



increased yields leading to improved livelihoods of farmers. To improve accessibility of BIOFIX<sup>®</sup>, MEA Limited has recruited agro dealers in rural trading centres, spread across the country that purchase the product at wholesale prices and retail the same to farmers. The partnership between MEA and UoN demonstrates how research technologies developed in universities and research institutions could be packaged in collaboration with private institutions in order to benefit farmers and which should be encouraged throughout the continent. The above partnership if embraced by both public and private institutions would see our continent achieve significant growth in agricultural development.

## **THE CASE FOR AN INTEGRATED APPROACH TO FOOD SECURITY, ECOSYSTEM MANAGEMENT AND SUSTAINABLE LIVELIHOOD IN ASALS**

**Mbugutha N.M. Poster Presentation**

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Kenya is expected to feed 30 million more people, between now (2013) and the year 2030 when her population is estimated to reach 73 Million people<sup>i</sup>. The role of agriculture, as the mainstay of the economy, in supplying enough food supply, sustaining the creation of industry and attendant services that are needed to transform Kenya into middle income status is, therefore, critical to success. The combined force of population growth, sub-division of land, over exploitation of the natural resources that leads to land degradation in the high potential areas and outright desertification in the ASALs is a critical constraint. Land degradation is defined as the temporary or permanent lowering of the productive capacity of land (UNEP, 1992b). It thus covers the various forms of soil degradation, adverse human impacts on water resources, deforestation and lowering of the productive capacity of rangelands. It is also defined as the long term loss of ecosystem function and productivity caused by disturbances from which the land cannot recover unaided. An integrated approach that seeks to improve food security, ecosystem management and sustainable livelihoods should be considered in building capacity among communities, particularly those living in ASALs, in land and water management. Its holistic focus lends itself well to addressing the myriad of challenges facing these vulnerable communities. By leveraging the mixed farming practices that most rural communities know and trust, while introducing new methods and technologies that will increase production, productivity and the capacity to better manage the natural resource base, this approach compliments what is on the ground and is not overly disruptive. Africa Harvest has implemented this approach in the ASAL areas of Makueni and Kitui Counties, since July 2010 to date, and below are the lessons learnt to inform future activities.



## **LAND AND WATER RESOURCES MANAGEMENT IN NKAMBE HIGHLANDS-CAMEROON: CHALLENGES AND PERSPECTIVES**

**Nfor J.T., Achankeng U.B and Maurice E.T.**

**University of Dschang; Department of Geography - Cameroon; E-mail: jtnfor2007@yahoo.com.**

In Africa, access to land and fresh water is becoming crucial in most rural and urban centers. This is evident as several rivers and lakes have undergone marked reduction in flow rates and surface area while land is available only to the privilege few. Land and water resources are constantly threatened by anarchy in land use and climate variability respectively. In the western highlands of Cameroon in general and Nkambe highlands in particular, this situation has accelerated the migration of agro pastoralist into marginal lands and agricultural production most especially market gardening is highly affected. In the face of persistent water stress and land degradation that continue to make life unbearable for agro pastoralist in the study area, the paper has as objective to assess how effective is the socio-economic and policy options adopted by the government, council, local population and civil society organizations to ensure sustainable land and water resources management. To attain our objective, the hypothesis considered was that the government, councils and civil society organizations have been playing a major role to enhance the sustainable management of land and water resources. To verify the validity of the above hypothesis, semi-structured and structured questionnaires have been used to sample the opinion of 100 respondents on how effective are the land and water resources management options adopted by the State and stakeholders. From data analysis, the main results were as follows; the government, council and civil society organizations have been doing their best to ensure the sustainable management of land and water resources through the application of institutional and legal provisions, appropriate technology, private sector participation, community participation, partnerships and fund raising, agroforestry techniques. However, the efforts of the state and stakeholders are limited by political, institutional, socio-economic and climatic constraints.

## **STAKEHOLDERS' DIVERGING INTERESTS AND EMERGING RESOURCE USE CONFLICTS IN APICULTURE IN WEST USAMBARA MOUNTAINS, TANZANIA**

**<sup>1</sup>Kimaro D.N., <sup>1</sup>Sinyangwe J., <sup>2</sup>Mbeyale G.E., <sup>2</sup>Kajembe G.C. and <sup>3</sup>Mogaka H.**

**<sup>1</sup>Department of Agricultural Engineering and Land Planning, Sokoine University of Agriculture, P.o Box 3003 Morogoro, Tanzania. <sup>2</sup>Department of Forest Management and Mensuration, Sokoine University of Agriculture (SUA), PO Box 3013, Morogoro, Tanzania. <sup>3</sup>Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Natural Resource Management and Biodiversity Programme, P.O. Box 765, Entebbe, Uganda. \*Corresponding author Email: [didas\\_kimaro@yahoo.com](mailto:didas_kimaro@yahoo.com).**

A study was conducted in West Usambara Mountains, Tanzania to assess stakeholders diverging interests and emerging resource use conflicts in apiculture



with respect to natural resource management (NRM) by local communities. The study aimed at generating knowledge base for effective governance of NRM by farmers from which lessons could be drawn for guiding appropriate NRM. Participatory Rural Appraisal (PRA) tools including focused group discussion, questionnaire survey and participant observation were used for data collection from 98 respondents randomly selected. Data collected were analysed using descriptive and inferential statistical analyses. Results show that majority of individual small scale farmers (73%) were driven by social economic interests than NRM. On the other hand, farmers' groups (10%) showed high interest in both economic and conservation of natural resources followed by faith based organisations (FBOs) (7%). Stakeholders' diverging interests in apiculture were significantly influenced by educational level ( $p=0.010$ ); household size ( $p=0.006$ ); marital status ( $p=0.011$ ) and major economic activities ( $p=0.029$ ). The most prevalent conflicts in the study area were between farmers practising apiculture and fellow farmers (74%) followed by neighbours (16%). The study demonstrated that for small scale farmers to engage in NRM, economic interest is vital. Recommendations on areas of further intervention are given.

#### **FARMERS' PERCEPTION OF CONSERVATION AGRICULTURE IN LAIKIPIA EAST DISTRICT IN KENYA**

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Agriculture sector contributes about 24% of Kenya's, GDP. Small scale farmers provide 75% of the labour force and 75% of the market output produce. Both land degradation and adverse climatic conditions threatens sustainable food production by small scale farmers. However, land degradation has decreased land resilience thereby exacerbating the effects of droughts. Conservation agriculture (CA) has the potential to contribute in addressing the challenge of adapting agriculture to land degradation and adverse climate. Adoption of a technology depends on several paradigms among them the perception paradigm Perceptions are influenced by factors such as culture, education, gender, age, resource endowments and institutional factors. Laikipia East district is arid semi arid area with the average yearly rainfall is 750mm, but the distribution is very unequal, and rain-fed agriculture is the predominant activity. Soil degradation is common due to unsustainable agricultural practices such as intensive tillage. The data was collected using 130 questionnaires in seven locations. The data was analyzed using SPSS version 16. Most of the farmer derive their livelihood on farm 75%, The level of education and gender influence farmers perception to CA with female and higher education lever with higher perception towards CA. Land ownership influence farmers perception to CA with higher positive perception in farmers with own land



compared to the ones leasing land. There is competition for crop residue between surface cover and livestock feed which negatively affect farmers' perception to CA. Farmers associate CA with herbicides that portrays CA as expensive. Socio-economic factors have influence on farmers' perception to CA.

## **CLIMATE CHANGE IMPACTS AND COPING/ADAPTATION STRATEGIES IN YATTA DISTRICT, MACHAKOS COUNTY IN SEMI-ARID EASTERN KENYA**

**Gatheru M., Gichangi E., Njiru E.N. and Mungube E.O.**

A study was carried out in three purposively selected divisions of Yatta district, Machakos county in semi-arid eastern Kenya. The three divisions selected were Katangi, Ikombe and Yatta. The study used data collected from 200 households through a survey during the month of July 2012. Data was collected through interviews using a structured questionnaire. The data were used to assess farmers' exposure to climate-related shocks and coping strategies, perceptions of climate change and climate change impacts, adaptation strategies and constraints to adaptation. The data collected was analysed through descriptive statistics using the Statistical Package for Social Sciences (SPSS) version 12.0. The study showed that drought is the key climate-related shock with 100% of households reporting that they had experienced drought. Erratic rainfall ranked second in importance, with 99.5% of households experiencing this climate shock. Floods affected a small share (5%) of households in the study area. The main effects of climate-related shocks were a reduction in crop yield (96%) and death of livestock (91%). Other effects reported by farmers include loss of entire crop (89%), food price increases (88%) and loss of income (86%). Purchasing food was the main coping strategy in response to climate-related shocks. The most common adaptation (long term) strategies in response to climate change in the district were growing of drought escaping crops, water harvesting and change of crop varieties. The community ability to adapt to changing climate is constrained by many factors including lack of resources, lack of water, lack of access to inputs and lack of information on climate change and appropriate adaptation. Development of water systems for irrigation, easy access to inputs, provision of climate change information and appropriate adaptations, and provision of credit facilities were government interventions the community thought would enhance adaptation to climate change.

