SCALING UP INTEGRATED SOIL FERTILITY MANAGEMENT (ISFM) FOR IMPROVED LIVELIHOODS

ASARECA/NRM/2012/09

Consolidated technical project report

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EXECUTIVE SUMMARY

Low and declining soil fertility is a major problem threatening the livelihoods of majority of people in ECA. There is limited adoption of proven Integrated Soil Fertility Management (ISFM) technologies partly attributed to inadequate capacity and knowledge amidst uncertain markets and marketing environment. Value addition is postulated to increase profitability of farming and thus promote farmer re-investment in ISFM. The project “Scaling up Integrated Soil Fertility Management for improved Livelihoods” sought to upscale best-bet ISFM and value addition technologies/innovations in Kenya, Tanzania, Rwanda and Uganda, increase market opportunities for priority commodities, build capacity of farmers and other value chain actors in ISFM and value addition, and facilitate ISFM adoption.

Building on the successes of past projects, this one-year project up-scaled ISFM and value addition technologies from pilot sites to a wider geographical area and reached out to more stakeholders than previously. In Western Kenya (Siaya county), ISFM technologies inclusive of DAP, FYM, Calliandra, Tithonia green biomass and Striga tolerant maize varieties (KSTP 94, IR maize, WS502, WS505) were used to improve maize productivity and manage Striga on-farm. High value banana (NGOMBE variety) and African indigenous vegetables (C*rotolaria ochroleuca and Solanum nigrum*) were promoted as income generating enterprises.

Use of ISFM technologies (farmyard manure) in the production of African indigenous vegetables (C*rotolaria ochroleuca and Solanum nigrum)*, increased farmers’ incomes from KSh 90,000 (US $ 1100) to KSh. 1,000,000 (US $ 12,000) per hectare/year. Currently Sixty (60) farmers are growing these vegetables on 30 ha. In addition, the vegetables have improved household nutrition and enhanced communal social responsibility through neighbors sharing the vegetables). In addition to increased income to increased household income, the demand for Crotalaria seed has increased tremendously. Maize yields and income were 4 to 5 times higher when grown with ISFM than farmers practice.

LIST OF ACRONYMS

ASARECA	:	Association for Strengthening Agricultural Research in Eastern and Central Africa
ANOVA	:	Analysis of Variance
CAN	:	Calcium Ammonium Nitrate
DAP	:	Di-ammonium Phosphate
ECA	:	Eastern and Central Africa
EHC	:	Excel Hort Consult Ltd
FYM	:	Farmyard Manure
FARA	:	Forum for Agriculture Research in Africa
FAO	:	Food Agriculture Organization
GDP	:	Gross Domestic Profit
ISFM	:	Integrated Soil Fertility Management
KARI	:	Kenya Agricultural Research Institute
KEFRI	:	Kenya Forestry Research Institute
KSh	:	Kenya Shillings
KU	:	Kenyatta University
Kg	:	Kilograms
LM	:	Low Midland
LSD	:	Least Significant Difference
MAK	:	Makerere University
M&E	:	Monitoring and Evaluation
MOU	:	Memorandum of Understanding
N	:	Nitrogen
NGO	:	Non Government Organisation
NRM&B	:	Natural Resource Management and Biodiversity
OMs	:	Organic Materials
PME&L	:	Participatory Monitoring, Evaluation and Learning
RAB	:	Rwanda Agricultural Board
RCBD	:	Randomized Complete Block Design
SSA	:	Sub Saharan Africa
SUA	:	Sokoine University of Agriculture
VA	:	Value addition
WAE	:	Weeks after emergence

1.0 INTRODUCTION

1.1 The problem

Eastern and Central African (ECA) countries depend largely on agriculture forming a main source of livelihood for 80% of the population and 38% of the GDP (ASARECA, 2009). However, land degradation and soil fertility depletion grossly limit agricultural productivity (Sanchez, 2002), partly attributed to low investment in soil management technologies. Soil fertility decline can also be attributed to lack of appropriate information and low adoption of available technologies due to inadequate incentives (Lal, 2001). As a result, soil fertility has continued to decline to levels that are currently prohibitive to profitable agriculture. This is a threat to the a growing population in the region majorly dependent on agriculture. According to Breman and Debrah (2003), if ECA is to rely on agriculture for economic development, an annual increase of 4 to 7% in food production is required. The new "Vision for African Agricultural Research" developed by FARA and its member organizations calls for an annual growth rate of 6% in agricultural productivity by 2020 in order to achieve sustainable development in general (FARA, 2003). Given the current trends in agricultural growth, achieving this annual growth rate is an alarming challenge that has been worsened by climate change and variability (World Bank, 2008 and 2010).

By improving the quantity of food, income and resilience of soil productive capacity Integrated Soil Fertility Management (ISFM) has been demonstrated to address soil fertility management complexities on smallholder farms, help resource poor farmers mitigate poverty and food insecurity (Bationo et al., 2003). The ISFM approach involves use of combined application of organic and mineral resources, resilient germplasm and nutrient cycling and conservation (Vanlauwe et al, 2010). It is reported to be an overarching approach to restoring and maintaining soil productivity, and results into synergy and improved conservation and synchronization of nutrient release and crop demand, leading to increased fertilizer use efficiency and higher yields (Vanlauwe et al., 2002). However, synergies between ISFM and other innovations such as value addition and exposure to market opportunities which are critical incentives to investments in agriculture have often been overlooked. Yamano and Kijima, (2010), have shown a positive relationship between soil fertility and crop and livestock incomes. Achieving this requires that households first be linked to markets, so that they can identify higher value cropping opportunities to be able to market their produce. In many parts of ECA producers are only familiar with local markets (where opportunities are limited) and they can initially only offer small quantities of raw agricultural produce, which reduces their attractiveness to potential buyers. Access to markets will remove barriers to commodity exchange, lower transaction costs and improve bargaining power translating into better prices for smallholder farmers. Strengthening public-private sector partnerships is key to increasing the competitiveness of smallholders' produce through improved market access and collective marketing.

While research has developed a number of ISFM technologies, adoption is still limited, and in most cases confined to pilot project areas. Low technology adoption is partly attributed to unfavourable socio-economic conditions such limited access to information, markets and credit which also affect profitability of farming and consequently, re-investment in ISFM. Linking farmers to markets through improved access to market information will facilitate decision making at farm level, increase profitability and facilitate re-investment in ISFM.

1.2 Intervention

This project sought to upscale best-bet ISFM and value addition technologies/innovations to address the problem of rampant soil fertility decline, aggravated by limited investment in ISFM. The project focused on priority commodities to promote ISFM and value addition technologies, increase market options, build capacity of stakeholders in ISFM and value addition, and increase access to knowledge on ISFM and value addition. It was implemented in Kenya, Uganda, Tanzania and Rwanda. It comprised of within country up-scaling of the first phase successes (Kenya, Uganda, Tanzania), and a testing phase (Rwanda).

Results from the baseline surveys indicated a need for ISFM intervention in the project areas due to widespread soil-related problems affecting productivity of most crops. Inorganic fertilizer use is minimal, being unaffordable; animal manure and crop residues are commonly used for soil fertility enhancement. Other options such as Tithonia and compost are not utilized. Farmers also identified lack of adequate storage facilities, lack of cash before produce is sold, inability to access profitable markets and lack of standard measures for farm produce. Farmers expressed a need for capacity enhancement in ISFM, better agronomic practices, post-harvest handling and value addition, as well as marketing and market access to improve farm productivity and profitability.

