Increasing food security and improving livelihoods through the promotion of integrated pest and soil management in lowland maize systems.

R8452 (ZA0676)

FINAL TECHNICAL REPORT

CROP PROTECTION PROGRAMME

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Start and end dates
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Acronyms

ASARECA	Association for strengthening agricultural research in eastern and central Africa
CIMMYT	International maize and wheat improvement centre
CPP	Crop Protection Programme (of DFID)
DAEO	District Agricultural Extension Office
DFID	Department for International development (UK Government)
EARZ	Eastern Agricultural Research Zone (Tanzania)
ECAMAW	East and Central Africa Maize and Wheat Research Network
EZCORE	Eastern Zone Client Orientated Research and Extension
IARI	Ilonga Agricultural Research Institute
masl	metres above sea-level
MDC	Muheza District Council
MTI	Mbegu Technologies Incorporated (a Tanzanian seed company)
NGO	Non Government Organisation
NRI	Natural Resources Institute
MRI	Mlingano Research Institute
OPV	Open pollinated varieties
OVIs	Objectively verifiable indicators
PREA	Participatory research and extension approach
PTD	Participatory technology development
SRI	Silsoe Research Institute
VEO	Village extension officer

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CONTENTS

Executive Summary

A very brief summary of the purpose of the project, the research activities, the outputs of the project, and the contribution of the project towards DFID's development goals. (Up to 500 words).

This project was a nine month extension of two and a half year's work (R8215)

Project Purpose

The project extension had the same purpose as Phase 1, aiming to develop and promote strategies that reduce the impact of pests in particular *Striga* (whose effect was compounded by conditions of low soil fertility) and stemborer on poor people's maize crops, through: improved understanding of local coping strategies, identifying constraints to adoption, on-farm evaluation of selected technology options, improving access to inputs and linking stakeholders as partners during the project

Outputs

[Summarise the significant results and the new knowledge obtained.]

Key outputs were:

i) <u>Evaluation of farmer selected pest and soil fertility management options through farmer testing in Muheza District, Tanzania, selected as being representative of lowland maize production areas.</u> This was based on participatory evaluation of appropriate maize varieties (TMV-1, Syn 98 and Syn White), alternative green manure crops (*Canavalia, Mucuna* and *Crotalaria*) and low cost methods of controlling stemborer (neem and napier grass) over a further nine months providing in all a three year, six season evaluation period. The use of PREA ensured the development of appropriate and viable technologies, which are being widely adopted

ii) <u>Improved access to inputs through establishment of two community based seed production units linked with a local seed production company.</u> Three communities have established their own seed production units, many individuals are producing their own seed and a private sector company has played a role in stimulating the demand for improved seed. .

Contribution of Outputs to Project Goal

[Have the outputs of the project been achieved? In what way has the project contributed to meeting the research goal?]

Project Outputs have been achieved and the Muheza District Council in conjunction has expanded activities to other parts of the District and a considerable number of households are using at least one of the technology options. In particular those farmers who have started to use new varieties of maize have achieved a considerable increase in production and food security.

Despite adverse climatic conditions during much of the project, improved soil and pest weed management techniques have been adopted in target villages, indicating the success of PREA in allowing farmers and communities to identify and seek solutions for their own priority problems. At the same time close liaison between stakeholders (researchers, extension agents and close involvement of policy makers at village and District levels) has ensured that wide scaling-up should now be possible.

Follow-up indicated/planned

Muheza District Council will use the outputs from the project in:

i) Building on existing farmer trials and their use in community-based group training approach in conjunction with EZCORE/DAEO.

ii) Promoting seed production and sales through establishment of village level supplies linked to local seed production.

Background

Project leaders should feel free to simply cut and past this information from the background section of their project memorandum (RD1)

This research builds on an earlier phase of the work (R8215) undertaken in Muheza District, Tanga Region, Tanzania. This area is typical of the Lowland tropical Zone (0-1,000 masl), covering 18% of the maize area in eastern and southern Africa and is one of three target agro-ecologies for maize varietal improvement for CIMMYT and the Tanzanian Government[1]. Community analysis and social mobilisation activities (Mbwaga *et al*., 2003) identified low soil fertility, drought, stemborer, and *Striga* among the priority constraints to improved maize production as priority problems in Muheza. Consequently a participatory research and extension approach gave emphasis to the use of *Striga* tolerant varieties, green manures, neem powder and Napier grass for stemborer control, as well as soil and water conservation.

Despite serious drought conditions, which had affected much of the lowland tropical zone in Kenya and Northern Tanzania in 2003 and 2004 early achievements (Ellis-Jones *et al*., 2005) included

- Nearly 100 farmers in four groups had been actively involved with on-farm trials undertaken over four seasons (two short and two long rains) in four villages.
- Green manures had been assessed over three seasons but assessment of maize productivity increases had only been possible for a single season due to crop failures, resulting from the drought conditions.
- *Striga* tolerant lines TMV1, 98 SYN WEC and New SYN W-STR had been selected by farmers for further evaluation
- Introduction of rain water harvesting techniques had met with widespread adoption in a very short period and resulted in some crops being produced.
- Unfortunately no evaluation of stemborer control practices had been possible, although use of Napier grass for stemborer control and associated with rain water harvesting proved to be popular with farmers, with demand for planting material outstripping supply. More than 20 farmers had started experimenting with Napier grass with some being used as fodder for goats and dairy animals.
- Extension material (Mbwaga *et al*., 2004) had been developed and was being tested during training provided by the project for 10 VEOs and lead farmers from the four villages where the project had been operating, as well as a further six identified by the District Agriculture Office as having similar problems.
- Detailed baseline information (Hella., 2004), a marketing survey (Akulumuka *et al*., 2003) and a survey of maize storage practices provided detailed information on which to base this proposal.
- A private sector seed company (Mbegu Technologies Incorporated) had started working with the project from the end of 2004, with a view to establishing themselves as a provider of maize and legume seed in 2005. Four tonnes of TMV-1 seed were packed in one kg packs for distribution to farmers.
- EZCORE used the early findings to expand their activities to a further six villages during 2004/5

Evaluation of green manure crops indicated that benefits make them attractive, in both terms of additional yield and *Striga* reduction (Akulumuka *et al.,* 2004). Short duration *Striga* tolerant maize varieties were ranked by farmers as most appropriate but uptake had been limited due to non-availability of seed because of drought conditions. Although difficult to reach firm conclusions before more households had had a chance to evaluate a number of cycles of the legume/maize rotation, initial conclusions indicate that green

[1] ASARECA ranks maize as first priority among crops grown in the region and lists low soil fertility, drought, foliar diseases (including maize streak), stemborer, and weeds including *Striga* among the priority constraints to improved maize production.

manures were attractive and likely to be adopted, if, i) sustained increases in maize yield are achieved, ii) additional benefits over and above improving soil fertility and reducing *Striga* infestation, such as food or fodder for household use or sale are obtained and, iii) land is not limiting and green manures can be used to improve fallows. Where land is limiting grain legumes (cowpea, soybean or groundnuts), which induce suicidal germination of *Striga* followed by a *Striga* tolerant maize variety. Alternatively relay cropping maize with Canavalia/Sunhemp is possible for farmers with limited land.

Project Purpose

The purpose of the project and how it addressed the identified development opportunity or identified constraint to development.

The project addressed a CPP output, namely:

"Strategies developed and promoted to reduce the impact of pests on poor people's crops and to improve quality and yield from maize-based systems in semi-arid areas".

The project aimed to develop and promote strategies that reduce the impact of pests in particular *Striga* (whose effect was compounded by conditions of low soil fertility) and stemborer on poor people's maize crops, through: improved understanding of local coping strategies, identifying constraints to adoption, on-farm evaluation of selected technology options, improving access to inputs and linking stakeholders as partners during the project

Research Activities

This section should include detailed descriptions of all the research activities (research studies, surveys etc.) conducted to achieve the outputs of the project. Information on any facilities, expertise and special resources used to implement the project should also be included. Indicate any modification to the proposed research activities, and whether planned inputs were achieved.

Two sets of activities were undertaken each contributing to the two outputs.