## **FARMERS' UP-TAKE RESPONSE TO SOIL FERTILITY MANAGEMENT PRACTICES DISSEMINATED BY THE NATIONAL AGRICULTURAL RESEARCH ORGANIZATION (NARO), PALLISA DISTRICT, EASTERN UGANDA**

**\*Otim M., Kyazze F. and Isubikalu P.**

**School of Agriculture and Environmental Sciences, Makerere University, P.O. Box 7062 Kampala. \*Corresponding author Email: [macleansotim@gmail.com](mailto:macleansotim@gmail.com).**

Soil fertility in Sub Saharan Africa is the major cause of decline in crop yields per unit area, resulting in food insecurity and poverty in the region. This problem has many dimensions and to tackle it, there is need to understand those different dimensions. This study focused on understanding different practices farmers have



used to maintain soil fertility over the years, what have changed to these practices down the years, how different methods of disseminating research recommended soil fertility management practices influence their uptake/adoption by the target beneficiaries. Focus group, individual discussions accompanied with field observations and a survey among participants in the training were methods used for data collection. Qualitative and quantitative data were analyzed by content and using SPSS software respectively. Results: crop rotation, maintaining grass strips in between plots; rotation of kraals, land fallow, returning residues to the field were the indigenous practice used. These have undergone a lot of changes over time and become ineffective. Of the 4 introduced practices, use of animal manure was most adopted, followed by inorganic fertilizers. Use of mother-baby approach worked better for farmers than use of print materials in promoting uptake of use of soil practices. Major constraints to the application of these practices by the beneficiaries include: poor accessibility/scarcity, high labor and monetary costs involved, droughts, poor handling and transportation facilities (for animal manure) and low farm gate prices of farm products. Conclusions: indigenous methods are being abandoned due to growing land shortage; dissemination methods that involve hand-on training are most preferred by farmers; uptake of introduced practices, especially inorganic fertilizers and animal manure is most constrained by low and unstable farm-gate prices, drought, inaccessibility, high monetary and labor costs involved and limited capital aggravated by lack of saving culture and poor prioritization. Therefore, farmers should adopt an integrated soil management approaches, and policies that facilitate application of ISFM should be in place, soil information dissemination should take a more practical approach like in the case of mother-baby. Sensitization of farmers on the value of sharing soil information and mechanism for reward be put in place.

#### **MAKING FARMER RECOMMENDATIONS FROM EXPERIMENTAL DATA: A CASE STUDY OF GUCHA AREA OF KISII COUNTY**

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Studies have shown low soil nutrient levels in the Lake Victoria Basin, attributing this to inappropriate soil and water resource management methods used. Organic and inorganic fertilizers are recommended but farmers need to get economically viable fertilizer options for increased benefits. A study was carried out in Gucha District, one of the severely degraded areas in the Lake Victoria basin, to determine fertilizer options that are economically viable to small scale farmers. On-farm trials were conducted with different levels of organic and inorganic fertilizers. The organic fertilizers gave high yields. However by use of the marginal rate of return the results showed that the use of DAP, CAN and Mavuno gave economically viable results. The results also showed limited options for farmers in their prevailing circumstances.



## **ENSURING FOOD SECURITY BY PROMOTING UPTAKE AND SCALING UP THE APPLICATION OF AGRICULTURAL LIME TO COMBAT SOIL ACIDITY IN KENYA**

**<sup>1</sup>Kimani S.K., <sup>2</sup>Kihanda F.M., <sup>3</sup>Mbakaya D.S., <sup>1</sup>Miriti J.M., <sup>1</sup>Lekasi J.K and <sup>1</sup>Njeru P.M.**

**<sup>1</sup>Kenya Agricultural Research Institute, Muguga South, P.O. Box 30148, Nairobi, Kenya. <sup>2</sup>Kenya Agricultural Research Institute, Embu, P.O. Box . <sup>3</sup>Kenya Agricultural Research Institute, Kakamega, P.O. Box 30148, Nairobi, Kenya**

Soil acidity is rapidly becoming a problem in our Kenya. Acidic soils create production problems by limiting the availability of some essential plant nutrients and increasing that of the soil solution's toxic elements, such as aluminum and manganese, the major cause of poor crop performance and failure in acidic soils. Results from several decades of natural resource management (NRM) research have shown that farmers in different environments can increase their farm productivity by up to 5 times if they adopted sustainable soil fertility management (SFM) technologies that are already available. These technologies include the use of agricultural lime to combat soil acidity. However, despite the availability of several technologies, including liming, little impact has been registered so far because only a small proportion of research results or good practices are scaled up, accessed and utilized by the extension workers, farmers, Non Governmental Organizations (NGO's), the Private Sector, and policy makers. This paper highlights the main policy-induced constraints with respect to use of agricultural lime in Kenya and the key steps that stakeholders, including government, need to take to remedy the situation. These include the need to prioritize soil acidity as a constraint within National Agricultural Research and Extension Systems (NARES). This can be achieved through development of comprehensive policy documents on crop yield increases due to use of agricultural lime for different cropping systems and agro-ecological zones. Secondly, the Government of Kenya needs to increase and maintain budgetary allocations to agricultural sector Ministries to a minimum of the 10% of Gross Domestic Product (GDP) as recommended by NEPAD and improve both input and output markets. In addition, the Government of Kenya need to develop, support and strengthen institutional frameworks such as research-extension linkages for efficient and effective coordination of soil fertility and land management by empowering them and providing the requisite resources. There is also need to fast track harmonization of the existing policies and institutional arrangements for efficient delivery of SFM technologies including use of agricultural lime.

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Maize and grain legumes are the dominating enterprises in western Kenya. Whilst maize provides the backbone to food security, grain legumes are multi-functionally sources of household protein, fix atmospheric nitrogen to the soil and provide



livestock feed. The yield of maize on smallholder farms is typically  $0.5 \text{ t ha}^{-1}$  compared to about  $7 \text{ t ha}^{-1}$  obtainable under research, mainly due to low soil fertility and *Striga* weed. Against this backdrop, during long rain seasons in the years 2010 and 2011, a total of 24 on-farm demonstrations were set up to disseminate Integrated Soil Fertility Management (ISFM) in four districts in western Kenya. The demonstrations were designed in a Randomised Complete Block Design (RCBD) involving four treatments: 1. Maize-bean; 2. Maize-soybean, 3. Sole maize (control) and 4. Maize-groundnut intercrops. The objectives of this study were twofold: to evaluate effect different maize-legume intercrops on maize and legume grain yields; and to analyse costs and benefits of the maize-legume intercrops. Data were collected on maize and legume yields, quantities of inputs applied and prices of both inputs and outputs. The data were evaluated by Analysis of Variance (ANOVA) and cost-benefit analysis. Results showed that the highest maize grain yields ( $4.8 \text{ t ha}^{-1}$ ) were obtained from maize-bean, followed by maize-groundnut ( $4.7 \text{ t ha}^{-1}$ ). Amongst the legumes, soybean gave highest grain yield ( $0.5 \text{ t ha}^{-1}$ ). The highest benefit-cost ratio of 2.5 was obtained from maize-bean intercrop and the lowest (1.9) was from sole-maize mainly because beans had the highest demand and market price per unit. The findings of this study point to the need to develop policies that promote smallholder farmers' access to efficient input and output markets.

#### **FARMERS' RISK PERCEPTIONS AND ADAPTATION TO CLIMATE CHANGE IN LICHINGA AND SUSSUNDENGA, MOZAMBIQUE**

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In Africa, climate change exerts significant pressure on the agricultural sector. Current changes in climate for most parts of Mozambique have resulted in increased frequency of droughts, dry spells and uncertain rainfall. This has resulted in loss of food production and smallholder farmers are most vulnerable to these climatic disasters as they affect the food security status of the household. Despite an increased number of country-level case studies, knowledge gaps continue to exist at the level of impact analysis. In addition, while adaptation and coping strategies with climate change and variability have become key themes in current global climate discussions and policy initiatives, literature on adaptation in Mozambique appears to be limited. The objective of this study was to assess the perception of smallholder farmers to climate change and adaptation strategies in Lichinga and Sussundenga districts of Mozambique. Using data obtained from a survey carried out in Lichinga and Sussundenga districts in Mozambique descriptive statistics analysis was undertaken using SPSS software to characterize the households, in terms of perceptions and coping strategies of the household to climate change. The farmers from both districts sited rainfall variability and higher temperatures to have severely affected maize production. Due to the late onset of rains, in Lichinga the planting period has changed from November (47.5%) to December (70%) while in Sussundenga the planting period has changed from September/October (40%) to November (62.5%). The rain seasons have become shorter and dry seasons are



longer. Some farmers have switched from growing maize to growing drought tolerant crops, such as cassava, sweet potato and cultivation of horticultural crops in wetlands as strategies to cope with the climate change.