In Western Kenya (Siaya county), ISFM technologies inclusive of DAP, FYM, Calliandra, Tithonia green biomass and striga tolerant maize varieties (KSTP 94, IR maize, WS502, WS505) were used to improve maize productivity and manage striga on-farm. High value banana (NGOMBE variety) and African indigenous vegetables (crotalaria, *solanum Nigrum*) were promoted as income generating enterprises.

1.3 Project goal, purpose and objectives

1.3.1 Goal:

The overall goal of the project was to contribute to competitiveness of the sub- regional agricultural systems.

1.3.2 Purpose:

This project aimed at enhancing the utilization of ISFM and value addition technologies in the region by focusing on priority commodities selected by farmers in the target project sites. Three purpose-level indicators were addressed: (i) Number of households adopting ISFM technologies; (ii) % change in yields at farm level and (iii) Number of households accessing profitable markets over baseline.

1.3.3 Project objectives

i. To promote gender responsive ISFM and value addition technologies
ii. To increase market options for selected commodities/enterprises
iii. To enhance the capacity of key stakeholders to undertake ISFM and value addition
iv. To enhance the availability/accessibility of knowledge, information and lessons learnt on up-scaling ISFM and value addition

1.3.4 Research sites:

The Kenyan and Siaya County Context

Like other African countries, Kenya's economy is predominantly dependent on agriculture. The sector directly contributes 26 per cent of the GDP and another 25 per cent indirectly. It employs over 40 per cent of the total population and over 70 per cent of the rural people. Food security and poverty remain major challenges for the Government. In Siaya county absolute poverty is over 47 per cent while 37 percent of the county' population is food insecure with about 58 per cent rural inhabitants, living below absolute poverty.

Agricultural Activities

The County relies on rain-fed crop production which is sporadic in nature, consequently leading to seasonal food shortages and dependence on imported supplies from other counties and the neighbouring country of Uganda. However, promotion of Traditional High Value Crops (THVCs), promotion of local poultry, modern small stock systems, and fisheries aquaculture, are the most suitable enterprises for the County. Despite the moderate land sizes with potential for higher crop yields, low household incomes are still a major problem in this county. This is important, taking into consideration that the region has on average of 48% poverty level. More farmers should engage in the production of crops like sorghum, millets, sweet potatoes, rice, groundnuts, cassava among others; since these crops are more suitable than maize that is continuously grown here. Similarly, livestock enterprises like local poultry, intensive dairy systems, small stock, bee keeping and fish cage culture are important.

In general food insecurity in the County is linked to inadequate use of inputs, use of poor agricultural technologies, high dependency on rainfed agriculture, low purchasing power, poor infrastructure and environmental degradation.

The County has relied on food and non food imports continuously for several years to cover the huge food deficits. This has created high levels of households' dependency, complacency within the community, hindering innovativeness and participation in other development initiatives.

Many interventions are needed to put these households and their land into more economically viable productivity; which will go a long way in reduction of food insecurity, increased household incomes, and check on environmental degradation. It is also prudent to mention alternative livelihood engagements of this community such as value addition, crafts, small businesses and fishing especially among women and youth. These are popular traditional coping strategies in this region hence, areas that are also worth exploring for the purposes of increased household food security and improved incomes.

Land and Land Use

Table 1: Land Use data in Siaya County

Item	Status
TOTAL Area (KM^2)	2,530 km^2
Cultivated (Ha)	32,800 Ha is average cultivable area.
Irrigable (Ha)	32,800 Ha
Irrigated (Ha)	582 Ha- this is small farmer holder irrigation along riverine/riparian areas for small holder vegetables and rice production with Dominion Farm.
Dominant soils	Sandy loams, sandy clay loams and clay soils.

Source: FMHB Nyanza Province 2007

Ugunja Sub-County;

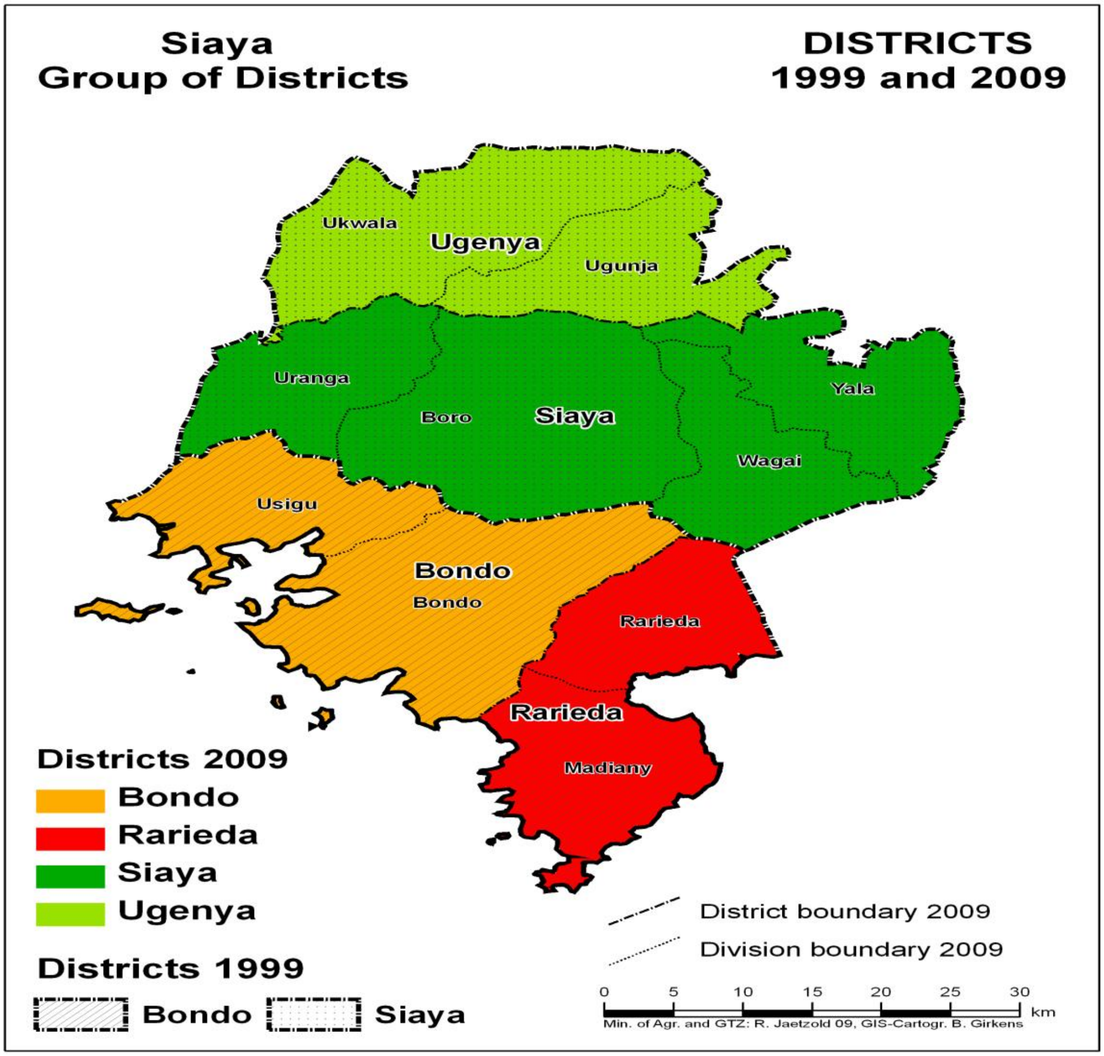
Ugunja Sub County is bordered by Gem and Siaya sub counties to the South, Butere and Mumias sub counties to the East and Ugenya Sub County to the West and North. It covers an area of 212.9 Km^2, with a population of about 93,372 and 17,1559 farm families (2009 population census).It receives bimodal type of rainfall and is suitable for most crops mostly cotton and sugarcane for industrial crops and maize, cassava, bananas, sorghum, and beans, the major source food crops. The population density is average with 440 persons per Km^2 and therefore pressure on land for agricultural cultivation is critical. The road infrastructure is poor with only one tarmac road crossing the sub county and the murram roads are impassable during the rainy seasons. It lies in the lower midland zones as indicated in the table below.