Participatory technology development and promotion

Stakeholder workshop

A stakeholder workshop involving farmers, the Muheza District Council including District Agricultural extension staff and research professionals from Ilonga and Mlingano Research Institutions discussed results from earlier work (R8215) and agreed a plan for continuation of the work (R8245) (IARI, 2005).

Implementation of a series of farmer led trials

On-farm trials were continued for a further season by the same farmer groups. These continued to evaluate a range of pest and soil management options, which included:

- Integrating crop protection technologies with soil fertility improvement methods in particular *Canavalia spp, Crotalaria* spp, and *Mucuna pruriens*.
- Reducing losses to stemborer by planting borders of maize plots to Napier grass to reduce populations of the pest in the crop. This was compared with use of neem powder, endosulpan as well as no treatment.
- The use of *Striga* tolerant maize varieties
- Integrating rainwater-harvesting techniques with crop protection activities.

Ongoing farmer evaluations initiated during the short rains of 2004-5 (R8215) were extended into the long rains of 2005 with some expansion to six other villages in the district, facilitated by EZCORE and the DAO, Muheza (Table 1).

Table 1: On-farm trials implemented over two phases

	Phase 1 (R8215)					Phase 2 (R8245)	
Village	**2003/2004**			**2004/2005**		**2005/2006**	
	Nov 02 -Jan 03 *Vuli*	Mar-July 03 *Masika*	Nov03-Jan 04 *Vuli*	Mar-July 04 *Masika*	Nov 04 - Jan 05 *Vuli*	Mar-July 05 *Masika*	Nov 05 – Jan 06 *Vuli*
Mtakuja and Mbambakofi	GM	M GM SB	GM M	M GM SB RWH	GM M SB RWH	GM M SB RWH	Farmers continued working with GMs, M, RWH and SB with no input from researchers[1]
Mapatano and Paramba		GM	M GM	GM M RWH	M GM RWH	M GM RWH	
Kibaoni, Songa Kilongo, Mashewa, Masuguru, Mkanyageni and Ngomeni					M/GM	M/GM	

GM=Green Manure, M=Maize, SB=Stemborer, RWH=Rain Water Harvesting.
[1]The 05-06 vuli crop was still in the ground after the project completion date

At the same time that these trials were taking place, improving soil water management through introduction of appropriate rain water harvesting method (ditches, *fanya-juu*, *fanya-chini*, tied ridges, deep tillage and mulching with weeds and grass was encouraged. Napier grass used for stemborer control was planted sometimes below and sometimes above the ditches. An evaluation of these technologies was based on observation rather than yield comparisons.

Research-managed testing of Ilonga and CIMMYT supplied maize varieties also continued using recently released varieties as well as those found to be performing well under local conditions. Trials were undertaken at two locations (Melela-Morogoro, a site infested by both *S. asiatica* and *S. forbesii* and Mwele-Tanga, a site in Muheza infested by *S. asiatica*) during 2005 *masika* seasons.

Climatic conditions

Phase 2 of the work started in April 2005, allowing trials of green manures and *Striga* tolerant maize varieties initiated during Phase 1 to be continued during the Masika rains of 2005, allowing five rotational cycles of green-manure to be completed in four village sites (Figure 1 and Figure 2). These show that rainfall was below average in four of the five seasons that the work took place, with the three long masika rains being more than 25% below average and two of the three short vuli rains being below average.

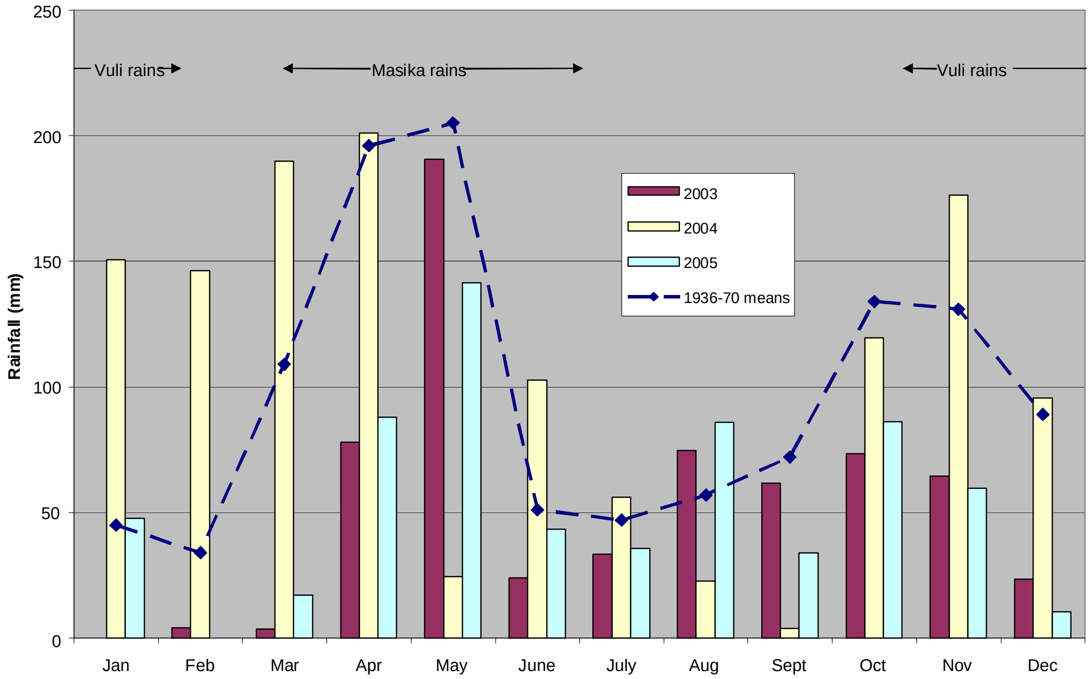

Figure 1: 2003-2005 rainfall compared with long term means at Mlingano (Mlingano Research Institute, 2005).

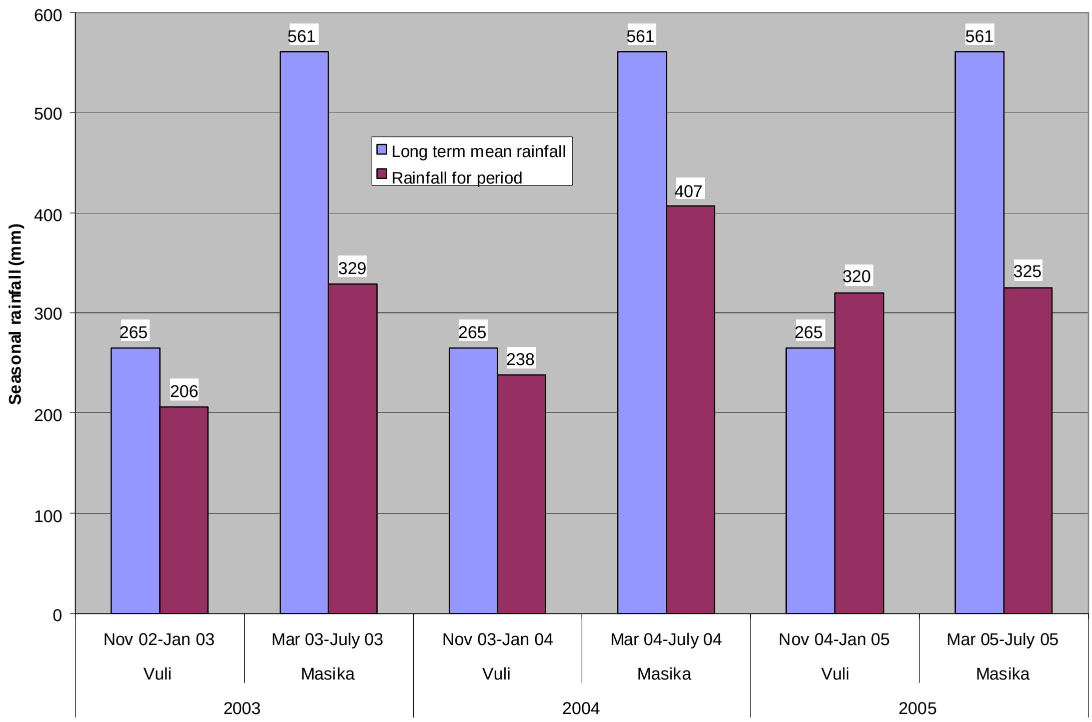

Figure 2: Comparison of long term rainfall means with that received (Milingano, 2005)

Participatory monitoring and evaluation of the trials
Monitoring and evaluating the trials was undertaken during the middle and at the end of the 2005 *masika* cropping season and again towards the end of the 2005-6 *vuli* season. Participatory technology evaluations (PTE) were undertaken in each village (Table 2) using the steps indicated. This followed a similar approach and built on the work undertaken in Phase 1.