## THE EASTERN AND SOUTHERN AFRICA COUNTRY LEVEL SOIL HEALTH CONSORTIA

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Owing to highly degraded soils and limited use of fertilizers, average crop yields for most crops in sub-Saharan Africa (SSA) are stuck at less than 50% of attainable yield. Agronomic trials have demonstrated a possibility of doubling and tripling yields across sub-Saharan Africa for major food crops through use of integrated soil fertility management (ISFM) technologies. ISFM technologies are suitable for smallholder farmers as they are flexible and compatible with farmer conditions. The main challenge for full integration of ISFM technologies into African agricultural systems is the wide array of possible ISFM options which are also not properly harmonised and effectively communicated to stakeholders. A key question in this respect is what works best where and how best it can be scaled out to similar agro-ecologies to reduce duplication of efforts, investments and boost crop yields over large areas in Africa. The country level soil health consortia brings together research institutions, extension agents, universities, private sector organizations, policy makers and other stakeholders working on ISFM in 8 African countries with a aim of consolidating, synthesising and communicating existing ISFM knowledge for easy access and use by farmers and other stakeholders. Each of the 8 countries represents a fully functional consortium made up of multi-institutional and multi-disciplinary teams. All country consortia are collating information from past agronomic trials, journal publications, reports, thesis and other existing sources on impacts of different ISFM technologies on crop yields, soil health and incomes to build a functional one stop-shop country level database and to develop effective communication tools. For purposes of uniformity of harmonized information within and between countries to facilitate robust comparisons, all the eight countries are using, similar data collection instruments/templates. Further, IPNI is coordinating all the 8 consortia, to optimize knowledge flow across the participating countries. By combining datasets from different countries, IPNI is developing a comprehensive regional one-stop database. This regional database will contain meta-analyzed datasets and articles that articulate the impacts of ISFM at a regional level, while also identifying the best fitting niches for different ISFM interventions. By use of spatial interpolation and mapping of agro-ecological characteristics, regions where certain technologies can perform best will be identified. The results of this work will be disseminated through various types of country-level and regional-level communication tools. In this paper we present the consortia model of increasing adoption of ISFM technologies, approaches and some of the initial outputs and impacts.



## **CRITICAL ANALYSIS OF POLICY RELATED DOCUMENTS IN THE CONTEXT OF INTEGRATED LAND AND WATER MANAGEMENT IN KENYA**

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In terms of GDP generation and employment creation, agriculture is the single most important sector in the economy. Water and land are vital for humans and economic development of a country, hence, need to maintain available water and land resources and provide good quality water for optimum development of the country. Therefore, integrated land and water resources management (ILWM) system is fundamental. Agricultural policies in Kenya focus on increasing productivity and income; enhanced food security, emphasizing on irrigation for agricultural output stability, thus underlining the importance of sustainable ILWM through an integrated approach, and therefore a need for an enabling policy environment. Main objectives of the study included critical review of the extent that the existing policies favour or hinder implementation of ILWM practices; and propose interventions and recommendations for improvement. Materials on policies and strategic documents related to ILWM were collected, reviewed and analyzed for strength, weaknesses identification, and propose recommendations on improvement. Results showed that most materials that were reviewed have strong and sustainable indicators of natural resources and environmental management issues. However, from the broader ILWM perspective, most of the materials appeared weak on specificities of ILWM, though may be implicitly embedded in soil, water and environmental management issues. Therefore, there is need to explicitly incorporate ILWM issues in the existing policies and strategic plans, have an enabling legal framework, identify gaps between the proposed policies and actual implementation, as well as lobby the policy makers for enhanced incorporation of ILWM issues in the relevant policies.

## **AN ASSESSMENT OF GENDER SENSITIVE ADAPTATIONS OPTIONS TO CLIMATE CHANGE IN SMALLHOLDER AREAS OF ZIMBABWE, USING CLIMATE ANALOGUE ANALYSIS AND CONSIDERING FARMER PERCEPTIONS**

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Current projections suggest that the impacts of warmer climates on smallholder production by the middle of this century, are expected to be mainly negative. Both the livelihoods and food security of smallholder households can be improved through suitable strategies for handling climate- induced risks and socio-economic and biophysical constraints. This paper describes the use of climate analogue areas



together with an assessment of farmers' perceptions, within the framework of the project CALESA. In particular, it considers them as tools for climate-risk analysis and assessment of adaptation options. The importance for mainstreaming gender sensitive options for climate change planning and policy is also herewith illustrated. Climate analogues for 2050s were identified in smallholder areas of Zimbabwe based on 30 years meteorological data. Pairs of sites with similar annual rainfall totals, which differed by 2-4 degrees Celsius in mean annual temperature (following the forecast effects of global warming for the 2050s) consist of Chiredzi which represent Matobo for drier areas, and Kadoma for wetter areas, which represent Mazowe/Goromonzi. Preliminary results for the 2010/2011 cropping season show different preferences for crop management strategies, particularly between the dry analogue pair, with respect to crops choices as well as soil and water management strategies. In drier areas, implications are for increased uptake of small grains, in 2050s climates. For wetter climates, soil and water management strategies are important options for smallholders. Gender issues for differently managed households seem to vary across sites. At drier sites, gender issues include labour for production and processing of the small grains, against a background of male labour migration. At wetter sites, access to draft power, labour, agricultural assets, social and financial capital in differently managed households are important for increasing adoption of effective crop management strategies.

#### **ANALYSIS OF ANALYTICAL TOOLS FOR CLIMATE CHANGE IMPACTS ON AGRICULTURE IN KENYA**

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Climate change poses a major threat to the environment, economic growth and sustainable development globally. Agriculture is arguably the most important sector of the Kenyan economy that is highly dependent on climate. Since the first Intergovernmental Panel on Climate Change (IPCC) assessment report was published in 1990, substantial efforts have been directed toward understanding climate change impacts on agricultural systems worldwide. The resulting advances have come from development of methods, models and data collection in addition to the observation of actual changes in climate and its impact. Although a large body of scientific data and models have been developed to predict the impacts of the contemporary and future climate, there is little knowledge on the level of application of the models in Kenya. The availability of such knowledge is critical for designing technologies and policies to mitigate climate change and facilitate adaptation to the changes that now appear inevitable in the next several decades and beyond. The study conducted key informants interviews to identify the analytical tools used to estimate the impacts of climate change and the level of utilization on productive sectors of the economy; namely crops, livestock, water and natural resources. The



respondents were purposively selected from Universities, Research institutions and policy institutions. All respondents reported that climate change has already exerted stresses on the biophysical, social and institutional environments that underpin agricultural production. However, 77% of the respondents had not used any analytical tools to estimate the on impact of climate change on any sector of the economy; a meagre 3% used crop simulation models. This was attributed to weak knowledge on analytical tools that could be used to estimate the impact of climate change on major sectors of the economy and therefore requires capacity building to empower researchers and decision makers to use analytical tools that would enable them make informed decisions on the appropriate adaptation and mitigation strategies.

### **ANALYSIS OF TECHNICAL EFFICIENCY OF SORGHUM PRODUCTION IN LOWER EASTERN KENYA**

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Most Kenyan rural households depend on agriculture as a major source of food and livelihoods. Declining agricultural productivity has resulted in increased food insecurity in the country. Consequently, there is a renewed interest in promoting drought-tolerant orphan crops such as sorghum for increased production in the ASALs of Kenya. However, performance of sorghum production among the smallholder farmers has remained low. This study was conducted to determine technical efficiency of sorghum production and its associated factors in Machakos and Makindu districts. The study surveyed 143 sorghum farming households during 2010-2011 growing seasons. DEA and Tobit models were used to estimate efficiency scores and factors that influence the technical efficiency. Results showed that mean technical efficiency was 41%, which is low. The technical efficiency was influenced positively by farm and farmer characteristics. It is concluded that technical efficiency of sorghum production in the study districts can be improved further by 59%. Similarly, innovative institutional arrangements enhancing farmer training should be instituted to enhance farmer capacity to efficiently use available resources to improve sorghum production.