Table 2: Statistical Summary of Basic Sub County Information Data

County Assembly Ward Name	County Assembly Ward Population (Approx.)	County Assembly Ward Area In Sq. Km (Approx.)	Extension Units	Farm Holdings	Farm Families	Ward Extension Staff (WES)	WES/Farmer Ratio
Sidindi	24,527	56.20	1	5,574	4,507	1	1 : 4,088
Sigomere	29,632	72.40	1	6,736	5,445	2	1 : 2,469
Ugunja	39,213	84.30	1	8,912	7,206	2	1 : 3,268
TOTAL	**93,372**	**212.9**	**3**	**21,222**	**17,1559**	**5**	**1 : 3,112**

Remarks

Out of the 212.9 Km^2, 169.5 Km^2 is arable while the rest are covered by road networks, homesteads, hills and swamps which are not under agricultural cultivations.



2.0 EXPECTED OUTPUTS

The project had four outputs: (i) Gender responsive ISFM and value addition technologies promoted. This output aimed at up-scaling best bet ISFM and value addition technologies developed during the first phase ASARECA NRM projects, among stakeholders of different gender categories. The ISFM and value addition technologies differed for each enterprise. Efficient use of ISFM and value addition technologies/innovations would enhance farm productivity and profitability. Output (ii) Market options for selected commodities/ enterprises increased. This output aimed at increasing markets and marketing options for priority enterprises through commodity value chain studies, provision of market information, training in agri-business planning and development, collective marketing among others. Output (iii) Capacity of key stakeholders to undertake ISFM, value addition and marketing enhanced. This output focused on involving, informing, preparing and strengthening the capacity of key stakeholders to jointly promote ISFM and value addition technologies and marketing options for sustained production and increased market opportunities. Output (iv) Availability/accessibility to knowledge, information and lessons learnt on up-scaling ISFM and value addition enhanced. This output aimed at increasing access to knowledge and information on ISFM, value addition and marketing, as well as lessons learnt in up-scaling ISFM and value addition approaches. Progress was tracked through 13 indicators.

3.0 LITERATURE REVIEW

3.1 Integrated soil fertility management

Despite the limitations outlined above, soil productivity must be stored in sub Saharan in order to ensure food security. If Africa seeks to rely on agriculture for economic development, an annual increase of 4 to 7% in food production is required (Breman and Debrah, 2003). Integrated soil fertility management (ISFM) is proposed as an overarching approach to restoring and maintaining soil productivity, better suited to the particularities of smallholder farming systems in sub-Saharan Africa. A comprehensive but yet simpler definition of ISFM refers to the combined use of organic and mineral resources and resilient germplasm to ensure efficient use and cycling of nutrients to achieve food security, while maintaining soil productivity in the long term (Vanlauwe *et al*., 2002). A core principle in ISFM is the use of organic resources in combination with mineral fertilizers, which often leads to synergies or additive effects. The combination of organic and inorganic nutrient sources has been reported (Vanlauwe *et al*., 2002) to result into synergy and improved conservation and synchronization of nutrient release and crop demand, leading to increased fertilizer use efficiency and higher yields. Although the mechanistic basis of such interactions was not always clearly understood, different technological options have been developed to capitalize on such synergies. Palm *et al*. (2001) developed a database containing numerous organic resources of use in the tropics and derived a simple decision tree for managing such resources, based on their N, ligin, and polyphenols contents. Extensive research efforts have been devoted to guide decisions on organic resource management that ensure a proper match between nutrient release from organic resources with crop demand for nutrients, with particular emphasis on N (Giller *et al*., 2002).

However, while a considerable body of information has been developed on different approaches for soil fertility management in smallholder Africa farms (Vanlauwe *et al*., 2002), there is notably scarce uptake and implementation of such knowledge by farmers. Despite dissemination failures, restricts to technology adoption can be sought among socio-economic, cultural and political factors. A fundamental problem is also the lack of integration and implementation of knowledge by the scientific community (Giller *et al*., 2006). Much information on different technologies for soil fertility management (e.g. multipurpose agroforestry trees, green manure, organic and mineral fertilizer combinations, etc.) has been derived from research done mainly on plot scale. Few studies have compared the potential of these options at the scale of a farm system, considering multiple constraints and opportunities in the short and long term.

The implementation of ISFM faces a number of challenges due to the particularities of smallholder farming systems in sub-Saharan Africa. Farming systems are diverse, heterogeneous and dynamic. While different regions, agroecological zones or types of farmers may experience different opportunities and constraints for the implementation of ISFM, heterogeneity within single farm affects the performance of various soil improving technologies. Often the evaluation of ISFM technologies must be done considering long term, strategic time horizons, while farmers are more concerned with meeting immediate needs.

3.2 The problem of Striga (witchweed) and control practices

3.2.1 Striga in sub-Saharan cereal production systems

In low-input, cereal cropping systems in sub-Saharan Africa, the genus *Striga* (*Orobanchaceae*) *is* one of the most important biotic constraints affecting crop production (Esilaba and Ransom, 1997). *Striga* weeds are found in most regions of SSA except areas, where either precipitation is too high or temperatures are too low for its development (Lagoke *et al*., 1991). It is found from sea level up to 1600 m altitude, in agricultural production systems with rainfall from 500 up to 2000 mm and in almost all soil types. Current estimates put the number of species in this genus at between 25 and 60 (Ejeta *et al*., 1992). Yield losses in staple cereal crops from damage by *Strig*a range from a small percentage up to complete crop failure depending on factors such as crop species, the inherent sensitivity of the crop the cultivar, level of infestation, rainfall pattern and soil fertility (Weber *et al*., 1995). Infestation may even reach critical levels, making continued cultivation impossible and leading to the abandonment of fields (Parker, 1991).

S. hermonthica (Del) Benth. and *S. asiatica* (L.) Kuntze are the two most widespread and the most economically significant species that paratisize on sorghum *Sorghum bicolor* [L] Moench), pearl millet *Pennisetum glaucum* [L.] R Br. maize (*Zea mays* [L.] and rice (*Oryza sativa* [L.]), whereas *S. gesnerioids* (Willd.) Vatke attacks crops such as cowpea *Vigna unguiculata* L. Walp.) and peanut *Arachis hypogaea* L.) Oswald, 2005. The various *Striga* species have coevolved with their respective hosts and have been present in these cropping systems for many years. Because these systems included prolonged fallow, crop rotations, and intercropping, populations of this parasitic weed seldom reached epidemic proportions. However, since cropping systems changed to more permanent monocropping *Striga* poses an increasing problem especially in cereal-based cropping systems (Kroschel, 1999). *Striga* is considered an indicator of low soil fertility (Orr and Ritchie, 2004: Oswald, 2005). Consequently, *Striga* is most problematic on infertile or nutrient–depleted soils with low organic matter content and a weakened host crop. Under conditions of successive and sole cultivation of susceptible crops and crop-varieties, a large *Striga* seed bank can rapidly build up. This results from increasing inputs of *Striga* seeds on one side, and on the other hand, degrading soil conditions under continuous cultivation that diminish presence and activity of micro-organisms that could affect decomposition of *Striga* seeds in the soil. As a result, the extent and intensity of *Striga* spp. infestations have rapidly increased and become threats to food production in the entire semi-arid and sub-humid region’s farming systems of Africa. From all parasitic plant species, *S hermonthica* is considered as the most damaging and widespread parasitic weed species on a wide scale (Plate 1).