Table 2: Evaluations undertaken (2005)

	Paramba	Mbambakofi	Mtakuja	Mapatano
Green manures				
Matrix ranking comparing green manures using farmers' criteria	√	√	√	√
Participatory budgets comparing best green manure and farmer practice over two seasons	√	√	√	√
Maize varieties				
Matrix ranking comparing varieties using farmers' criteria	√	√	√	√
Stemborer control				
Matrix ranking comparing control methods using farmers' criteria		√	√	
Participatory budgets comparing alternative stem borer control methods		√	√	

Development of extension and training materials
A range of extension material in Swahili was finalised, tested and used in training activities with extension workers and farmers.

Training using a "community led group" approach
Training was provided to extension workers and lead farmers from 12 villages in Muheza District at Mlingano Research Institute in use of the extension material in raising awareness and scaling-up project activities over a period of one week. In addition exchange visits were organised to allow farmers from new villages to view ongoing practices on existing farmer trial plots and learn from more experienced farmers. Lead farmers from each group were the main channels of communication between the group and extension staff. This process was established as part of ongoing agricultural extension activities of the DAO, and formed part of the project's scaling-up and exit strategy.

Two complimentary methods of assessing technology adoption were used, i) a formal survey (Juma, 2006) and ii) a participatory assessment with farmers during January 2006.

Market development for maize seed

Linking farmers with seed producers and input suppliers
Earlier work showed that there were very few input agents, inputs are rarely promoted and most suppliers have little technical knowledge of the inputs they sell, referring customers to extension officers for information (Akulumuka and Hella, 2003). Greatest input demand from farmers was identified for improved seeds, though smaller packs are required than are presently available. Contact was made with a local seed supply firm (Mbegu Technologies Incorporated - MTI) to supply TMV-1 in two kg packs. As a result over four tonne of such seed was supplied to 10 villages for the *Vuli* rains in 2004-5 and commercial seed production was initiated by MTI on land made available by the sisal estates during *vuli* 2005.

Initiating a process of village/farmer based input supplies
At the same time a process of community based seed supply initiated during the short *vuli* rains of 2004-05 in three communities, Mapatano, Mbambakofi and Mtakuja as group maize production enterprises was continued. In all three villages TMV1 or Syn 98 has now been grown for three successive seasons with produce being used for both grain and seed, some sold and some retained.

Research outputs

The research results and products achieved by the project. Were all the anticipated outputs achieved and if not what were the reasons? Research results should be presented as tables, graphs or sketches rather than lengthy writing, and provided in as quantitative a form as far as is possible.

Technology development and promotion

Appropriate cost effective management strategies

Performance of maize in rotation with green manures in Muheza in masika season 2005
Participatory ranking of the green manures in the four experienced villages was similar for both vuli and masika seasons (Table 3). Overall *Canavalia* was ranked highest, but lowest in one village, where *Mucuna* was ranked highest. In no areas was *Crotalaria* preferred. In the less experienced newer villages, testing by farmers was still occurring.

Table 3: Farmer preference ranking of green manures.

	Canavalia	***Mucuna***	***Crotalaria***
Older more experienced villages			
Mapatano	1	2	3
Mbambakofi	1	2	3
Mtakuja	1	2	3
Paramba	3	1	2
New less experienced villages[4]			
Kilongo	2=[3]	1	2=
Mashewa	2	1	3
Songa Kibaoni	2	3	1

[1]If the rain is good, Crotalaria is the best, but when there is drought no seed is produced
[2]Crotolaria is attacked by pets and produces little seed after growing vigorously.
[3]Canavalia was attacked by pests
[4]Other villages did not rank the green manures as they did not have the necessary experience

Yield assessments undertaken at harvest of the 2005 *masika* season in four villages provided reliable data from 20 farms. However, as this data set was unbalanced with 8 farms in Mbambakofi, 7 in Mtakuja, 3 in Paramba and 2 in Mapatano an analysis of variance approach was not feasible. A “restricted, maximum likelihood” mixed model (REML) analysis was therefore used using the linear mixed model routine in GENSTAT. The green manure crop grown in the previous *vuli* season significantly effected maize yield in the masika season (p <0.001). Maize grown after any of the green manures produced significantly higher yields than continuous maize (Table 4). Maize productivity was increased by rotation with green manure in the order *Canavalia* >*Mucuna* >*Crotalaria* although these differences were not significant. Farmers’ preferences however followed this order.

Table 4: Mean maize yields following green manure crops (kg ha^{-1})

Previous crop	Yield kg ha^{-1}
Canavalia	2508
Mucuna	2266
Crotalaria	2070
Continuous maize	1403
S.E.D (37 d.f.)	220

Rotation also had a significant effect on maize yield in Mbambakofi ($p < 0.001$) and Mtakuja ($p = 0.005$) where there were sufficient sites to undertake an analysis. Highest mean maize yields were harvested from plots previously planted to *Canavalia* in both of these villages (Table 5). However the median measured yields following each of the three green manures were similar in Mbambakofi and similar for *Canavalia* and *Marejea* in Mtakuja. Individual farmers recorded very low yield of maize in rotation with either *Mucuna* (in Mbambakofi) or *marejea* (in Mtakuja) reflecting poor performance of these green manures during the *vuli* season. Highest minimum yields in both villages came from plots of maize in rotation with *Canavalia*. A similar pattern was observed in the data for all farms in the four villages where farmers tested the green manure rotations (Table 5). Median yields of maize following the three legume species were almost identical and approx. 1200 kg ha^{-1} greater for continuous maize.

Table 5: Measured yields (kg ha^{-1}) of maize following green manure treatments on-farm in Mbambakofi and Mtakuja and across four villages in Muheza in *masika* season 2005.

	Previous crop			
	Canavalia	***Mucuna***	***Marejea***	**Maize**
Mbambkofi				
No. of sites	6	7	6	8
Mean	3083	2144	2250	1388
Median	2720	2560	2640	1120
Minimum	2400	640	1280	608
Maximum	4800	2880	4000	3040
S.E.Mean	±372	±322	±437	±279
Mtakuja				
No. of sites	7	7	4	6
Mean	2400	2011	2120	1573
Median	2240	1600	2560	1600
Minimum	1600	1120	640	640
Maximum	3840	3680	2720	2720
S.E.Mean	±275	±336	±495	±352
Four villages				
No. of sites	18	18	14	19
Mean	2663	2247	2251	1477
Median	2528	2560	2560	1280
Minimum	1280	640	640	608
Maximum	4800	3680	4000	3040
S.E.Mean	±203	±190	±250	±181

Photo 1: Farmer trial showing Canavalia, Mucuna and Sunhemp

Photo 2: Canavalia

Photo 3: Mucuna

Photo 4: TMV1 after Canavalia

Photo 5: Rainwater harvesting ditch with Canavalia and Sunhemp

Photo 6: Sunhemp

Photo 7: Sunhemp relay cropped with TMV1

Economic analysis
Preliminary conclusions reached at the end of Phase 1 were that that the green manure-maize system can increase productivity of maize-maize. Longer term potential benefits make the new technology attractive, in both terms of additional yield and overall productivity. However this needs to be seen against the concerns raised by farmers of losing a maize crop and the consequent short term risks of food and seed shortages in case of drought.