## CLIMATE CHANGE ADAPTATION AND AGRICULTURAL DEVELOPMENT PLANNING IN KENYA

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Climate change has become a major threat to economic development in sub-Saharan Africa (SSA). Studies indicate that the impacts of climate change will significantly add to the development challenges, and hamper progress to meeting Millennium Development Goals (MDGs). There is a general consensus that agriculture-based livelihood systems predominant in the region will be most affected by the increased frequency and intensity of variable weather from predicted climate change. Kenya is among SSA countries that are already experiencing the climate change phenomena. The country is particularly vulnerable owing to the fact that the economy is heavily reliant on climate sensitive sectors such as agriculture. Agricultural production is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather. It is dominated by smallholder resource poor farmers who account for 75% of the total agricultural output and provide nearly all the domestic food requirements. A baseline survey to determine the status of climate change projects undertaken in Kenya in the past five years was conducted in 2012. The study targeted key informants in academia, research and policy makers. Results indicated that 60% of climate change projects undertaken were centered on adaptation, with over 66.7% of these being in the crop and livestock subsectors. However, 50% of the respondents did not know any source of information regarding climate change adaptation, while government departments have only 8.3% of the information data bases. In the absence of relevant scientific and technical information, adaptation investment planning by policy makers will continue to be prone to uncertainty.

## DETERMINANTS D'UTILISATION DE LA FUMURE ORGANIQUE FACE A LA BAISSSE DE LA FERTILITE DES SOLS DANS LA REGION SEMI-ARIDE DE KIBWEZI AU KENYA

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Soil fertility is declining in many parts of sub-Saharan Africa due to various factors including climate change and human action. This article analyzes the socioeconomic factors that influence the use of organic manure to adapt to declining soil fertility to climate change in the semiarid region of Kibwezi in Kenya. A logit model is



estimated to isolate the variables affecting the use of the strategy. The results show a correlation between socioeconomic variables and the use of organic manure in the face of declining soil fertility. Thus, we find that socioeconomic variables such as marital status, local expertise, access to resources, social relations in the village on the one hand, and the level of education of household heads to other hand, have respectively a significant influence on the probability of use of organic manure at the 5% and 10%. Other factors relevant a priori, in the model have no significant effect on the choice of strategy by farmers, although they influence the choice. Thus, for a more efficient use of this strategy, development actors must mobilize to support farmers in this action for sustainable agricultural resources in the region.

## **FACTORS AFFECTING INTEGRATED WATER MANAGEMENT PRACTICES IN MWANIA AND KALII WATERSHED IN MACHAKOS AND MAKINDU**

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Agriculture in Kenya continues to be the lifeline for the majority of the rural poor. The sector contributes up to 25 percent of the total gross domestic products (World Bank, 2011). Eighty per cent of the agricultural land in Kenya is under rain-fed agriculture, with generally low yield levels and high on-farm water losses. This problem led the KARI Katumani scientists to come up with this project which aimed at promoting IWM technologies an effort geared towards increased food security in Mwanja and Kalii watershed. This pilot project is based in Machakos and Makindu County. Therefore to warrant up scaling of the technologies it was important to conduct this study which aimed at trying to establish whether there are constraints which affected the implementation of the technologies. Ethnographic research methods were applied in data collection which included: Focus group discussions, direct observation and documentary information. The result showed that there were many challenges that faced implementation of IWM practices. They included poverty, delay in delivering subsidized fertilizers and seeds to farmers, myths surrounding success stories, inadequate labor, lack credit facilities, limited information on early warning, limited extension services, poor transportation means, and inadequate information on policies guiding IWM practices. This study recommends that the farmers should be linked to banks and other micro finances which would assist them to get loans, and to be encouraged to form cooperatives. The government to deliver farm in puts on time, farmers to be equipped with weather forecast information on time, and to consider constructing feeder roads.



## **FARMERS' PERCEPTION OF SOIL FERTILITY PROBLEMS AND THEIR ATTITUDE TOWARDS INTEGRATED SOIL FERTILITY MANAGEMENT FOR COFFEE IN NORTHERN TANZANIA**

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A study was conducted in Hai and Lushoto districts, Northern Tanzania to establish the farmers' perception of soil fertility problem and their attitudes towards integrated soil fertility management (ISFM) for coffee, thereby identifying the appropriate intervention strategies. The study was based on a structured questionnaire involving 126 respondents. Both farmers' awareness of the problem and their attitude were highly significant (at  $p < 0.01$ ). Age, household size, and adoption of improved coffee varieties affected farmers' awareness significantly ( $p < 0.05$ ). As for farmers' attitudes, six of the eight predictors were significant ( $p < 0.05$ ). Age, household size, adoption of new varieties and total farm income were highly significant ( $p < 0.01$ ). Age, total land under coffee and total off-farm income showed to negatively affect farmers' attitude. As farmers get older, they tend to refrain from innovation. Multiple ventures tend to compete for the farmers' time, resources and attention. For the two districts, ISFM interventions will make a better impact to younger and more energetic farmers with enough land for commercial coffee production and who depend largely on this resource for their livelihood.

## **FOOD SECURITY, A CASE OF MAIZE PRODUCTION IN KANDARA COUNTY, MURANGA DISTRICT**

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A maize agronomic study was conducted between May and August 2012 in a 10 x 10 km block within Kandara County. The work was conducted jointly by Kenya Soil Survey and Plant Nutrition Programme, KARI Kabete with financial support provided by African Soil Information Service Project (AFSIS). The objectives of the study were 1) To determine factors affecting maize production in the county and 2) To determine actual maize production under farmers own practices and management. The soils of the area are described as well drained, extremely deep, dusky red to dark reddish brown, friable clays, with an acid humic topsoil classified as humic Nitosols. Crops grown under rainfed and irrigation are maize and bananas while sweet potatoes, kales, sugarcane and cut flowers are under irrigation. Other rainfed crops and fruits include tea, coffee, beans, mangos, avocados and macadamia nuts. The livestock in the farms consists of dairy and goats under zero grazing with nappier grass as the main fodder crop. A questionnaire was used to capture information on maize growing, management practices and actual harvests under

farmers' practices. Questionnaires were administered to farmers in 16 clusters spaced 2.5 km x 2.5 km from each other within the block. Each cluster had 15 to 20 farmers. A total of 302 farmers were interviewed between May and July 2012. Maize harvests from 238 farms were done in August 2012 from replicate plots measuring 2 m x 3 m within a 5 m x 5 m plot. Soil analysis for available Nutrients was carried out at National Agricultural Research Laboratories, KARI Kabete. Majority of the farms 30.5% and 29.5 % produced 1 to 2 tons of maize per ha and 2 to 3 tons per ha respectively. Six point four percent of the farms produced more than 5,000 kg ha<sup>-1</sup> while 9.3 % had less than 1 ton ha<sup>-1</sup>. To get an insight into household food security each farmer's yield (kg ha<sup>-1</sup>) in LR 2012 was multiplying with actual household plot sizes under maize and converted to 90 kg bags. Thirty two percent of the households produced less than 1 bag of maize in that season while 19 % produced between 1 and 2 bags. Only 9 % produced more than 10 bags indicating Kandara farmers are food insecure. Two hundred and one farms out of a total of 231 used their own unique maize spacing. Only 30 had a form of shared spacing. Twenty point five percent of the farmers plant a local maize variety while another 20.5 % prefer using more than one variety per farm per season. Popular varieties include local, Pan 4m-19, H513, Pioneer, Dk, Duma and H614. Sixty two percent of the farms had Nitrogen deficiency (< 0.2 % total N) while 25 % of the farms had phosphorus deficiency (< 30 % ppm of P). Eleven percent and 3% had Calcium and Manganese deficiency respectively (< 2 me % and < 0.11 me % respectively). Potassium, magnesium, copper, iron and zinc were in adequate quantities. Twenty one farms out of 228 farms (9.2 %) had a pH of 6.0-7.13. Thirty five point five percent of the farms had pH of 5.50-5.99, 36.8 % had a pH of 5.48 - 5.0 and 18.4 % had a pH of 4.99-4.27. Maize require a pH of 5.5 -8.0. Improvement in soil pH would increase Nitrogen, Phosphorus, Calcium and Manganese availability. NPK compound fertilizer are the most popular fertilizer for planting followed by DAP. Eighty one farmers used the wrong fertilizer (CAN) for planting in long rains 2012. A few farmers used NPK and DAP for top dressing instead of using CAN or urea. For the three seasons a mean of forty point nine percent of the farmers who used fertilizers applied between 10 and 25 kg ha<sup>-1</sup> fertilizer with 29 % applying less than 10 kg ha<sup>-1</sup> and 29.9 % applying more than 25 kg ha<sup>-1</sup> during planting. Forty eight point one percent of the fertilizer users applied less than 10 kg ha<sup>-1</sup> fertilizer during top dressing while 30.3 % applied between 10 and 25 kg ha<sup>-1</sup> and 21.6 % applied more than 25 kg ha<sup>-1</sup>. On average 91 % of the farmers said they used manure during planting in LR 2012, SR 2011 and LR 2011. Farmers who attained yields of over 5000 kg ha<sup>-1</sup> reported that they used between 24 - 462 t ha<sup>-1</sup> of manure during planting. Eighty two percent of these farmers used between 132-522 kg ha<sup>-1</sup> of fertilizer during planting in LR 2012 while 67 % used 200-694 kg ha<sup>-1</sup> fertilizer for top dressing with 60 % satisfying the 50 kg Nutrient ha<sup>-1</sup> Abuja 2006 recommendation. Fertilizer applications in Kandara are low considering the application amounts are in kg ha<sup>-1</sup> fertilizer and not kg nutrients per hectare. A lesson can be learned from one Kandara farmer who attained the highest maize yield of 11 t ha<sup>-1</sup> by applying an equivalent of 120 kg N ha<sup>-1</sup> and 120 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> at planting, 70 kg N ha<sup>-1</sup> at top dressing and Pan 4m-19 hybrid maize. Since plot sizes in Kandara are small food security can only be improved by increasing maize