Plate 1: Striga infested maize field at Nyabeda in western Kenya

3.2.2 Striga control and its challenges

Striga primarily is a problem in small–scale subsistence farming systems with few options for external inputs including pesticides and fertilizers (Ransom, 2000). Under these conditions, there are major challenges to effective control of *S. hermonthica*. One of the main challenges is the fact that these root-parasitic weeds cause most of their overall damage to the host crop during their subterranean stage (Eplee and Norris, 1995). This implies that controlling the emerged *S. hermonthica* plants gives limited immediate benefit.

A large variety of agronomic, genetic, chemical and biological methods to combat *Striga* have been developed so far, ranging from measures that are directed at soil fertility improvement to those that have an immediate effect on emerged *Striga* plants (Oswald, 2005). Various studies have shown that *Striga* infestation is frequently associated with low soil fertility, reflected in low organic matter content, low biological activity and a weakened host crop (Oswald, 2005). A substantial amount of work has been carried out to study the effects of soil fertility on *Striga* infestation (Abunyewa and Padi, 2003; Gacheru and Rao, 2005; Reda *et al*., 2005). Increasing soil fertility not only stimulates the growth of the host but also adversely affects longevity of the seeds in the soil, germination and attachment. Hence, improved soil fertility conditions, whether by crop rotation, fallowing or farmyard manure, are likely to lead to reduced infestation. However, these methods often require several years of intervention to improve the soil fertility status and, consequently, *Striga* infestation level.

Other, more direct, *Striga* control methods are directed on prevention of reproduction of the parasite and reduction of viable seedbank in the soil (Lendzemo *et al*., 2005; Oswald, 2005). These control methods which include hand-weeding, herbicides, biological control, are known to reduce the number of parasites attached to the roots of the host. Transplanting, use of resistant seed varieties, use of seed dressed with herbicides, trap cropping and ethylene directly reduce the seed bank in the soil.

An important element of *Striga* control strategies is host plant defence. Two main groups of defence mechanisms against *Striga* can be distinguished: resistance and tolerance. Resistant varieties are defined as those that show reduced infection level of the host plant. Tolerance on the other hand enables a host plant to perform well, despite the parasitic infection. However, complete resistance, or immunity, against *Striga* has not been developed. Since a small number of *Striga* attachments can cause high levels of yield reduction, resistance alone may not be adequate to prevent crop losses. It is therefore recommended to direct breeding efforts towards developing varieties that combine resistance with high levels of tolerance (Rodenburg, 2005).

Despite the high potential of some of those control methods, none of these methods alone has proven to efficiently reduce *Striga* and improve crop yield in a sustainable way. Many authors (Berner *et al*., 1995; Oswald, 2005) have emphasized the need for implementing several control methods as an integrated control approach that may improve efforts to maintain the *Striga* population at manageable levels and at the same time reduce crop losses. The development of high yielding, *Striga*-resistant and tolerant crop varieties, combined with cultural and mechanical control methods, may play a key role in reducing *Striga*-infestation and increase cereal production in *Striga* infested areas.

4.0 TECHNICAL NOTE ONE

4.1 EFFECT OF INTEGRATERD SOIL FERTILITY MANAGEMENT ON MAIZE YIELD AND STRIGA INFESTATION IN WESTERN KENYA

ABSTRACT

Declining soil fertility and *Striga hermonthica* (Del) Benth infestation are serious threats to sustainable food production in western Kenya. We assessed the effect of integrated use of three organic resources (Calliandra, Tithonia and farm Yard manure) applied alone or in combination with DAP and CAN on *Striga* infestation and maize yield in a field experiment carried out for two consecutive seasons on a clay loam Ferralsol in western Kenya. The organic resources were combined with inorganic fertilizers as to supply at 75 kg N ha^{-1}. Data on *Striga* infestation and grain yield of maize were recorded at harvest in each season.

All the yield components were significantly affected by treatments ($P < 0.05$). Highest grain yield (2.53 t ha^{-1}) and total biomass (5.93 t ha^{-1}) were recorded in 15kg N from Calliandra plus 18 kg N DAP and 26 kg CAN. The same treatment out yielded the control by 400% and sole inorganic fertilizer by 49% respectively. The control gave consistently the lowest yields. The study showed soil nitrogen was critical for reduction in *Striga* infestation and maize production. Farmer led evaluation of the various technologies will determine which of those is really most acceptable under the prevailing farming conditions. Further studies are needed to establish the optimal combinations of other plant residues with DAP and CAN.

INTRODUCTION

Soil fertility decline is increasingly viewed as a critical problem affecting agricultural productivity and environmental welfare in Sub-Saharan Africa (SSS) (Bationo *et al*., 2004). Studies indicate the decline is a result of combination of high rates of erosion, leaching, removal of crop residues, continuous cultivation of land without adequate fertilization or fallowing (Sanchez and Jama 2002). This is aggravated by the inherent poor fertility in most tropical soils (Okalebo *et al*., 2003). Consequently, SSA has experienced a decrease in overall per capita food production with soil fertility being recognized as the fundamental root cause for declining food security.

In Kenya, maize (*zea mays)* is a major food crop and dominates all food security considerations with a capita consumption of 103 $kgyr^{-1}$ (Pingali, 2001). Smallholder famers in western Kenya rely on maize as the staple food crops but its production is low estimated at 0.5 to 1.5 t ha^{-1} yr^{-1} (Ouma *et al*., 2002) against a production potential of 4 ha^{-1}. The major cause of this low yields is soil nutrient depletion indicated by negative nutrient balances. The average annual loss in soils nutrients of 42 kg, N, 3 kg P and 29 kg Kha^{-1} in Kenya is among the greatest in Africa (Smaling *et al.,* 1997). Reversal of soil fertility depletion is required to increase per capita agricultural production. Use of inorganic fertilizers is one of the ways of addressing this situation but is constrained by the high costs that the resources poor farmers cannot afford. On the other hand the sole use of organic materials (OMs) to supply N for crop production is not a practical option because most of the OMs are low in N, thus large amounts would be required to produce moderate yield increases (Palm *et al*., 2001). There is therefore an urgent need to develop and promote alternative appropriate technologies that will replenish soil nutrients to enable farms to be more productive in order to meet the ever rising food demand. One of the approaches is the integrated nutrient management that combines use of organic inputs with chemical fertilizer. The beneficial effects of combined organic and inorganic sources of soil fertility, crop yields, and maintenance of soil organic matter have repeatedly been shown in field trials (Mugwe *et al*., 2007, Mucheru-Muna *et al*., 2007., Vanluawe, *et al*., 2002., Nyambati, 2011). Research has focused on development of alternative cost effective technologies using organic and /inorganic inputs to address the problem. Most of the research evaluating these inputs has emphasized on the inputs that have the ability to achieve high yield responses without taking into consideration farmer evaluation and economic implication of the investment. However yield alone is not a good indicator of production efficiency and farmer preference. This is because soil nutrient replenishment is an investment (Franzel *et al*., 2002) and therefore farmers adopt technologies that are profitable according to their evaluation, which may be based on other consideration other than biophysical yield. Few studies have been conducted to evaluate the performance of these inputs with farmers.The objectives of this study is therefore to assess the effect of applying organic materials, solely or combined with inorganic fertilizers on maize yields (ii)

MATERIALS AND METHODS

Experimental site

This study was conducted at Nyabeda (N 0° 08', E 34° 24') in Siaya District of western Kenya. The area is classified as midlands (LM 2) with an altitude of approximately 1330 m above sea level (Jaetzold and Schimdt 1983). Rainfall is bimodal, allowing two cropping seasons a year with the long rains starting from March ending in July and the short rains starting from August ending in November, with a mean annual of 1800 mm (Figure 1). Mean annual temperature ranges between 22^0C and 24^0C. The soils are classified as Ferralsols/Nitisols (Kandiudalfic Eutrudox), clayey, reddish, deep and well drained (Jaetzold and Schimdt, 1983). The soil chemical and physical properties at the onset of the experiment are shown in table 1.