A further season has now provided opportunity to re-assess these preliminary conclusions, through yield assessments over five seasons, which although less than average rainfall was experienced provided contrasting seasons of better and poorer yields. Yield benefits over these five seasons, based on statistical analysis across the four villages, indicated that maize after green manure gave an mean yield increase of 37% over maize following maize (48% more in the case of Canavalia, 37% more in the case of Sunhemp and 26% more in the case of Mucuna) (Table 6). This was highest in the masika, 2005, when yield increases of over 60% were achieved and lowest in the masika, 2003 when a yield increase of 22% was achieved.

Table 6: Maize yields (kg ha^{-1}) (2003-2005)

Maize[1] following	2003-4 *Masika* Mar 03-July 03	2004 *Vuli* Nov 03-Jan 04	2004 *Masika* Mar 04-July 04	2005 *Vuli* Nov 04-Jan 05	2005 *Masika* Mar 05-July 05	**Average over 5 seasons**	**Increase over maize**	**%**
Canavalia	2048	0	0	3386	2508	1588	518	48%
Sunhemp	2048	0	0	3021	2286	1471	401	37%
Mucuna	2076	0	0	2624	2070	1354	284	26%
Mean (green manure)	*2057*	*0*	*0*	*3010*	*2288*	*1471*	*401*	*37%*
Maize	1699	0	0	2250	1403	1070	0	0%

[1]Maize yields were derived from improved varieties, either, TMV1 or Syn 98.

Detailed end of masika season evaluations were undertaken in the four villages using participatory budgeting techniques using benefits and costs specific to each village. The cost of growing most crops is largely a labour cost. Labour requirements for green manure production varied from 35-75 days ha^{-1}, compared with maize which varied from 102-163 days ha^{-1}, with the green manures requiring some 45% of the labour required for maize production (Table 7). This variability is explained by different soil conditions, soil slopes, different perceptions by men and women as well as cost differences in different areas. However farmers indicated lower land preparation and weeding costs in maize following a green manure with an average saving of 15 days ha^{-1}, or 12% over continuous maize.

Table 7: Labour requirements for green manure[1] and maize production (days ha^{-1})

	Mapatano	Mbambakofi	Mtakuja	Paramba	Average
Maize following maize					
Land clearing/preparation	17	40	25	27	27
Planting/thinning	5	16	13	10	11
Weeding	17	23	30	23	23
Harvest/shelling/transport	63	83	33	54	59
Total	*102*	*163*	*102*	*114*	*120*
Green manure (GM)					
Land clearing/preparation	17	40	33	31	30
Planting/thinning	5	17	7	9	9
Weeding	7	13	5	9	9
Harvest/shelling/transport	7	5	5	5	6
Total	*35*	*75*	*50*	*54*	*54*
Green manure as % of maize	34%	46%	49%	47%	45%
Maize following green manure					
Land clearing/preparation	17	25	25	23	22
Planting/thinning	5	16	13	10	11
Weeding	7	17	13	15	13
Harvest/shelling/transport	63	83	33	54	59
Total	*92*	*141*	*85*	*102*	*105*
Maize following GM as a % of maize following maize	90%	87%	83%	89%	88%

Note: [1]labour requirements are similar for Canavalia and Mucuna. Little or no weeding is required for Sunhemp

Source: Participatory budgeting (Muheza, October 2005)

Maize and green manure production costs were established during participatory budgeting exercises with farmers (Table 8), in which both benefits and costs over two seasons were ascertained.

Table 8: Maize and green manure costs of production over two seasons

Maize-maize	**Total (US $/ha)**	**Green manure maize**	**Total (US $/ha)**
1st season maize crop		**1st season green manure crop margin**	
Value of crop produced (a)	113	Value of green manure seed (a)	60
Costs of maize-S1		*Costs of green manure production*	
Seed (maize)	6	Seed (green manure)	30
Labour (maize)	180	Labour (green manure)	81
sub total (b)	*186*	*sub total (b)*	*111*
Gross margin)(a-b)	**-73**	***Gross margin)(a-b)***	**-51**
2nd season maize crop		**2nd season maize**	
Seed (maize)	6	Seed (maize)	6
Labour (maize)	180	Labour (maize)	158
sub total (c)	*186*	*sub total (c)*	*164*
Total cost (a-b)+c	**113**	**Total costs (a-b)+c**	**113**

The base-line assumptions used for the inputs used and their costs are shown in Table 9.

Table 9: Baseline material and cost assumptions

Item	units per ha	Tsh per unit	US $ per unit	Total (US $/ha)
Maize seed (kg)	20	300	0.30	6.00
Maize grain (kg)		150	0.15	
Green manure seed (kg)	100	300	0.30	30.00
Yields from green manure production-S1 (kg)	200	300	0.30	60.00
Yields from alternative crop-S1 (kg)	1070	150	0.15	160.50
Labour – maize-maize (days)	120	1500	1.50	171.00
Labour – maize after green manure (days)	105	1500	1.50	171.00
Labour - green manure (days)	54	1500	1.50	81.00
Exchange rates		1000	1	

S1=Season 1, S2=season 2

These assumptions are based on local inputs used and their opportunity values (based on local market costs). Key assumptions are the yields achieved from the first season's crop. In this case a maize yield of 1070 kg ha^{-1} is assumed, and in the case of green manure a saleable seed yield of 200 kg ha^{-1}, even though yields well in excess of 1000 kg ha^{-1} are likely to be obtained. Labour is valued at US $1.50 (Tsh 1500) per day, being the local cost of hiring labour for farm work. A detailed economic analysis based on these assumptions shows yields, gross output, and gross margins for both season 1 and season 1 and 2 combined, over the period 2003-2005 (Table 10).

Table 10: Yields, gross output, and gross margins (2003-2005)

	2003-4	**2004**		**2005**				
	Masika	***Vuli***	***Masika***	***Vuli***	***Masika***	***Average***	***Increase over maize***	***%***
	Mar 03-July 03	Nov 03-Jan 04	Mar 04-July 04	Nov 04-Jan 05	Mar 05-July 05			
Yields								
Canavalia	2048	0	0	3386	2508	1588	518	48%
Sunhemp	2048	0	0	3021	2286	1471	401	37%
Mucuna	2076	0	0	2624	2070	1354	284	26%
Mean (green manures)	**2057**	**0**	**0**	**3010**	**2288**	**1471**	**401**	**37%**
Maize	1699	0	0	2250	1403	1070	0	0%
Values ($ per ha)								
Canavalia	307	0	0	508	376	238	78	48%
Sunhemp	307	0	0	453	343	221	60	37%
Mucuna	311	0	0	394	311	203	43	26%
Mean (green manures)	**309**	**0**	**0**	**452**	**343**	**221**	**60**	**37%**
Maize	255	0	0	338	210	161	0	0%
Gross margins (S2 only)								
Canavalia	144	-164	-164	344	213	75	100	394%
Sunhemp	144	-164	-164	290	179	57	83	325%
Mucuna	148	-164	-164	230	147	40	65	256%
Mean (green manures)	**145**	**-164**	**-164**	**288**	**180**	**57**	**83**	**325%**
Maize	69	-186	-186	152	24	-25	0	0%
Gross margins (S1 and S2)								
Canavalia	93	-215	-215	293	162	24	75	147%
Sunhemp	93	-215	-215	239	128	6	57	112%
Mucuna	97	-215	-215	179	96	-11	40	78%
Mean (green manures)	**94**	**-215**	**-215**	**237**	**129**	**6**	**57**	**112%**
Maize	43	-212	-212	126	-1	-51	0	0%

Table 10 shows that:

- In masika 2003, maize following green manures shows an increase in gross margin of \$75 ha^{-1} over maize following maize when the second season is compared. When both seasons are accounted for there is an increase in gross margins of \$50 ha^{-1} in favour of green manures.
- In the vuli and masika 2004, negative gross margins are achieved in all circumstances due to crop failures, as a result of drought conditions.
- In the vuli season in 2005, maize following green manure showed higher gross margins than maize following maize for season 1 only (US \$288 vs. \$152), and for season 1 and 2 combined (US\$ 237 vs. \$126).
- In the masika season in 2005, maize following green manure showed a greater difference in gross margin compared with maize following maize for season 1 only (US \$180 vs. \$24), and for season 1 and 2 combined (US\$ 129 vs. \$-1).
- Over the five seasons, green manures were 112% more productive, with Canavalia showing the greatest increase (147%) compared with Sunhemp (112%) and Mucuna (78%).