production per unit area (agricultural intensification). Farmers in Kandara are dedicated to farming and chances of adopting realistic recommendations are high.

## **GENDER DYNAMICS INFLUENCING ADOPTION OF INTEGRATED WATERSHED MANAGEMENT TECHNOLOGIES: THE CASE OF LOWER EASTERN KENYA**

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Women play a critical role in the agricultural sector. Any intervention focusing on improving agricultural productivity must take into account gender differences (needs and preferences) as a major factor likely to influence success of the development intervention. This case study paper analyzes gendered needs and preferences influencing adoption of identified integrated watershed management (IWM) technologies among targeted male and female beneficiaries during the early stages of project implementation in lower Eastern Kenya. Focus group discussions (FGDs) were conducted among 171 male and female smallholder farmers randomly selected from Mwanja and Kaliu watersheds in Machakos and Makindu districts respectively. Among other results, the study revealed higher adoption rates among male farmers as compared to female farmers despite higher proportions of female than male farmers participating in project activities. The paper derives important policy implications for enhanced adoption of IWM technologies in lower eastern Kenya.

## **SMALLHOLDER FARMERS DECISION TO ADOPT AND UTILIZE ISFM TECHNOLOGIES IN TORORO DISTRICT, UGANDA**

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Soils in Tororo district like in other parts of Uganda are of low inherent fertility, which is declining due to low use of external inputs by farmers and poor management. Integrated Soil Fertility Management (ISFM) offers considerable promise for increasing food. However it is unclear whether ISFM techniques are easily adopted by smallholder farmers. The study focus was on smallholder farmers' adoption and utilization of ISFM technologies in Tororo district. Soil management technologies were introduced, fine-tuned and disseminated in the study area using participatory approaches by the National Agricultural Research Laboratories of the National Agricultural Research Organization, Africa 2000 Network and government extension. The objectives of the study were to examine household factors and their implication on adoption of ISFM; to assess the methodologies used to disseminate ISFM technologies; to establish the level and nature of adoption of ISFM by smallholder farmers; and to examine the effects of structural and ecological factors on farmers' decision to adopt ISFM technologies. Research results indicated that



farmer wanted the price for ISFM technologies be reduced; farmers lacked enough training for efficient use of ISFM. Technology use was affected by farm size, farmer educational knowledge and age, economic and institutional support characteristics and farmer's perceptions. The three most effective dissemination methodologies/approaches in descending order were trainings, farmer field schools and demonstration farms. Respondents revealed that trainings played a greater role in teaching farmers about fertilizer use. The major problematic aspects were technology accessibility and labour constraints. Strengthening of advisory services and facilitation of inputs delivery by the government through private sector supply would play a critical role in soil fertility replenishment in Uganda. These findings raise important questions as to whether ISFM and related techniques are really affordable to smallholder farmers, so the government should encourage input facilitation such as credit and microfinance to farmers through the private sector in order to facilitate the use of soil management inputs and also there is for more training on ISFM technologies by organizations like National Agricultural Advisory Services.

#### **SMALLHOLDER FARMERS' USE AND PROFITABILITY OF LEGUME INOCULANT IN WESTERN KENYA**

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Research on the use of *Rhizobia* inoculants has been conducted in Africa since 1950s. However, the technology has not been widely applied in Sub-Saharan Africa. The aim of this study was to examine factors that drive the use of BIOFIX legume inoculant and its profitability in smallholder farms. The study uses data collected from 210 soybean farmers in Western Kenya. Regression analysis finds area under crop production, distance to markets and knowledge of legume root nodules, education, contacts with organizations promoting BNF technologies, membership in group, soybean market and location of the farmer determines the use of BIOFIX. Partial budget analysis finds a highly significant difference in yields between farmers who inoculate their soybean (864 kg ha<sup>-1</sup>) and farmers who do not inoculate (686 kg ha<sup>-1</sup>) (p<0.01), a 26% increase in soybean yield. Difference in gross margins achieved by users of inoculants (\$278 ha<sup>-1</sup>) and non-users (\$175 ha<sup>-1</sup>) is highly significant (p<0.01). The findings of this study imply that there is need to strengthen local institutions, commercial sector, particularly local agro-dealers, and extension efforts to enhance promotion of inoculants use. The findings also highlight the importance of markets as drivers of technologies adoption.



## **THE ROLE OF AGRO-INPUT DEALERS IN DISSEMINATION AND COMMUNICATION OF SOIL FERTILITY MANAGEMENT KNOWLEDGE: THE CASE OF SIAYA AND TRANS NZOIA COUNTIES, KENYA**

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Lack of access to necessary agro-inputs contributes to low agricultural productivity and slows the overall economic growth and development in most parts of sub Saharan Africa (SSA). Agro-input dealers make inputs more easily accessible to rural-based smallholder farmers. This study assessed the role played by agro-input dealers in disseminating and communicating integrated soil fertility management (ISFM) practices and information to smallholder farmers. The study was conducted in Siaya and Trans Nzoia counties in Kenya, and looked at agro-input dealers' awareness of ISFM practices and communication channels used to access agricultural information. The study interviewed 144 agro-input dealers randomly selected across the study area. The field surveys were conducted where agro input dealers were the main respondents. The result from logit regression model estimates showed that gender, age, educational level, experience in agro-input business and visit by extension staff significantly influenced the agro-input dealers' awareness of ISFM technologies. Factor analysis of the communication channels that agro-input dealers used to access agricultural information indicated that community based (Cosmopolite interpersonal) channels of communication were the most preferred communication channels among the agro-input dealer network in two study areas. The study underscores the important role played by community based channels of communication in the ISFM knowledge dissemination. The study findings suggest the need to improve the provision of extension services to agro-input dealers to enable them effectively communicate information about ISFM technologies to farmers. Such initiatives on capacity building should take into consideration gender of the agro-input dealers.

## **UNDERSTANDING THE POTENTIAL OF TREE TOMATO PRODUCTION IN EASTERN KENYA FOR IMPROVED NUTRITION AND FOOD SECURITY**

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Agriculture in Kenya continues to be the main stay for the majority of the rural communities. The sector constitute of six sub-sectors food crops, livestock, industrial crops, fisheries, forestry and horticulture. Among these sub-sectors horticulture is the largest and contributes to 33% of the GDP and 38% of the export of Kenya. Fruits contribute to the growth of this sector as well as vegetable and flowers. A tree tomato (*Solanum betaceum*) is a fruit of Andean origin and scantily grown in Kenya.



The fruit is used as fresh fruit, juice and the food processing industry. It is high in vitamins and iron and low in calories which is about 40. A sample of population of all tree tomato producers was done in representative sites of Tea-Dairy and Coffee-Dairy Land Use Systems (LUS) of Embu County. Then a random sampling to select 30 households in each LUS, to constitute a sample size of 60 households was conducted. A structured questionnaire was used in order to understand the socio-economic and biophysical environment of tree tomato, understand production and marketing potential and identify the main tree tomato production and marketing constraints. Results indicated that most of the farmers are either intercropping them with other crops like maize and beans (59%) or planting them in a scattered form within the farm (32%). Main production constraints were pests (20%), diseases (24%) and moisture stress leading to drying up (nine percent) among others. Most of the farmers (77%) in the study area who sell their tree tomato fruits in the market do not experience any low market demand,

The study indicated that the main objective of its production is household production, the proportion that is producing for both household consumption and market is increasing; hence an implication of its enterprise potential in the area, if well promoted.