Table 1: Properties of (0-15cm) soil at Nyabeda experiment site in western Kenya

Attribute	**Value**
pH (1: 2.5 soil: water)	6.1
Organic C (%)	2.33
Total N (%)	0.23
Olsen P (mg kg^{-1})	2.75
Calcium ($cmol_c$ kg^{-1})	7.96
Magnesium($cmol_c$ kg^{-1})	4.78
Potassium ($cmol_c$ kg^{-1})	0.05
Sodium ($cmol_c$ kg^{-1})	0.40
Exchangeable bases($cmol_c$ kg^{-1})	13.2
Clay (%)	23
Silt (%)	14
Sand (%)	63

Experimental design, establishment and management

This experiment was laid out in a randomized complete block design (RCBD) with six treatments replicated four times with each treatment plot measuring 6m x 6m. Treatments consisted of organic resources applied alone or in combination with DAP and CAN. Organic resources were combined with inorganic fertilizers to supply 75 kg N ha^{-1} except the control i.e treatment 0:0 (Table 2). The organic materials were weighed, chopped and incorported into the soil at a depth of 15 cm at planting in all the seasons. This was followed by CAN at six weeks as topdressing. One day after treatment application a commercial maize variety WH 502, commonly grown by farmers in the area, was planted as a test crop at a spacing of 75 cm between rows and 30 cm between planting holes. Two seeds were planted per hill and later thinned to one seedling per hill two weeks after emergence (WAE) to give a total maize population of 44,444 plants ha^{-1}. Maize was planted at the beginning of every rainy season (March in long rains and August in short rains). Other agronomic practices for maize production will be appropriately followed after planting.

Table 2: Description of treatments used in the field trial

Treatment No.	Organic resource	N equivalency[kg N ha^{-1}] in plant residues	DAP [kg N ha^{-1}]	Top-dress (CAN)
1	None	0	0	0
2	*Calliandra*	30	18	26
3	*Calliandra*	15	18	42
4	*FYM*	30	18	26
5	Tithonia	30	18	26
6	None	0 (0%)	18	57

Striga count and collection in the field

Data were collected on *Striga* infestation in all the plots. *Striga* shoots that emerged in the field were counted in the four middle rows (4.5m*4m) at 2 week intervals starting from the day of *Striga* appearance and the maximum number of shoots recorded in each plot was recorded as *Striga* infestation. *Striga* emergence data were converted to the number of Striga plants m^{-2}. All *Striga* plants collected were sun dried and their weights recorded.

Statistical analysis

Analysis of variance (ANOVA) and mean comparisons on the data to determine the effects of treatments on *Striga* incidence and maize grain yield were done using Genstat 10 for windows (Release 16). Data of *Striga* infestation was transformed by natural logarithim to eliminate heterogeneity before conducting the ANOVA. A regression analysis was carried out to determine the relationship between *Striga* incidence and maize grain yield. The treatment differences were tested on the transformed values using the Least Significant Difference (LSD) test at 5% propbability.

RESULTS

Maize grain yields

Grain, stover, core and total biomass yields of maize are shown in (Table 3). All the yield components were significantly affected by treatments ($P < 0.05$) in season one. Mean grain yield was 1.64 t ha^{-1} and ranged between 0.5 t ha^{-1} control and 2.53 t ha^{-1} under a combination of 15 CC+DAP+CAN. Mean total biomass yields was 4.72 t ha^{-1} and ranged between 2.16 t ha^{-1} control and 5.93 t ha^{-1} under a combination of 15kg N from Calliandra plus 18 kg N DAP and 26 kg CAN. On average, 15kg N from Calliandra plus 18 kg N DAP and 26 kg CAN out yielded the control by 400% and sole inorganic fertilizer by 49% respectively. A combination of 15kg N from Calliandra plus 18 kg N DAP and 26 kg CAN out yielded the control by 175 and sole inorganic fertilizer by 11.7% respectively. The control gave consistently the lowest yields.

Table 3: Effect of treatments on maize yields

Treatment	Grain yield (t ha^{-1})	Stover (t ha^{-1})	Core (t ha^{-1})	Biological yield (t ha^{-1})
T1	0.5	1.5	0.16	2.2
T2	1.8	2.7	0.48	4.9
T3	2.5	2.8	0.56	5.9
T4	1.5	2.2	0.42	4.2
T5	1.9	3.6	0.44	5.9
T6	1.7	3.2	0.38	5.3
Mean	1.6	2.7	0.41	4.7
P	0.002	0.006	0.009	0.001
lsd	0.75	0.97	0.19	1.56
cv	13.9	2.8	11.2	5.0

T1=Control, T2=30kg N Callindra+18 kg N DAP+26 kg N CAN, T3=15kg N Callindra+18 kg N DAP+42 kg N CAN, T4=30kg N FYM+18 kg N DAP+26 kg N CAN, T5=30kg N Tithonia+18 kg N DAP+26 kg N CAN, T6=18kg N DAP+57 kg N CAN,

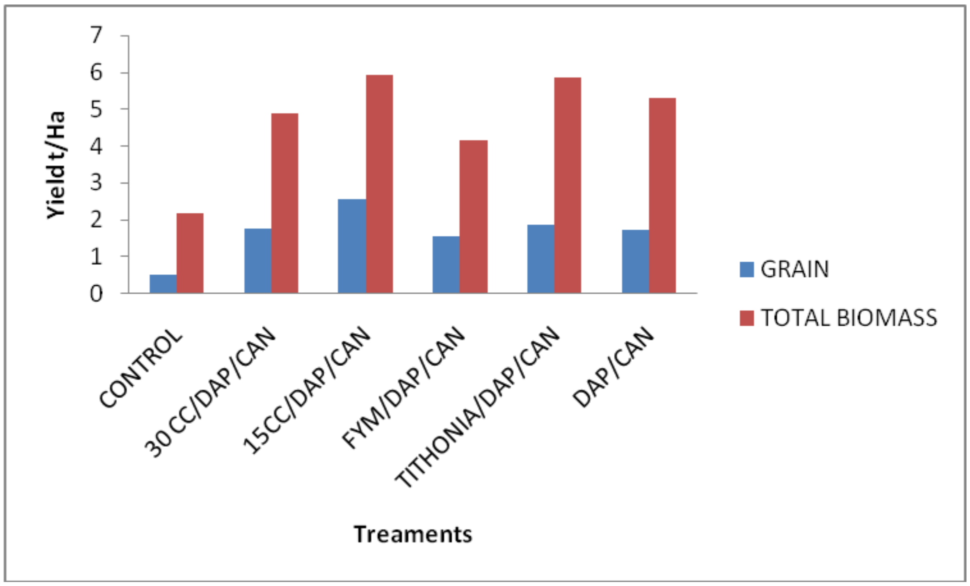


Figure 3: Grain and total biomass yield in LR 2013 as recorded at Nyabeda

Relationship between *Striga* density and maize grain yield

Maize grain yields generally decreased with increase in *Striga* infestation (Figure 3). However, the negative linear relationship between maize (y) yield and *Striga* population (x) was not significant in the 2013 long rains (Figure 3).