These results are calculated on certain base-line assumptions, which will vary in different circumstances. For this reason a sensitivity analysis (Table 11) was undertaken on the key variables, notably:

- Decreasing the yields of the first season maize by 50% to 535 kg ha^{-1}, close to the average for Muheza District.
- Increasing the yields for the first season maize by 50% to 1605 kg ha^{-1}, being similar to the maize yields that were achieved for maize following maize during better years of the on-farm trials.
- Increasing the saleable yield of green manure seed by 100% to 400 kg ha^{-1}. No significant market in green manure seed has developed with most farmers giving some seed away, sometimes in exchange for other goods or services. However if a market developed the amount of green manure seed that could be sold is likely to increase substantially.
- Increasing maize yields in the second season, following the green manure, by 20% over those actually achieved to reflect those achieved by better farmers.
- Reducing the value of labour to either zero or by 50% to US\$ 0.75 per day, in view of the fact that often household labour is used and many households do not necessarily value their labour.

Table 11: % increase in gross margin of maize following green manure, over maize following maize.

Maize following	**Baseline**	**S1 Maize yields -50%**	**S1 Maize yields +50%**	**S1 GM yields +100%**	**S2 Maize yields +20%**	**Labour (zero value)**	**Labour (50% of baseline)**
Canavalia	147%	118%	19%	264%	240%	15%	25%
Sunhemp	112%	105%	79%	230%	199%	21%	34%
Mucuna	78%	91%	139%	195%	157%	27%	42%
Mean (green manures)	**112%**	**105%**	**79%**	**230%**	**199%**	**21%**	**34%**
Maize	0%	0%	0%	0%	0%	0%	0%

The results of the sensitivity analysis show.

- When maize yields are 50% lower in the first season, productivity of green manures is increased by 105% over the maize-maize system, while 50% higher yields result in a productivity increase of 79%.
- Increasing saleable green manure seed yields by 100% increases productivity to 230%.
- A 20% increase in maize yields following the green manure crop increases productivity to 199%.
- By far, the largest impact on productivity is the value of labour. If this is given no value or alternatively valued at 50% of its opportunity cost, increased productivity falls to 21% and 34% respectively when green manures are used. This compares with the baseline productivity indicator of 112% when labour is valued at its opportunity cost.

On the basis of this economic analysis, it can be concluded that the green manure-maize system will outperform maize-maize. Clearly increased benefits make the new technology attractive, in both terms of additional yield and overall productivity, especially as labour costs increase. However the benefits still need to be seen against the risks, with which farmers may be faced, notably loss of a food crop while the green manure is grown, possible drought in the following season when the benefits of the green manure are realised. It can however be concluded green manures are attractive and likely to be adopted, when:

- Sustained increases in maize yield are achieved and a ready market is available for surpluses to household food requirements.
- The green manures provide additional benefits over and above improving soil fertility and reducing *Striga* infestation, such as food or fodder for household use or sale.
- Land is not limiting and green manures can be used to improve fallows.
- When land is limiting.

At the same time green manures are less attractive and less likely to be adopted, when:

- Maize yields have not yet fallen to very low levels.
- Farmers perceive the risks of using a green manure to be unacceptably high, due to possible failure of the maize crop due to drought or low market prices.
- Land is limiting and it is not possible to relay crop with Canavalia or Sunhemp.

In such cases grain legumes that improve soil fertility and suppress *Striga* may be more appropriate. This could include cowpea, soybean or groundnut crops which induce suicidal germination of *Striga* followed by *Striga* tolerant maize variety (Ellis-Jones *et al.*, 2004; Schulz *et al.*, 2003).

<u>*Maize cultivar evaluation*</u>

Four maize cultivars were used in the on-farm trials. The majority of farmers (nine sites) chose to grow Staha while Syn 98 was grown at five, TMV1 at four and Syn White at two sites. Participatory ranking in four villages for vuli and masika seasons indicated a farmer preference for TMV1 and Syn 98 for both vuli and masika (Table 12).

Table 12: Farmer ranking of maize varieties.

	Mbambakofi	Mtakuja	Mapatano	Paramba	Overall
Vuli					
TMV1	2	3	1	2	2
Syn 98	1	1	1	1	1
Syn White	3	-	4	-	4
Staha	4	3	1	3	3
Masika					
TMV1	2	1	1	1	1
Syn 98	1	2	1	2	2
Syn White	3	-	4	-	
Staha	4	3	1	3	3

Analysis was again by REML, with highest yields being produced by TMV1 and Staha (Table 13) but these were not significantly different (P = 0.568) to the other cultivars.

Table 13: Mean yields of four maize cultivars grown on-farm during masika 2005 (kg ha^{-1})

Cultivar	Yield kg ha^{-1}
TMV1	2315
Staha	2219
Syn White	2011
Syn 98	1703
S.E.D. (16 d.f.)	545

A range of materials, including lines provided by CIMMYT East Africa programme were evaluated in replicated trials at both Mwele seed farm in Muheza (infested by *S. asiatica*) and at Melela, a site infested by both *S. asiatica* and *S. forbesii* in Morogoro Rural District. Only limited quantities of seed were available so plots were restricted to four, 5 m long rows. Yield data has been analysed by ANOVA. *Striga* incidence was inconsistent and not sufficient to justify statistical analysis. Maximum emergence on the three replicate plots and the number of plots with emerged *Striga* show indicative susceptibilities in the following tables.

<u>Early maturing lines</u>

There was no significant difference in the yields harvested from early maturing lines at Mwele (Table 14). Acr 94 TZEComp 5 – W and Acr 94 TZEComp 5 – Y produced the highest yields. Greatest numbers of emerged Striga stems were observed on 98 Syn WEC, the line distributed for on-farm trials and considered by farmers to be tolerant to the parasite. Acr 94 TZEComp 5 – Y was also among the three highest yielding lines at Melela and Mwele although once again there was no significant difference between entries (Table 14 and Table 15). TMV1 and Acr 94 TZEComp 5 – Y supported the least numbers of emerged *Striga*.

Table 14: Grain yield and *Striga* reaction (number of replicates of 3 and maximum number of emerged parasite stems per plot) of 6 early maturing maize lines at Mwele.

Line	Yield kg ha^{-1}	*Striga* reaction	
		No. of replicates	Max number
Acr 94 TZEComp 5 - W	800	2	5
Acr 94 TZEComp 5 - Y	762	1	7
Comp 4C2	686	2	18
98 Syn WEC	609	2	103
KSTP 94	572	3	25
TMV 1 (local check)	685	1	14
P	0.679		
SED (10 d.f.)	154		

Table 15: Grain yield and *Striga* reaction (number of replicates of 3 and maximum number of emerged parasite stems per plot) of 6 early maturing maize lines at Melela.

Line	Yield kg ha^{-1}	*Striga* reaction			
		No. of replicates		Max number	
		S. asiatica	S. forbesii	S. asiatica	S. forbesii
Acr 94 TZEComp 5 - Y	1556	2	3	12	8
KSTP 94	1244	3	3	54	52
Comp 4C2	1066	2	2	26	26
Acr 94 TZEComp 5 - W	711	1	1	10	20
98 Syn WEC	578	3	3	40	30
TMV1 (local check)	889	2	2	6	4
P	0.083				
SED (10 d.f.)	307				

Late maturing lines

Data for late maturing lines is presented for Mwele only, stands at Melela of many entries were very poor. Similar yields were also produced by the 12 lines with none significantly out yielding TMV1, included as a check. *Striga* was only observed on five of the lines (Table 16).

Table 16: Grain yield and *Striga* reaction (number of replicates of 3 and maximum number of emerged parasite stems per plot) of 12 late maturing maize lines at Mwele, 2005. Yields adjusted for plant population used as covariate ($P<0.001$).