#### **FARMERS' UP-TAKE RESPONSE TO SOIL FERTILITY MANAGEMENT PRACTICES DISSEMINATED BY THE NATIONAL AGRICULTURAL RESEARCH ORGANIZATION (NARO), IN PALLISA DISTRICT, EASTERN UGANDA**

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There is growing decline of soil fertility in Sub Saharan Africa with its attendant decline in crop yields per unit area, resulting in food insecurity and poverty in the region. This problem has many dimensions and to tackle it, there is need to understand those different dimensions. This study focused to understand different practices farmers have used to maintain soil fertility over the years, what have changed to these practices down the years, how different methods of disseminating research recommended soil fertility management practices influence their uptake/adoption by the target beneficiaries. Focus group, individual discussions accompanied with field observations and a survey among participants in the training were methods used for data collection. Qualitative and quantitative data were analyzed using SPSS software. Results: crop rotation, maintaining grass strips in between plots; rotation of kraals, land fallow, returning residues to the field were the indigenous practice used. These have undergone a lot of changes over time and become ineffective. Of the 4 introduced practices, use of animal manure was most adopted, followed by inorganic fertilizers. Use of mother-baby approach worked better for farmers than use of print materials in promoting uptake of use of soil practices. Major constraints to the application of these practices by the beneficiaries include: poor accessibility/scarcity, high labor and monetary costs involved, droughts, poor handling and transportation facilities (for animal manure) and low



farm gate prices of farm products. Conclusions: indigenous methods are being abandoned due to growing land shortage; methods that involve hand-on training are most preferred by farmers; uptake of introduced practices, especially inorganic fertilizers and animal manure is most constrained by low and unstable farm-gate prices, drought, inaccessibility, high monetary and labor costs involved and limited capital aggravated by lack of saving culture and poor prioritization. Therefore, farmers should adopt an integrated soil management approaches, and policies that facilitate application of ISFM should be in place, soil information dissemination should take a more practical approach like in the case of mother-baby. Sensitization of farmers on the value of sharing soil information and mechanism for reward be put in place

### **PARTICIPATORY GIS IN THE LOWER TANA RIVER FOREST COMPLEX**

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PGIS is a tool to empower and convince communities on the importance of conserving land resources hence minimizing undesirable effects of future land-use changes on natural resources. The objective of this study was to use participatory GIS to map forest resources in the Lower Tana River region and develop an inventory of images of the changes in land use. Mental (PGIS) maps showing extent of land use and land cover (forest cover, agricultural land, settlements and water bodies) within each of the villages were drawn on manila papers for the years 1970, 1990 and 2011. Ground truthing of major physical features was done using GPS. The mental maps were geo-referenced, area under each land use and land cover change calculated and percentage changes of land use and land cover types determined for the period between 1970-1990 and 1990-2011. Forest cover percentage change of (1990-2011) was used to quantify the magnitude of forest cover reduction as influenced by the forest management regimes. Genstat software Discovery Edition 3 was used to perform analysis of variances (ANOVA) using one-way ANOVA. MODIS 2001, MODIS 2004 and Africover Land Cover 1995 (Vector file) of the study area were classified and percentage changes of land use and land cover types determined for the period between 1995-2001 and 2001-2004. PGIS community forums were carried out in eight selected villages. Comparison of the satellite and mental developed maps was done with the help of the community. Changes of major land resources over the years, resultant benefits and undesirable effects associated with the reduction in forest cover and expansion of agricultural and settlement area was discussed. From the mental maps, agriculture was seen to be the main land use in the area, covering an area of between 40.27 to 73.90% of the villages. Settlement covered an area of between 3.93 to 49.68%, while natural forest covered the remaining area of between 1.40 to 46.46%. Forest cover decreased by a range of 0 - 65.51 and 5.65 - 98.6%, agricultural land increased by a range of 0 - 118.63 and 1.08 - infinity% and residential area increased by a range of 0- 201.79 and



23.47 - infinity% of the original area for the period between 1970-1990 and 1990-2011 respectively. The reduction of forest cover can be attributed to pressure from human activities such as illegal logging, cultivation, charcoal burning, overgrazing, and encroachment by people from other parts of Kenya. Based on the interpretation of the mental maps by the community participants, forest cover reduced, some water bodies dried up and agricultural and settlement area expanded. These land cover and land use changes were associated with benefits like creation of enough land for settlement and cultivation hence increased crop production. Reduced rainfall amounts (drought), higher temperatures and human-wildlife conflicts were mentioned as the major undesirable effects associated with the reduction in forest cover and expansion of agricultural and settlement area. Forest management regimes influenced ( $P = 0.013$ ) the magnitude of forest cover percentage reduction in the LTRF complex. Kenya Forest Service management regime showed the highest magnitude of forest cover percentage reduction of (95%). Private management regime showed a reduction of 67.2%, Kenya Wildlife Service reduction of 44.5% while community management regime showed the lowest magnitude of 13.6%. The community management regime was the most effective while the Kenya Forest Service was the least effective in the protection, management and conservation of LTRF complex. The communities in the LTRF complex were all convinced on the importance of conserving the Lower Tana River Forest complex and recommended afforestation, stop deforestation, to practice agro-forestry, use of organic manure and crop rotation to avoid nutrients depletion in the LTRF complex.

#### **ENHANCING SMALLHOLDER FARMERS ADAPTIVE CAPACITY TO RAINFALL VARIABILITY AND SOIL FERTILITY PROBLEMS BY THE USE OF THEIR TACIT KNOWLEDGE. A CASE OF CHIPEPO IN SOUTHERN ZAMBIA**

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The study investigated how farmers in a low rainfall area of Southern Zambia have used their tacit knowledge to respond to rainfall variations as well as soil fertility problems. Southern Zambia has been undergoing increased rainfall variability hence the need for adaptation measures by local farmers. This is an example of how to enhance application of adaptation to climate change and variability. Semi-structure interviews, key informant interviews and observations were employed to collect data on how farmers have used their tacit knowledge to adapt to rainfall variation and soil fertility problems. A total 60 smallholder farmers from the study area, 6 key informants from the Agriculture Ministry, the Zambia National Farmers Union as well as longtime residents of the study area were interviewed. Chipepo area has two agriculture systems practiced with varying problems related to each. While the entire area falls in the low rainfall region, the upland area is more affected by moisture stress and poor soil fertility compared to the valley areas located close to tributaries of the Zambezi River. The intermittent, poorly distributed rainfall and the poor soil fertility in the upland regions poses a challenge to farmers with upland



fields. On the other hand, the annual flooding of the tributaries of the Zambezi River not only deposit alluvium to the valley fields but also floods these fields potentially resulting in loss of yields. The results showed that all the farmers in the area have adapted to the problems of low moisture in the upland fields and too much moisture in the river valley fields by practicing crop diversification concentrating on three main food crops namely; maize, sorghum and bulrush millet which all differ not only in their moisture requirements but also in their maturity periods. They have also engaged themselves in off-farm activities. Of the interviewed farmers about 50% have adapted by the use of drought tolerant crop varieties as well as planting early crop varieties. Maize was planted in the river valley fields due to its high water requirements while sorghum and millet which are drought tolerant were planted on the upland fields. The farmers used their knowledge of particular flowering plants which bloom at the beginning of the rain season to forecast the onset of rains and this was their cue for early planting. The farmers with upland fields have adapted to problems of poor soil fertility by adopting indigenous soil classification techniques based on vegetation types, soil colour, texture and soil workability. These methods help farmers adapt to their environment by utilizing particular soils for each of the crops they grow. Integrating this tacit knowledge into modern technologies will enhance smallholder farmers' adaptation to impacts of climate change and variability.