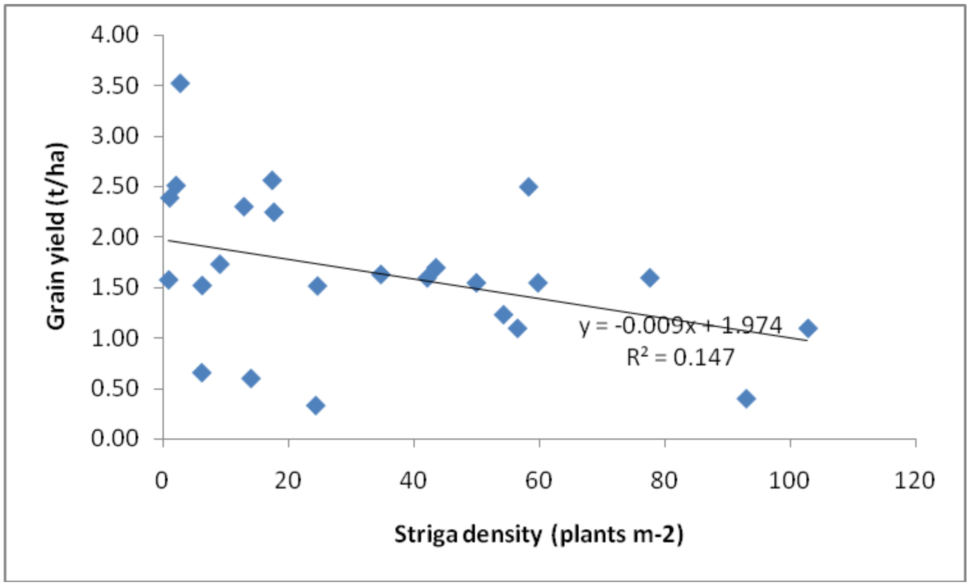


Figure 3: Relationship between *S. hermonthica* density and maize grain in LR 2013 as recorded at Nyabeda

Discussion

Effect of treatments on maize yields

The consistently higher maize yields recorded where 15kg N CC+18 kg N DAP+ 42 kg N CAN than sole inorganic fertilizer treatment was attributed to higher amounts of nutrients mainly nitrogen that was availed by these inputs for maize growth. This is an indication that integrated use of organic and inorganic nutrient sources of N is advantageous over the use of inorganic fertilizer alone. Earlier studies that demonstrated that the use of organics could enhance efficiency of chemical fertilizers (Mucheru *et al*., 2006; Mugwe, 2007). The combination of organic and inorganic nutrient sources has been reported (Vanlauwe *et al*. 2002) to result into synergy and improved conservation and synchronization of nutrient release and crop demand, leading to increased fertilizer use efficiency and higher yields. The higher soil mineral nitrogen may have led to reduced production of *Striga* stimulant by the host plant. Nitrogen has been associated with inhibiting germination of *Striga* seeds and their subsequent attachment on the host plant (Gacheru and Rao 2001). Soil nitrogen also promotes vegetative growth of the host plant, helping it to escape severe *Striga* parasitism (Gacheru and Rao 2001). Earlier reports have suggested that fertilizer application can reduce *Striga*–inflicted crop damage but may also be the result of a healthier crop rather than reduced *Striga* emergence (Showemimo *et al*., 2002).

The lower maize yield in manure treatments in comparison to those of *Tithonia*, and *Calliandra* could be attributed to lower rates of manure decomposition and therefore slow rate of availing nutrients to the maize crop. Though the amount of N added via all these organic materials was the same (75 kg N ha^{-1}), cattle manure contained lower nitrogen concentration than all the others and could have released the N slower due to higher C:N ratio compared to the other organic materials.

Low grain yields obtained in the control could be attributed to nutrient deficiency particularly nitrogen or reduced N release (Delve *et al*., 2001; Mwale *et al*., 2000b) and high levels of *Striga* infestation under these treatments. Crops growing in N deficient soils are often more severely damaged by *Striga* than those growing in soils well supplied with nitrogen (Menkir and Kling, 2007). *Striga* infestation has a direct effect on maize leaf N uptake and biomass production through competition for nutrients. *Striga* is known to draw food (photosynthates, minerals and water and carbon compounds) from its host (Kim, 1991). Apart from parasitism, *Striga* impairs photosynthetic efficiency (Stewart *et al*., 1991) and exerts phytotoxic effects (Ransom *et al*., 1996). Yield loss can range from 20 % in low infested to 100 % where infestations are high (Ransom *et al*., 1996).

5.0 TECHNICAL NOTE TWO

5.1 Effects of *Striga hermonthica* on components of different maize varieties in western Kenya

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in eastern Africa, where it serves as both food and cash crop for millions of people. However, maize production is carried out in environments that pose serious threats to crop production leading to low crop yields. Grain yields under farmers' conditions in western Kenya (1.0-0.5 ha) have been observed to be less than 25% of the potential yield (Tittonel *et al*., 2005). Declining soil fertility and *Striga* spp.(witchweed) have been ranked as the major constraints to maize production in western Kenya (Odendo *et al*., 2001).

Abiotic stresses are as important as biotic stresses in limiting maize production in Sub-Saharan Africa. Moisture stress affects yields on an estimated 40% of the maize sown in low land tropical environments (Edmeades *et al*., 1989). Soils are generally inherently infertile and most especially those under subsistence agriculture have been mined for nutrients for years without replenishment with fertilizer inputs. Although not an abiotic stress, the parasitic weed *Striga* is a symptom of inappropriate maize production system and soil impoverishment, affecting an estimated 20 M ha of land in sub-Saharan Africa. (Lagoke *et al*., 1991). *Striga* weed attaches to the roots of the maize and other gramminea species and competes with the host plant for water and nutrients as well as exerting a potent phytotoxic effect on the host (Ransom *et al*., 1996).

An estimated 20 to 40 million hectares of farmland in sub-Saharan Africa are infested with *Striga* where it causes as much as US$ 7 billion in lost yield per annum and affects the welfare and livelihood of over 300 million people (M'Boob, 1989). In the Lake Victoria basin of Kenya alone, *Striga* ssp. infests about 212,000 ha which is about 15% of the arable land (www.fao.org; CEPA, 2004), causing yield losses of between 30-50%, although losses of upto 100% have been reported (Hassan *et al*., 1995).

In Africa, where farmers are resource poor and cannot afford high input options, the use of resistant/tolerant varieties is acknowledged as the most practicable and sustainable solution. Of the 23 species of *Striga* species. Prevalent in Africa *Striga hermonthica* is far by the most socio-economically important in East Africa (Emechebe and Ahonsi, 2003). Maize is the dominant cereal crop in the moist savanna area of sub-Saharan Africa (FAO, 1992) where *S. hermothica* problem has been most severe. Maize varieties developed for the western Kenya region show different levels of tolerance to *Striga*. Tolerant varieties are infected underground but are able to minimize damage and yield losses due to parasitism (Kim *et al*., 1997).

Yield, a quantitative trait, is functionally related to yield components. Information on the effects of *Striga* on maize yield components could be useful to physiologist, modelers, and plant breeders. Such information is, however scanty in the literature. Such information provides a vehicle for increasing efficiency of input and resource use by the crop, reducing the risks farmers face in using purchased inputs and perhaps encourages the adoption of improved technologies. The aim of this study was therefore to: (i) determine the effect of integrated nutrient management on *Striga* incidence in maize (ii) determine the effects of integrated nutrient management on yield and yield components of maize under *Striga* infestation.