Line	Yield kg ha^{-1}	*Striga* reaction	
		No. of replicates	Max number
WH 502	670	0	0
KBO2- OA15- 4IR	655	0	0
Acr 93 TZL Comp 1-W	624	2	5
WH 904	623	1	3
KBO2-OBO4-28	583	0	0
TZ 96 STR SYN - Y	581	0	0
IWD STR Co	538	2	19
KSTP 94	507	0	0
TZ 96 STR SYN - w	462	2	6
KSTP 94	414	0	0
TMV1 (local check)	581	1	6
P	0.812		
SED (21 d.f.)	253		

Stemborer control options

Three on-farm trial sites in Mbambakofi and two in Mtakuja had reliable experiments. In both areas, materials used against stemborer showed good performance. Plots treated with endosulfan had lowest number of stemborer symptoms ($P<0.05$) and comparable yields to that obtained from neem treated plots. Significant differences ($P<0.05$) were observed on yield, symptoms due to stemborer and number of cobs m^2 (Table 17).

Table 17: Results from stemborer trials (Masika 2005)

TRT	No of plants $25m^{2-1}$	No of cobs $25m^{2-1}$	Cob Weight kg $25m^{2-1}$	Symptoms of MSB damage $25m^{2-1}$	Larvae or cocoon 10 stems^{-1}	Yield tonnes ha^{-1} grain maize
Napier	82.6	79.5	5.6	1.8	13.1	2.2
Neem	80.0	78.2	7.6	1.6	4.8	3.0
Endosulfan	78.0	93.3	8.6	1.5	4.8	3.4
Untreated	65.6	66.2	3.3	4.8	30.4	1.3
CV (%)	7.8	13.9	41.9	74.1	191.6	41.9
SE (±)	4.9 ns	4.2 s	0.9 s	0.7 s	6.3 ns	0.4 s

- Yields were highest following application of endosulfan, with neem ranking 2nd and Napier 3rd. The highest costs of control were for chemical control. Neem ranked second in terms of both outputs and costs with Napier third, although fodder and planting material sales could make Napier increasingly attractive (Table 18).
- Margins over additional costs showed chemical, neem and napier treatments outperforming nil treatments.
- Neem can be used as alternative to chemical insecticides and if used in combination with Napier may achieve as good control as with endosulfan.
- Mbambakofi village was more prone to stemborer attack than Mtakuja

Table 18: Partial budget analysis of stem borer control options (US $ ha^{-1})

Outputs	Neem	Napier	Endosulphan	Nil
Grain kg ha^{-1}	3000	2200	3400	1300
Price kg^{-1}	0.09	0.09	0.09	0.09
Grain Value	270	198	306	117
Fodder value[1]	0	50	0	0
Total value	*270*	*248*	*306*	*117*
Costs of treatment				
Material	12.5	7.5	31.3	0.0
Labour for application	13.0	0.0	10.0	0.0
Total cost	*25.5*	*7.5*	*41.3*	*0.0*
Margin over costs	244.5	240.5	264.8	117.0
Margin over no treatment	127.5	73.5	147.8	0.0
Cost per kg maize	0.13	0.12	0.15	0.0
Rank	2	3	1	4

[1]An additional income from sale or use of Napier grass for fodder was estimated to be 500 bundles at US$ 0.10 per bundle
[2]Exchange rate US $1 =Tsh 1000

Community group training approaches

Visits were made to both old and new villages to establish the extent of adoption of both the process and the technologies by local farmers as a result of the training activities. Discussions with participants indicated that considerable quantities of both green manure and improved varieties of maize seed had been given way (Figure 3). TMV1 and Syn 98 had been given in greatest quantities reflecting a faster spread of maize varieties than green manures. Although gifts and sales of green manures were less, quantities provided reflected farmers views of their suitability, with Canavalia being the most popular. The fact that other green manure seed was given also reflects a continuation of farmer investigations.

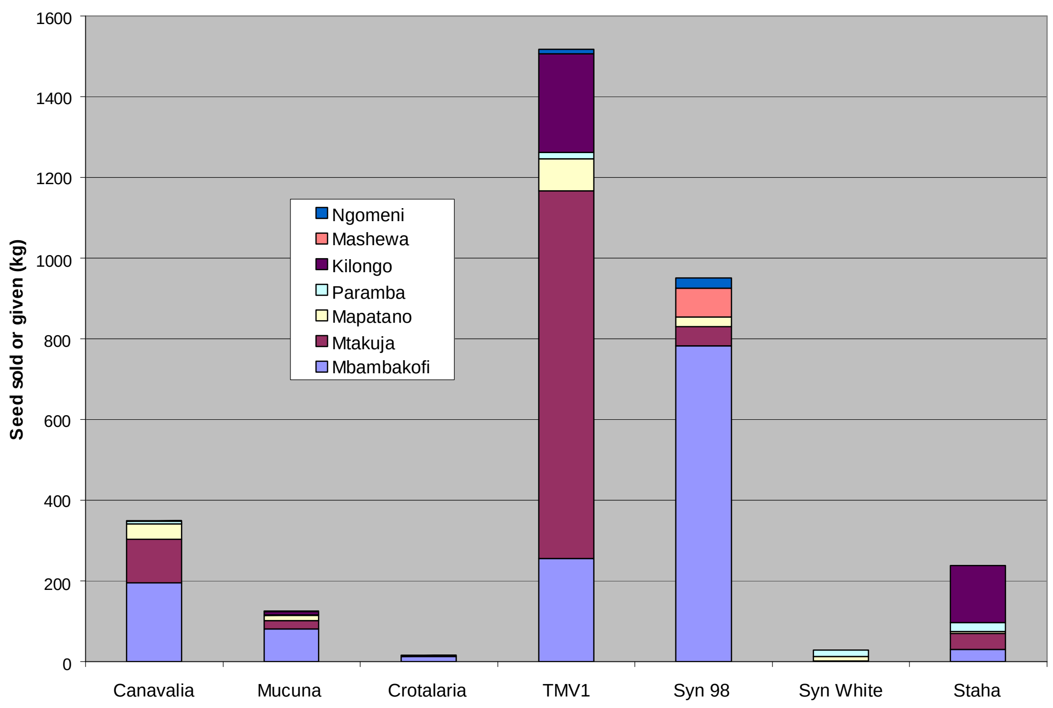

Figure 3: Quantities of seed given or sold to other farmers by participants in discussions (n=98)

The numbers of farmers involved in the discussions as well as giving/selling seed were higher in those villages with longer involvement with the project (Table 19). This also reflects almost equal participation by men and women in project activities, with both sexes giving and selling seed, though more men were involved in the older villages. The reasons for this are unclear.

Table 19: Numbers of men/women involved in discussions and giving or selling seed (January 2006)

Village	N=	Men/women	Canavalia	Mucuna	Crotalaria	TMV1	Syn 98	Syn White	Staha
Older villages									
Mbambakofi	16	12/4	5/2	3/2	4/1	7/4	6/2	1/0	4/0
Mtakuja	11	5/6	5/4	1/2		5/5	4/3		1/0
Mapatano	9	5/4	5/3	2/2	0/1	2/3	1/1	0/1	0/2
Paramba	11	7/4	2/0	1/0	1/0	1/0	1/0	1/0	2/0
Sub totals	*47*	*29/18*	*17/9*	*7/6*	*5/2*	*15/12*	*12/6*	*2/1*	*7/2*
New villages									
Kilongo	9	5/4		1/1		1/2			
Mashewa	14	3/11	0/1	0/1			2/8		
Ngomeni	28	11/17				1/2	1/4		
Sub totals	*51*	*19/32*	*0/1*	*1/2*		*2/4*	*3/11*		
Totals	***98***	***48/50***	***17/10***	***8/8***	***5/2***	***17/16***	***15/18***	***2/1***	***7/2***
		49%/51%	28%	16%	7%	34%	34%	3%	9%

Juma's study (2006) showed the relative importance of information sources for learning for both project participants and non participants (Table 20).