#### VALIDATION AND UP SCALING OF APPROPRIATE AGRI-BIOTECHNOLOGIES FOR IMPROVING RURAL LIVELIHOOD IN AFRICA

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Considering the comparable situations of India and Africa, Transfer of Technology (TOT) pertaining to a few time tested innovations in agri-biotechnology is a possibility due to low transaction cost for the benefit of farmers. These are production & adoption of *Trichoderma* spp, production of mushrooms, cultivation of seasonal vegetables and aerobic methods of Rice cultivation have potential. *Trichoderma* spp is environmentally friendly bio-agent suppressing plant parasitic root knot nematodes with favorable effects on plant growth is an organic method of agriculture. Encouraging production (culture) of *Trichoderma* in rural areas will make farmers self reliant as also improve their financial position, through generation of additional employment and income. Oyster mushroom can be grown widely on a wide range of agricultural wastes including degraded agricultural wastes (Spent substrata) and checks ecological pollution. Farmers can richly be benefitted in terms of income from sale as well as improving nutritional status of their food in their family. Similarly cultivation of short duration vegetables augments income as also nutritional security. Water is becoming a limiting factor all over the world and has to be used efficiently and sustainably. Aerobic method of rice cultivation saves upto 50% of water without greatly sacrificing productivity and profitability. Accordingly aerobic rice can also be propagated for the benefit of farmers. The objective of this



proposal is to promote adoption of the appropriate agri-biotechnologies in production of *Trichoderma* spp; Oyster mushrooms, seasonal vegetables and aerobic rice to improve rural livelihoods for sustainable gains on farm incomes in Africa. In the process it is intended towards capacity building through training and demonstration of the technologies at community level. These result in formulating strategies and policies for diffusion and adoption of innovations. The expected outcomes are (i) generation of management information system for improved agricultural biotechnologies, (ii) up-scaling and fast-tracking diffusion of production & adoption of innovations, (iii) generation of package of practices and (iv) networking and partnerships among communities. These result in inclusive growth of farming community with appropriate technologies of Indian agriculture. The University of Agricultural Science, Bangalore, India (UASB) in partnership with research / extension centers in Kenya and Zambia coordinates this program by involvement of technologists in the fields of Agricultural Extension, Agricultural Economics, Agricultural Entomology, Plant Pathology, Plant Breeding) through Participatory Technology Development strengthening capacity of stakeholders and information management. The African partners inter alia will be drawn from Kizimbani Agricultural Training Institute, in Agricultural Extension, Njala Agricultural Research Centre (NARC) in the field of molecular biology, Africa Amaranth Institute in economics and marketing.

## **SOCIOECONOMIC FACTORS AND SOIL QUALITY ASSESSMENT IN THE RICE FARMING SYSTEMS IN SOUTHERN HIGHLANDS OF TANZANIA**

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The soil quality assessment and constraints to rice cultivation in selected areas of Southern Highlands of Tanzania was carried out. There are many factors that hinder the smooth development of the rice subsector in Tanzania. Low soil fertility is the major constraint and over 70% of farmers do not use fertilisers, low and unreliable rainfall affect rice farming. Levels of N, P and K were noted in many fields that were surveyed thus affecting the nutrient balances of major nutrients. The declining soil productivity problem is exacerbated by the fact that rice farmers do not completely apply or sometimes do not adequate amounts of inorganic fertilisers. Even though the role of organic manures e.g.FYM is appreciated strangely enough no organic nutrient resources to restore soil fertility is applied in the fields. It was recommended that, for sustained rice production, rice farming systems should be monitored for variations in soil quality and nutrient losses as well as for rice yields taking place over time. Also, it was recommended that one of the major interventions by the government should be to subsidise fertilisers.



## **GENDER PERCEPTIONS, UNDERSTANDING AND ADAPTIVE STRATEGIES TO CLIMATE CHANGE AND VARIABILITY BY SMALLHOLDER FARMERS IN SEMI-ARID SOUTH SUDAN**

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This study focuses on understanding the perceptions of farmers, their knowledge, attitude and practices in adapting to climate change and climate variability in the Semi-Arid Agro-ecological Zone of South Sudan. Eighty four (84) questionnaires were administered using systematic random sampling method, while key informant interviews and focus group discussions were also implored to generate data on various variables. No significant ( $P>0.05$ ) gender differences (between men and women) were observed in level of awareness and understanding of climate change and climate variability. However, significant differences ( $P<0.05$ ) were observed for proposed gender adaptive strategies to climate change and variability. Focus group discussions revealed that the elderly men and women are the custodians of indigenous knowledge on climatic information. The focus groups further acknowledged the weaknesses of traditional systems and lack of or inaccessibility of convectional climate based-forecasts that would be more useful and reliable for planning and decision making. On the whole, the study suggests that there is a considerable gap between the information needed by small-scale farmers and that provided by the meteorological services, as such better community understanding and monitoring of climate related risks is a prerequisite. Furthermore, dissemination of climate information and products to decision makers and user community should be improved. It is envisaged that the use of weather products in resource allocation, planning and policy decisions can have wider applicability as well as generate synergies to other interventions by other development partners or NGOs. This paper contributes to the sub-theme, adaptation to climate change, lessons learnt and challenges ahead.

## **CLIMATE CHANGE AND DETERMINANTS OF ORGANIC MANURE USE TO COMBAT SOIL FERTILITY DECLINING IN THE SEMI ARID DISTRICT OF KIBWEZI, KENYA**

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Soil fertility is declining in many parts of sub-Saharan Africa due to various factors including climate change and human action. This article analyzes the socioeconomic factors influencing the use of organic manure to adapt to the declining soil fertility due to climate change in the semiarid region of Kibwezi in Kenya. A multinomial



*logit* model is estimated to isolate the variables affecting the use of the strategy. The results show a correlation between socioeconomic variables and the use of organic manure in the face of declining soil fertility. Thus, we find that socioeconomic variables such as marital status, local expertise, access to resources, social relations in the village on the one hand, and the level of education of household heads to other hand, have respectively a significant influence on the probability of use of organic manure at the 5% and 10%. Other factors relevant a priori, in the model have no significant effect on the choice of the strategy by farmers, although they influence its choice. Thus, for a more efficient use of this strategy, development actors must mobilize themselves to support the farmers in their adaptation process for a sustainable agricultural development in the region.

## **LAND HOLDING AND HOUSEHOLDS' PROBABILITIES OF ADOPTING MONOCULTURE IN UGANDA**

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In this paper we describe households' land holding and allocation to major crops in Uganda. Descriptive and analytical statistics were derived from the national household data collected by UBoS in 2005/06 and 2009/10. Households' in Uganda owns on average 3.46 acres of land that are utilized for crop production. Central 1 reported the lowest landholding at 2.5 acres while North-West had the highest at 4.8 acres. Farmers cultivated multiple crops with banana, maize, cassava, coffee and beans allocated the high proportion in that order. Share of land allocated and yields for various crops differed across sub-regions. A Tobit analysis showed that sub-regions and compatibility of crops for intercropping were the major factors that influenced share of land allocated to various crops. In case of adopting one major crop for commercialization farmers would select banana, maize, cassava, bean and coffee in that order. Crops insurance, improving produce markets and infrastructural development will inculcate households specialize on one crop that yield the best.

## **THEME X: OTHERS**

### **USE OF HAND-HELD X-RAY FLUORESCENCE ANALYZER FOR RAPID SCREENING OF SOILS**

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Laboratory analysis has at its disposal a wide range of chemical, physiochemical and physical methods that can be used to characterize and evaluate fertility and quantify pollutants. Development in analytical techniques have enhanced the use of multi-



nutrient extractants, decreasing the detection limits by several order of magnitude and in addition allowing for a shift towards multi-element analyzes. Chemical methods are being progressively replaced by reliable physical or physiochemical methods that are more sensitive, faster and more selective, making it possible to determine the very low concentrations of free micronutrient ions such as those of Cu and Zn in solution. One such technique is the Hand-Held X-ray Fluorescence (HHXRF) spectrometry that has the potential to provide information about the quantities of individual elements in soil that are essential for the crops (e.g. Copper) and those that may be undesirable (e.g. Lead). HHXRF that can directly analyse soils in the field and on prepared samples for mineral and total elemental compositions could be effectively applied to achieve an economical detailed screening analysis and mapping of soils across individual fields.

### **ASSESSMENT LEVEL OF ALOE PRODUCTION, PROCESSING AND MARKETING IN EMBU COUNTY**

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Aloe (Liliaceae) plant species have been known for their medicinal properties in many countries. Aloe can survive in wide range of climatic conditions. The thick nature of their leaves assist in water storage and this is a strong quality for them to serve in arid and semi arid regions. The history of this plant in Kenya is that its leaves have been exploited as medicine for livestock. In Embu and Mbeere aloe has been promoted by various stakeholders through farmer training on crop management, supply/sell of seedling to farmers and promise of good market for the crop. The study was to evaluate the progress of aloe in the area in terms of path production, processing and marketing. Stakeholders' workshop was held followed by household survey in the two districts. It was established that Barberdensis and Turkanensis are the two exotic aloe varieties that have been adopted by farmers beside the local variety. The aloe plants in Embu in some farms have matured and ready for harvest but there is no market. The number of aloe plants per farm for the aloe farmers in Embu is 96 while in Mbeere district was 55, the two figures being significantly differently ( $p=0.049$ ). Aloe farmers aged between 31 - 40 years had the highest mean number of aloe stems (153) being significantly different to other evaluated groups ( $p=0.0288$ ). Due to scarce market for aloe leaves, some farmers in Embu have opted to process some products from aloe leaves using some informal methods. The products processed are medicine, cosmetics and juice both for home consumption and little for sell. This study identified several challenges in aloe farming. For example in Embu and Mbeere districts aloe is being infested by insect pests and attacked by diseases (leave rust). This has caught farmers unaware because it was originally perceived that aloe are free from diseases. Processing of aloe products has been hit by lack of knowledge and equipments. There is no market for aloe leaves, extracts and products. Farmers who celebrated at the introduction of the crop due to its promised potential as a cash crop are now disappointed to the extent of neglecting the crop by not weeding. Some are threatening to uproot it and



use the space to grow other crops. Developing strategies to control disease and pests, installing processing machine and linking farmers to the market where they can sell aloe leaves and products will be step in the right direction.