Experimental design, establishment and management

The experiment was laid out in a randomized complete block design (RCBD) with four treatments replicated four times with each treatment plot measuring 6m x 6m. Fertilizer was applied at the rate of 75kg kg N. DAP was applied 33.3% at planting and CAN (66.6%) six weeks later. The following maize varities (KSTP 94, IR maize, H 520, H505) was planted at a spacing of 75 cm between rows and 30 cm within the rows. Two seeds were planted per hill and later thinned to one seedling per hill two weeks after emergence to give a total maize population of 44,444 plants ha^{-1}. Weeding was done at three and six weeks after planting.

Table 4: Field layout

BLOCK 1	**BLOCK 2**	**BLOCK 3**	**BLOCK 4**
101- KSTP 94	201-IR-MAIZE	301-H505	401-H520
102- IR-MAIZE	202-KSTP 94	302-H520	402-H505
103- H505	203-H520	303-IR-MAIZE	403-KSTP 94
104- H520	204-H505	304-KSTP 94	404-IR-MAIZE

Striga count and collection in the field

Data were collected on *Striga* infestation in all the plots. *Striga* shoots that emerged in the field were counted in the four middle rows (4.5m*4m) at 2 week intervals starting from the day of *Striga* appearance and the maximum number of shoots recorded in each plot was recorded as *Striga* infestation. *Striga* emergence data were converted to the number of Striga plants m^{-2}. All *Striga* plants collected were sun dried and their weights recorded.

Data collection was based on plants in the two central rows. Data on maize damage score was based on a scale of 1 to 9 (1=normal plant growth, no visible damage; 9= severe damage or death) at 10 weeks after planting of maize (Kim, 1994). Details of the rating are as follows:

1= normal plant growth, no visible symptoms,
2= small and vague purplish-brown leaf blotchets visible
3=mild leaf blotching with some purplish-brown necrotic spots
4=Extensive blotching and mild wilting. Slight but noticeable stunting and reduction in ear and tassle size
5= Extensive leaf blotching, wilting and some scorching. Moderate stunting, ear and tassle size reduction
6= Extensive leaf blotching with mostly fray necrotic spots. Some stunting and reduction in stem diameter, ear size and tassel size.
7= Definite leaf scorching, with gray necrotic spots, and leaf wilting and rolling. Severe stunting and reduction in stem diameter, ear size, and tassel size, often causing stalk lodging, brittleness, and husk opening at a late-growing stage.
8=Definite leaf scorching with extensive gray necrotic spots. Conspicuous stunting, leaf wilting, rolling, severe stalk lodging, and brittleness. Reduction in stem diameter, ear size and tassel size.
9= complete scorching of all leaves, causing premature death or collapse of host plant and no ear formation

Statistical analysis

Analysis of variance (ANOVA) and mean comparisons on the data to determine the effects of treatments on *Striga* incidence and maize grain yield were done using Genstat 10 for windows (Release 16). Data of *Striga* infestation was transformed by natural logarithim to eliminate heterogeneity before conducting the ANOVA. A regression analysis was carried out to determine the relationship between *Striga* incidence and maize grain yield. The treatment differences were tested on the transformed values using the Least Significant Difference (LSD) test at 5% propbability.

RESULTS

Maize damage score and emerged Striga plants

Differences among the damage scores of the hybrids were not significant ($p<0.05$). Damage score ranks of the hybrids corresponded to their known tolerance responses.

Although the mean Striga emergence count

Maize yields

Grain, stover, core and total biomass yields of maize are shown in (Table 4). There were significant differences ($P < 0.05$) between maize varieties in all yield components (Table 4). Mean grain yield was 1.8 t ha^{-1} and ranged between 1.5 t ha^{-1} (IR-Maize) and 2.0 t ha^{-1} (H 505). Mean total biomass yield was 5.0 t ha^{-1} and ranged between 4.3 t ha^{-1} (IR-Maize) and 5.7 t ha^{-1} (H 520) (Table 4). IR-maize gave recorded the lowest in all yield components.

Table 4: Maize yields

Maize variety	Grain yield	Stover yield	Core yield	Biological yield

	(t ha^{-1})	(t ha^{-1})	(t ha^{-1})	(t ha^{-1})
KSTP 94	1.6	2.7	0.30	4.5
IR-MAIZE	1.5	2.4	0.37	4.3
H505	2.0	3.1	0.42	5.5
H520	2.0	3.2	0.46	5.7
Mean	1.8	2.8	0.4	5.0
lsd	0.411	0.5	0.08	0.83
cv	14.4	4.0	9.9	8.1
P(0.05)	0.03	0.01	0.02	0.009

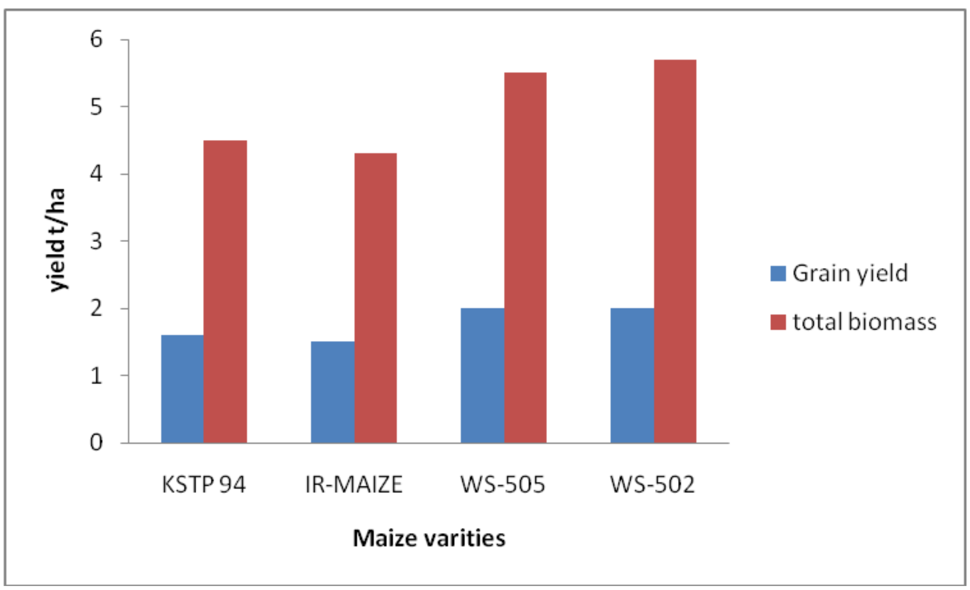


Figure 4:Grain yield and biological biomass of different manize varities in LR2013 at Nyabeda

Maize yield components

Ear traits

Data on yield components is shown in Table 5. Ear diameter showed highly significant differences among hybrids (P<0.05). The highest 5.0 cm was recorded by H505 and the lowest 4.3 was recorded under KSTP 94. Maize varieties did not show any significant differences between ear diameters. Although not significantly different ear aspect did not vary under among maize varieties. It ranged between 3.3 (H520) and 4.5 under (IR-Maize).

Kernel traits and grain yields

Kernel rows and 100-kernel weight were significantly different (P<0.05) among maize varieties. The highest kernel rows (16) were recorded was recorded by H505 while the lowest (12) was recorded by KSTP 94. The highest 100-weight (34.7) was recorded under KSTP94, while the lowest (22.5) was recorded under H520.