Table 20: Source of information on new technologies (n=119)

Information source	Participants (%)	Non-participants (%)
Participation in trials/demonstration	53.9	10.6
From farmers who participated	0.0	52.0
Exchange visits	5.0	0.0
Written media (leaflets/posters)	31.0	8.0
Village extension workers	10.1	25.8
Haven't head the technologies	0.0	3.6

This indicates the importance of participation in trials or demonstrations, reinforced by written media and input from extension workers with regard the participant farmers. For non participants learning from other farmers is particularly important reinforced by input from extension workers. The role of exchange visits was ranked more highly by non participants.

Information resources to support scaling-up

Training manuals for extension workers, a pictorial guide for use in conjunction the training manual, posters for use by extension workers and leaflets for farmers have been developed, used in training and widely distributed (Table 21).

Table 21: Extension materials produced

Material	Type	Quantity
Training manual for extension workers	Striga control and soil fertility improvement	2 000
Pictorial guide for use in conjunction with the training manual	Striga control and soil fertility improvement	2 000
Posters for use by extension workers	Canavalia	1 000
	Mucuna	1 000
Leaflets for farmers	Canavalia	2 000
	Marejea	2 000
	Mucuna	2 000
	Quality seed	2 000
	Rain water Harvesting	2 000
	Control of Stem borer	2 000
	Marejea	1 000

These were distributed as follows: ARI Mlingano (100) , Muheza District Council (300), Pangani District Council (50), Handeni District Council (50), Korogwe District Council (50), Tanga District Council (50), Morogoro District Council (50), Kyela District Council (50), Mbozi District Council (50), Chunya District Council (50), DRD (10), SUA (10), NRI UK (5) and Ilonga (remaining copies)

Access to inputs, particularly seed improved

When the project was initiated, surveys (Akulumuka and Hella, 2004; Ellis-Jones et al., 2003) indicated that most farmers used recycled seed and few had purchased new varieties. The project encouraged seed production through i) linking with a commercial seed company (MTI) to sell and produce in the first instance TMV1 seed, ii) encouraging local communities to produce seed, as seed producers for MTI.

Commercial seed distribution

A total of 4000 kg of TMV1 was distributed in one kg packages at the start of the vuli 2004-5 by MTI. The initial take was slow due to the dry conditions at the time. However this increased substantially during the masika 2005 when most seed was sold. At the same time, MTI established a seed farm on land leased from a sisal estate producing TMV1 in vuli 2004-5 intending this for future sale in the region. Although production was good, seed losses were experienced due to theft. At the same time farmers who had purchased TMV-1 from MTI did not wish to purchase new seed, recycling their own TMV-1 seed and giving or selling seed to other farmers. As a result MTI considered community-based production as competitors in the seed market and have reduced their activities in the area.

Community based seed production

Three community based seed production units initiated production using either TMV-1 or Syn 98 seed, both OPVs, after training in seed production (Table 22). Although most of the production was sold as grain, some is likely to have been used seed. Smaller quantities were sold for seed at prices between Tsh 300-700 per kg.

Table 22: Community based seed production and sales (masika 2005) (kg)

	Mapatano	Mbambakofi	Mtakuja
Area	1 ha	0.5 ha	1 ha
Variety grown	TMV1	Syn 98	Syn 98
Harvest	1500	800	1800
Grain sales	1000	500	1000
Seed sales	-	200	700
Retained for own use	500	100	100

Although it was hoped that further training leading to seed certification would be provided by QDS, QDS were unable to do so due to commitments elsewhere. Seed was therefore not certified. Unfortunately links with MTI did not develop as hoped for reasons indicated earlier.

Many individual farmers having purchased TMV1 seed from MTI used their own recycled grain for seed, and in many cases gave or sold seed to others. Village extension workers have also been advising on how best to isolate seed to limit cross-pollination. As a result the demand for seed from MTI has effectively collapsed in the project areas and MTI has not curtailed its activities.

Some conclusions

Community and individual farmer seed production has shown its potential, but requires QDS training and inspection to maintain seed quality. The loss of seed as a result of drought (two crop failures in five seasons) requires measures such as “community seed banks” to secure seed during such situations. In an environment where most farmers recycle their own maize grain as seed, the introduction of improved seed, including OPV maize varieties is unlikely to be resolved by the private sector acting on its own. It will require a joint initiative by with public sector, in this case Muheza District Council, where the public sector provides logistical support to the private sector for periodic introduction of improved germplasm.

Contribution of Outputs to developmental impact

Livelihoods of poor people improved through sustainably enhanced production and productivity of RNR systems

The ultimate beneficiaries of project outputs are rural communities, individual households and their families as a result of scaling-up activities. At the time of project completion evidence was available of considerable adoption of improved maize varieties (notably TMV-1 and Syn 98) as well as to a lesser extent soil fertility and pest management practices. This occurred as a result of both use of a process (PREA) and the availability of appropriate technology options for increasing crop productivity: In the case of declining soil fertility, use of green manures has not only improved soil fertility but has meant that the curse of *Striga* has been reduced. More widespread adoption will result from stakeholders promoting the technologies in other areas as well as continuing changes in knowledge and attitudes of farmers. This in turn is likely to lead to a strengthening of the rural economy with consequent advantages for local seed production and agents selling agri-inputs. By approaching crop production constraints using PREA, the impact of different crop management practices has been evaluated by farmers themselves. The opportunity to use these management practices has increased productivity. The combination of these outcomes in the long term should raise household incomes and improve basic food security.

Promotion pathways to target institutions and beneficiaries

Despite adverse climatic conditions during much of the project, improved soil and pest weed management techniques have been adopted in target villages, indicating the success of PREA in allowing farmers and communities to identify and seek solutions for their own priority problems. PREA has ensured that the improved management strategies have been evaluated by farmers themselves and the involvement of each community through existing groups and lead farmers selected by each group has contributed to improving farmer-to-farmer extension. At the same time close liaison between stakeholders (researchers, extension agents and close involvement of policy makers at village and District levels) has ensured that wide scaling-up should now be possible. The users of PREA have benefited from the knowledge generated both from their involvement with the participatory process as well as the development of alternative crop production practices. This has increased awareness of the constraints faced by farmers and the process is already being used in other villages by extension staff to promote wider farmer testing of technology options. Project partners who have also been target institutions include:

- Local research institutions (especially the Agricultural Research Institutions at Mlingano and Ilonga as well as Sokoine University of Agriculture).
- Private sector companies (notably, Mbegu Technologies Incorporated)
- Representative farmer and community organisations in Muheza District.
- Muheza District Council and its agricultural extension services, which have been given increased responsibility to promote local development initiatives.

Research outputs from this project are being promoted by project partners, communicating the knowledge gained to other stakeholders, including extension workers and farmers.

Enhancement of policy environment

Increased use of PREA is particularly important as many donors including DFID move from supporting free-standing projects in different sectors (including natural resources) to providing strategic level support for efforts to define and implement effective poverty reduction strategies through country assistance plans. If progress is to be made towards accelerated poverty reduction key elements are likely to include:

- Longer pre-project planning phases are planned to allow scaling-up activities to be planned and initiated. .
- Research and development activities are closely linked with long term funding commitments, tied to intermediate targets.
- Capacity building, multi-disciplinary partnership development and institutionalisation are given high priority within integrated research and development approaches.
- Funds for monitoring, evaluation and impact assessment systems will need to be substantially increased.

Follow up action to promote findings
Partners and stakeholders involved with this project are now more aware that research they undertake needs to be relevant and contribute to local, District and National development priorities. We are aware that project partners are using the project findings and approaches in implementing new research and development activities in ways that are appropriate to local conditions. However some support will need to be provided to ensure that the process approach is monitored and adapted to fit local circumstances. This will be particularly important for monitoring and evaluation of the collaborating institutions success in achieving the longer-term benefits of the processes implemented, if optimum benefit is to be achieved.

How outputs will be made available to intended users
These additional activities have given impetus to the work of EZCORE as well as underlying the importance of participatory research and extension approaches within the District Agricultural Office. Project activities will assist in creating demand for *Striga* tolerant maize varieties and green manure seed for distribution in small packs, affordable by farmers. At the same time it is envisaged that Tanzania's Agricultural Services Development Project (ASDP) will initiate operations in Muheza from the end of 2006. The project will assist in increasing demand from farmers in the District for ASDP support. This project has therefore worked closely with the District Council in preparing the ground for the Districts involvement in ASDP.