## ASSESSMENT OF GENETIC VARIABILITY AMONG KENYAN SOYBEAN (*GLYCINE MAX* (L.) MERILL) ACCESSIONS AND OTHER INTRODUCTIONS

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Knowledge on genetic variability forms the basis of a successful crop improvement. Unfortunately, Kenyan soybean accessions have not been characterized and little efforts have been made to assess their genetic variability and use it in the breeding programme. This study was conducted to evaluate genetic variability, heritability and genetic advance among Kenyan soybean accessions and other introductions. One hundred and ten (110) soybean genotypes were evaluated in three locations (Embu, Mwea and Igoji) for 2 seasons using alpha lattice design arranged in 10 rows x 11 columns replicated three times. The genetic variability was estimated using variance components. Genotypes were grouped using hierarchical cluster analysis. High to moderate genotypic coefficients of variation were observed for pod shattering, lodging scores, number of pods/plant, plant height and grain yield indicating sufficient variability of these characters for genetic improvement through simple selection. High heritability estimates coupled with high genetic advance were recorded for plant height, pod shattering and number of pods/plant indicating additive mode of gene action. Cluster analysis grouped the accessions into two major clusters. The clustering pattern had no clear relationship between the origin of the accessions and the genetic diversity. However, clustering was based on the similarity of traits, implying that genotypes from a certain cluster with greater similarities of a particular trait may be selected for hybridization. In this regard, genotypes GBK 033245, GBK 033251, GBK 045342, GBK 033229 and BRS MG46 would be selected and incorporated in hybridization programme to develop high yielding soybean varieties. Similarly, genotypes Dowling and PI 2007477A would be selected for developing short, early maturing, lodging resistant and large seeded genotypes. This study confirmed the presence of variability and an opportunity for breeders to exploit additive gene effects and hybridize diverse parents with complimentary traits to obtain desirable segregating generations that will eventually improve soybean yields and other attributes.



## INCREASING LAND PRODUCTIVITY THROUGH OPTIMUM CATTLE STOCKING RATES

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Elmba Rhodes (*Chloris gayana*, Kunth) grass is known to have wide climatic and soil adaptation; being persistent in growth under frequent grazing, producing high dry matter yield per hectare that is evenly distributed throughout the year. These characteristics make it a popular grass for improving grazing land in Kenya. General increase in beef output per hectare with increased stocking rate has been reported elsewhere. Hence the objective of the current study was to increase land productivity through the determination of optimum cattle stocking rates when cattle were grazed on Elmba Rhodes grass paddocks by evaluating available dry matter, yearling Boran cattle daily weight gain and beef yield per hectare. Three paddocks were fenced in an established Elmba Rhodes grass field to match the experimental requirements. Eighteen yearling Boran cattle were distributed in a randomized complete block design to treatments A, B and C where A, B and C, represented stocking rates of two, four and six yearling Boran cattle per hectare. The yearlings were continuously grazed on their respective paddocks for 240 days. Their initial mean weights were 191.0, 191.9 and 189.3 on treatments A, B and C respectively. The data was subjected to analysis of variance and the means separated using Duncan's multiple range tests. The stocking rate significantly affected available dry matter, yearling Boran cattle daily weight gain and beef yield per hectare. The available dry matter recorded a decreasing trend of 3.9, 2.8 and 1.3 tonnes per hectare and yearling Boran daily weight gain and beef yield increased to an optimum and thereafter decreased with trends of 453.9, 480.5 and 200.2g; 108.9, 230.6 and 144.2 kg per hectare on treatments A, B and C respectively. It can be concluded that improved grazing land planted with productive Elmba Rhodes grass provided to grazing cattle up to 3.9 tonnes dry matter per hectare monthly. Such productive grassland increased cattle growth rate to 480.5 g daily under continuous grazing and increased land productivity to the optimum beef yield of 230.6 kg per hectare. Hence to increase land productivity the optimum cattle stocking rate was 4 yearlings Boran was recommended under continuous grazing on Elmba Rhodes grass. Further research should be done to determine the optimum cattle stocking rates for cattle grazing Elmba Rhodes grass in the various ecological zones in Kenya.



## **OPTIONS FOR DEVELOPING BEE HONEY MARKET FOR LUSHOTO DISTRICT, TANZANIA (INDICATE RELEVANCE TO THE CALL)**

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Beekeeping plays a major role in socio-economic development and environmental conservation of several countries in the tropics. In Lushoto district, Tanzania favourable environment for bee keeping and production exists due to availability of microclimate and many plants that attract bee colonies for nectar production. Despite the potential for beekeeping and production in Tanzania several literatures have reported lack or limited and unreliable market for bee products as a major problem facing the sector. It is upon these considerations a study was carried out to identify bees' honey marketing options for beekeepers in Lushoto district in order to provide guidelines for honey marketing opportunities to honey producers. Specifically the aim of the study was to establish marketing options and market requirements for bees honey and to determine the best honey marketing options for Lushoto district and other areas with similar conditions. A structured questionnaire was used to collect data from 95 respondents comprising 80 households (beekeepers) from Lushoto District and 15 traders who buy Lushoto honey residing in Lushoto town, Dar es Salaam, Coast and Morogoro regions. Data were analysed using descriptive and quantitative methods. The quantitative analysis comprised profit margin analysis and benefit-cost analysis. Mapping honey marketing channels was also done to gauge different options /alternatives for bees honey marketing for farmers. The results indicated that, prices and margins obtained by different actors along the honey value chain varied significantly with the retailers obtaining higher prices and profit margins i.e. 940 TZS, 962 TZS, 1538 TZS and 1247 for beekeepers, assemblers, retailers and wholesalers respectively. The reason for such proportion was due to lack of market information to beekeepers. The bees honey production and marketing seem to be a potential business opportunities to the Lushoto people as the profit obtained covers both fixed and operational costs. There are little value adding activities (processing and packaging at local level) and the packaging type most used by producers includes 5L, 1L, 500mls and 340mls packs as most honey is consumed at local retail level. The study revealed that, both direct and indirect marketing options can be used by beekeepers to sell their produce in the sense that small scale beekeepers can maximize profit from selling directly to the ultimate consumers through road side market, on farm and /or retailing. Direct marketing will cut down transport and other marketing costs, hence for small scale beekeepers with low capital will obtain reasonable profit. The medium and large scale beekeepers in the study area were recommended to sell at both wholesale and retail markets as they have relatively high produce. It is recommended that, beekeepers in Lushoto District should utilise the opportunity of selling based on product



differentiation as there is increased demand for organic honey at both local and international markets.

## UTILIZATION OF PLANT HEALTH CLINIC (PHC) INNOVATION FOR SUSTAINABLE CROP PRODUCTION IN EMBU COUNTY, EASTERN KENYA

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Agriculture is the main contributor in the economies of the sub-Saharan countries. In Kenya it is a sector that is not only the driver of Kenya's economy but also the means of livelihood for the majority of Kenyans. However, there has been declining crop yields due to various factors that includes low soil fertility, poor crop husbandry, pests and diseases among others. Plant health clinic (PHC) is a new approach in Kenya that provides a low cost method to provide plant health advisory services to smallholder farmers. Farmer's recommendations are based on field diagnosis. This approach aimed to diagnose and manage plant health issues for increased yield and sustainable livelihood. The PHC were set in three markets of Embu county Kibugu, Kithimu and Embu market. They are run by crop protection expert referred to as 'plant doctors'. There were number of cases where the trend showed upward and downward trend indicating the approach was working and perhaps spreading among the farming communities hence need to set more the clinic within other centres within the County. The approach exposes the frequent pests and diseases in an area hence an innovation that can show early warning of any new disease or pest in an area and therefore recommended that more clinic be set and training of the farmers who can train others informally.

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