Table 5: Effect of Striga on yield components

TRT	Ears/plant	Diameter cm	Length cm	Kernel rows	Kernels/row	100-kernel weight(g)	score
KSTP 94	0.85	4.3	16.5	12	33.5	34.7	4.3
IR-MAIZE	0.83	4.3	17	14	36.5	26.9	4.5
WS505	0.94	5.0	18	16	37	26.0	4.0
WS520	0.95	4.4	17.8	14	38.5	22.5	3.3
Mean	0.89	4.5	17.3	14	36.4	27.5	4.0
P(0.05)	0.079	0.022	0.29	0.004	0.136	0.001	0.28
lsd	0.114	0.49	1.91	1.48	4.34	3.4	1.41
cv	2.1	2.5	3.8	2.3	3.6	0.6	13.5

Effects of Striga infestation on yield components

The remarkable differences in grain yields exhibited by the hybrids were related with variation for reduction in yield components by the parasite. This relationship was evident in the significant correlation obtained between yield and nearly all the yield components. *Striga* affected all the yield components although the severity for each component differed with treatments. Apparently grain yield variation was cumulative for crop response for hosts of yield components. Although KSTP 94 and IR-maize were expected to be superior in all yield components, this was not the case as the other two hybrids that are known to be susceptible to Striga outperformed them. The reason for this contrast performance are not clear.

In addition to host genotype, the nature of a stress factor determines the yield components affected and the magnitude of the effect. The life cycle of *Striga* is closely linked to that of its host, and the latter is exposed to parasitism for almost the entire duration of its life cycle. Apart from parasitism, *Striga* impairs photosynthetic efficiency (Stewart *et al*., 1991) and exerts phytotoxic effects (Ransom *et al*., 1996) on its host.

6.0 KEY LESSONS LEARNED

- Up-scaling requires a combination of approaches and is more effective where farmer groups are used as an entry point, as the officials are more accountable to other group members leading to easier mobilization and follow ups.

- Active involvement of farmers, extension officers and provincial administration in trial establishment, maintenance, and harvesting and data collection increases their interest and ownership may consequently enhance technology acceptability, adoption and eventually sustainability.

- Farmers have learnt that tree nursery development and local vegetable farming is a more lucrative business/enterprise than the prestigious dairy, poultry and maize-bean as highly perceived by the farming community.

- Adoption of long term projects like tree planting are highly enhanced with the integration of high value enterprises of short term duration leading to early investment recovery.

- It was a surprise that the much talked about Striga tolerant/ resistant varieties by the various research organization and seed companies were far much out done by a commercial variety in a Striga infested field. The promoters of the seed have never shown any pride on the Striga tolerant level of their seed despite the fact that Striga is major drawback in cereal production in Africa.

WAY FORWARD

1. Rain fed agriculture is a limiting factor in the commercialization of agriculture. Artificial water provision for the farmers needs to be exploited if farming is to be taken to a higher level from subsistence.
2. TOTs to be certified and be further capacity built to improve on their efficiencies. This should also be accompanied with some support in form of working tools e.g. mobility, communication equipments, establishment of recourse centres etc.

3. The programme may assist in the establishment of a credit scheme for the working groups to facilitate the adoption of farming as a business. These would entail the provision of the starter capital and capacity building among others.
4. Strengthened research, extension and farmer linkages to reduce the knowledge gap among the three players.

CHALLENGES AND SOLUTIONS IDENTIFIED

1. The project period was a limiting factor as ISFM technology up-scaling requires a much longer period of engagement with communities to concretise emerging successes and address emerging challenges.
2. Most partner institutions had inadequate capacity to analyse baseline survey data and even where the ASARECA-supported statistician was available to assist during regional meetings, time was too short to accomplish the task. As a solution, members resorted to the already stretched local staff, although this was also limited due to capacity issues.
3. There was inadequate transport capacity to enable the project team to implement the planned activities. Members relied on the few institution vehicles many of which were old and therefore in poor mechanical condition. In future ASARECA should facilitate project teams with vehicles to allow smooth implementation of activities.
4. There is need to strengthen the monitoring and evaluation system at the ground level. These would call for support to facilitate the interpretation refining and further development of the monitoring and evaluation tools with the full participation of the beneficiaries throughout the life of the project.

RECOMMENDATIONS

- There is need to initiate producer groups and marketing associations to sustain supply of improved seed and technology adaptation.
- Farmers through groups should be encouraged to pool financial resources to trigger farming as a business. This would improve the investment along the value chain and cautioning small-scale farmers from unaffordable credit.
- There is need to support communities in groups through the strengthening of collective marketing, developing of strategic collection centres and negotiations with market masters to set aside farmer only stalls at market places.

Q1 Strategies/approaches/methodologies and institutions structures which can be used to intensify/ sustain adoption of ISFM

i. The use of farmer institutions as an entry point e.g. farmer groups

ii. Existing institutions e.g. Forest officers, extension officers, Provincial administration, Stakeholders at different levels, Political wing, Faith based organizations, Fabricators
iii. Wholesome demonstrations addressing the whole value chains of the targeted enterprises

Strengthening Institutions

i. Indentify and carry out capacity building to the Institutions
ii. Given tasks to perform to enhance full participation and ownership
iii. Develop champions e.g. platforms as innovative ways to address sustainability
iv. Provision of facilities and equipments e.g. communication, hard and software, laboratory facilities etc.
v. Develop ToTs through capacity building and provision of support in terms of mobility to reinforce the weakening extension services.

Q2 Locally acceptable strategies to be promoted to enlarge the market option

i. Advocating for the formation of strong marketing groups
ii. Promotion of value addition at household levels
iii. Strengthening the weakest links within the value chains
iv. Develop champions e.g. platforms
v. Scale up demonstrations on best bet technologies as per the farmer evaluation reports

Q3 Mechanisms to increase the capacity of smallholder farmers to engage in value chains

i. Training in Enterprise identification, enterprise development, value chains, record keeping, farm business plans.
ii. Provision of relevant information on various enterprises e.g. on priority enterprises
iii. Market linkages
iv. Linkages to service providers e.g. researchers, extensions and credit providers
v. Encourage the formulation of policies that promote enterprise development through the provision of support services e.g. infrastructure to facilitate marketing, transport and communication

Q4 Approaches and mechanisms which can be used to increase availability of ISFM and value addition information

i. Study tours
ii. Establishment of demonstrations at village levels
iii. Provision of information e.g. documentaries, reading materials like manuals, brochures, pamphlets,
iv. Develop simple search engine (ICT) that can make use of mobile in market information provision
v. Strengthening cooperatives
vi. Formation of marketing farmer groups
vii. Direct linking of farmers to traders
viii. Upgrading value chains with a view of minimizing inefficiencies

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Market-focused ISFM changed Mr. Cosmos Oduor farm income and livelihood

Mr. Cosmos Oduor of Ugunja Division, Ugunja District, SiayaCounty, Kenya owns a 2.5 acre piece of land. Previously he grew kale, tomatoes, bananas, pineapples and kept local poultry.Since 2009, he diversified to banana and sugarcane production. Following training on Integrated Soil Fertility Management (ISFM) held in April 2013, the farmer has switched to indigenous vegetables. He has established 0.25 acre plot of crotalaria, using with improved soil management practices (farmyard manure and Diammonium phosphate).Within a 2 months period, he has harvested vegetables which have fetched KSh. 31,000 (US $ 370) as opposed to about KSh 17,000 (US $ 200)that he would have earned from tomatoes. Money realized has been used to clear an outstanding bank loan (US $ 240) and paid school fees (US $ 90). In addition, vegetables have improved household nutrition and the rest shared with neighbours (communal social responsibility). Mr. Oduor expects to harvest the vegetables up to February 2014, before he rotates to another crop. At an average of (US $ 150) for the next 6 months Mr. Oduor is expected to earn a total of (US $ 1270) from his 0.25 acre plot. Twenty of his neighbours have already adopted the technology. Approximately 12 customers visit Mr. Oduors farm every day to buy his vegetables. The ministry of Agriculture has so far held two field days on his the farm. Demand for crotalaria seed has increased tremendously following the field days.


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