Publications:

Journal publications and refereed papers

[List only those published and in press i.e. accepted for publication. Please highlight in bold or with an asterisk outputs which have not been previously reported]

LEY, G., MASSAWE, C, MBWAGA, A.M., MOSHI A.,MROSSO F., NYAKI, A., ELLIS-JONES J., WHITE, R., HELLA J., KYAKAISHO, P., and RICHES, C., 2005. Improving food security through *Striga* and soil fertility management in lowland maize: a participatory process**.** The BCPC International Congress – Crop Science and Technology 2005 Congress Proceedings Volume 1: 527-532

Internal Reports:

[List of reports and dates. Please highlight in bold or with an asterisk outputs which have not been previously reported]

IARI., 2005a. *End of season* participatory *monitoring and evaluation of on-farm trials: Muheza maize project Vuli-Masika 2004-5–November 2053.* Project Working Report No 7

IARI, 2005b. Increasing food security and improving livelihoods. Promotion of integrated pest and soil management in lowland maize systems, Muheza District, Tanga, Tanzania. Report of a Workshop held in Muheza, 13-14 June 2005.

Juma W., 2006. Farmers' knowledge and information flow towards integrated pest and soil management technologies: A case study of maize farmers in Muheza district. Ministry of Agriculture and Food Security, Draft report

Other Dissemination of Results:

[Please highlight in bold or with an asterisk outputs which have not been previously reported]

IARI, 2005.

Manuals:

1. Manual and training guide on control of Striga for use by extension workers
2. Pictorial guide on control of Striga for use by extension workers in participatory training with farmers

Posters for use in extension offices, schools, clinics etc.

1. The use of Canavalia to improve soil fertility 2005
2. The use of Mucuna to improve soil fertility 2005
3. The use of Marejea to improve soil fertility 2005

Leaflets for farmers:

1. The use of Canavalia to improve soil fertility 2005
2. The use of Crotalaria to improve soil fertility 2005
3. The use of Mucuna to improve soil fertility 2005
4. Rain water harvesting alternatives 2005
5. The use of improved quality maize seed 2005
6. Control of stem borer 2005

Listing and reference to key datasets generated:

[Please highlight in bold or with an asterisk outputs which have not been previously reported]

IARI, 2006. Dataset: On-farm trials: Excel spreadsheets. Agricultural Research Institute, Ilonga.

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Akulumuka V., And Hella J., 2003. Input-output chain for smallholder maize growers in Muheza District, Tanzania. Survey report. ARI-Ilonga and Sokoine University of Agriculture.

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Ellis-Jones J**.**, Kanampiu F., Kyakaisho P., Massawe C., Mbwaga A. M., Moshi A., Mrosso F., And Riches C., 2004. *Best Practices for Integrated Striga control: A group extension tool using pictures for discussions with farmer groups*.

Hella J., 2004. *Muheza maize project: Baseline data on production practices in Muheza district*. Sokoine University of Agriculture.

IARI., 2005a. *End of season participatory monitoring and evaluation of on-farm trials: Muheza maize project Vuli-Masika 2004-5–November 2053.* Project Working Report No 7

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Biometricians Signature

The projects named biometrician must sign off the Final Technical Report before it is submitted to CPP. This can either be done by the projects named biometrician signing in the space provided below, or by a letter or email from the named biometrician accompanying the Final Technical Report submitted to CPP. (Please note that NR International reserves the right to retain the final quarter's payment pending NR International's receipt and approval of the Final Technical Report, duly signed by the project's biometrician)

From: rodger white (RRes-Roth) [mailto:rodger.white@bbsrc.ac.uk]
Sent: Monday, January 30, 2006 5:14 PM
To: jim.ellis-jones@tiscali.co.uk
Subject: RE: Final report from work in Tanzania

Jim
I have read the relevant pages and only have one small change in the final paragraph on page 9. I would prefer to see 'residual maximum likelihood' (no comma) instead of 'restricted, maximum likelihood'. And with that small change, I send this note

I confirm that the biometric issues have been adequately addressed in the Final Technical Report for project R8452.

Rodger White
Biometrician

Annex 1: Project Logframe

Narrative Summary	**Objectively Verifiable Indicators**	**Means of Verification**	**Important Assumptions**
Goal			
Livelihoods of poor people improved through sustainably enhanced production and productivity of RNR systems.	*Leave blank.*		
Enter the Programme Purpose that you are addressing	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager
Benefits for poor people generated by application of new knowledge of crop protection in cereal-based Semi-Arid cropping systems.	By 2006, improved crop protection methods promoted by at least three target organizations in order to achieve beneficial impacts on poor farmers and, as measured against baseline data, are contributing to one or more of the following: • end-user satisfaction • Increased and/or stabilized crop production • increased productivity (labour, land use or capital) • enhanced marketing opportunities		
Purpose *Enter the Programme Output that you are addressing*	*To be completed by CPP Programme Manager*	*To be completed by CPP Programme Manager*	*To be completed by CPP Programme Manager*
Strategies developed and promoted to reduce the impact of pests on poor people's crops and to improve quality and yield from maize-based systems in semi-arid areas.	By Dec 2006 farmer support organisations are promoting the improved technologies	Project reports	Widespread adoption by farmers of technologies
Outputs			
1 <u>Participatory technology development and promotion</u> of pest management, and soil fertility management techniques, 2 <u>Market for crop seed in small packs promoted</u> through farmer access to input supplies through private sector and/or community based seed production units as well as local traders supplying inputs	By Dec 2005, appropriate and cost-effective pest management strategies identified and developed By Dec 2005, farmer field schools operational in four village areas By Jan 2006, appropriate information resources available to support scaling-up cropping practices by local stakeholders. By Jan 2006, access to inputs, particularly seed improved.	Project reports Jointly prepared refereed publications Extension and training material	Political and economic stability Suitable climatic conditions Partner organisations continue to collaborate during the course of the project Farmers continue to work closely with the project

Activities	Indicators	Means of Verification	Important Assumptions
1 Participatory technology development and promotion 1.1 In-country stakeholder workshop involving farmers, NGOs, DAO and research professionals. i) 1.2 Continuation of a series of farmer led trials in partnership with EZCORE, SFI and CIMMYT evaluating a range of pest and soil management options, which include: ii) Using *Striga* resistant maize varieties iii) Integrating crop protection technologies with soil fertility improvement methods such as use of *Crotalaria* spp, *Mucuna pruriens*, Sunhemp, manure where available and inorganic fertiliser when affordable. iv) Reducing losses to stalkborer by planting borders of maize plots to Napier grass to reduce populations of the pest in the crop 1.3 Participatory monitoring and evaluating the trials through a series of farmer led field days and end of season farmer workshops with stakeholders 1.4 Farmer field school approaches[1] established as part of the ongoing agricultural extension activities of DAE in Muheza District. 1.5 Development and use of extension materials and other published outputs to stakeholders including farmers and extension staff in FFS activities.	By June 2005 and Jan 2006 Stakeholder workshops proceedings available By October 2005, full evaluation completed By Dec 2005, 300 farmers (10 villages groups) are testing the range of technology options By Dec 2005, farmer, extension worker and scientist evaluations undertaken for all technologies. By Jan 2006, Impact assessment report available, monitoring the process of farmer testing, uptake, modification of technologies. By Dec 2005, experiences of using a FFS approach documented. By June 2005, suitable extension material available for use in FFS By Jan 2006, at least 2 research publications distributed to stakeholders and other institutions.	Project reports Jointly prepared refereed publications Extension and training material	
2 Market for crop seed in small packs validated 2.1 Opportunities for linking farmers with seed producers and input suppliers to ensure affordable sized packages of key inputs are available. 2.2 Initiating a process of village/farmer based seed supply.	By Jan 2006, key inputs available in affordable sized packages By Jan 2006, at least one community has established a process for accessing improved open pollinated maize varieties		

[1] This is a community led approach facilitated by Village Extension officers and lead farmers using group seed farms.