CROP PROTECTION PROGRAMME

On-farm verification and promotion of green manure for enhancing upland rice productivity on *Striga* infested fields in Tanzania
R No. 8194 (ZA No0511)

FINAL TECHNICAL REPORT

1stt September 2002 to 31st March 2005

Dr. Ambonesigwe M. Mbwaga

Ilonga Agricultural Research Institute, Kilosa, Tanzania

30th March 2005

"This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID." *[R8194 (ZA0511) Crop Protection Programme]*

CROP PROTECTION PROGRAMME

On-farm verification and promotion of green manure for enhancing upland rice productivity on *Striga* infested fields in Tanzania

R No. 8194 (ZA No0511)

FINAL TECHNICAL REPORT

1stt September 2002 to 31st March 2005

Project costs **£117 930**

Dr. Ambonesigwe M. Mbwaga

Ilonga Agricultural Research Institute, Kilosa, Tanzania

30th March 2005

"This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID." *[R8194 (ZA0511) Crop Protection Programme]*

CONTENTS

RESEARCH TEAM

TANZANIA

Department of Research and Development
Ilonga Agricultural Research Institute, Kilosa

Dr. A. M. Mbwaga Plant Pathologist/*Striga* specialist/Project Leader
Mr C. Massawe plant protectionist

Mlingano Agricultural Reserch Institute, Tanga
Dr. G. Ley

Sokoine University of Agriculture, Morogoro
Dr. J. P. Hella
Mr J. Kayeke (Post graduate Student)

District Extension Staff:
Morogoro rural
E. Masangya (subject matter specialist)
Kyela
Mr Mwampaja (subject matter specialist)

INADES Formation Tanzania (NGO)
Patrick Lameck

UK

Natural Resources Institute
Dr. C.R. Riches Weed Scientist
Mr R. Lamboll Agricultural Economist

Executive Summary

Project Purpose: This was: "Promotion of strategies to minimise impact of target pests in rice-based Land-Water interface cropping systems, for benefit of poor people". The specific objective was participatory evaluation and promotion of legumes (the green manure *Crotalaria ochrelucra* or pigeon pea) in rotation with rice for control of *Striga* to improve rice productivity on *Striga* infested soils. The project partnership involved Department of Research and Development, INADES Formation Tanzania and Sokoine University of Agriculture in Tanzania, and Natural Resources Institute UK with district extension staff from both Kyela and Morogoro rural districts. Working with district extension staff, village agricultural primary school teachers in Kyela and Matombo-Morogoro rural districts, a project was initiated in November 2002 to promote outputs of project R7564. This project had demonstrated that farmers can achieve improved rice yields on *Striga* infested soils by improving soil fertility with the use of green manure or pigeon pea.

Output 1 *Participatory evaluation and promotion of green manures used in rotation with rice on Striga infested soils:* Through a series of seminars farmer research groups were formed in eight villages in Kyela where rice is the major food and cash crop and five in Matombo, Morogoro rural districts, where both rice and maize yields have declined due to *Striga* infestation. Participants selected sites and established demonstrations, which included plots of *Crotalaria*/rice and pigeon pea/rice rotations compared with continuous rice. These groups undertook 117 and 122 demonstrations of the legume rice rotations in Kyela and Matombo respectively. Farmers assessed rice and maize planted following the legumes to be more vigorous than continuous cereal. Only one light weeding was needed in rice after *Crotalaria* compared to two or three in continuous rice, *Striga* infestation was much reduced by *Crotalaria*. Rice yield following *Crotalaria* increased more than 80% compared to continuous rice. There is a steady increase in the number of farmers adopting rice/legume rotation through "farmer to farmer" extension and demand for *Crotalaria* seed is out stripping supply. Kyela farmers have sold 400kg of seed to neighbours, to Matombo and to farmers participating in project R 8215 in Muheza district. They plan to take seed to the national agricultural show for sell to farmers who showed a lot of interest last year's agricultural show.

Output 2: *Identification, preparation and publication of information sources to support promotion of green manure in rice based farming system*: .A total of 21 village primary schools participated in the project by including knowledge on biology and *Striga* management in the agricultural school science curriculum. Schools demonstrated the value of *Crotalaria* and pigeon pea to increase soil fertility and control of *Striga* using songs, plays, poems, traditional dances and setting demonstration plots at their school farms. 2000 copies of a leaflet on the use of *Crotalaria* have been produced and are being used by extension staff, farmers, schools and farmers buying the *Crotalaria* seed. A poster on *Crotalaria* has been produced and 500 copies are being distributed to schools, hospitals, churches/mosques, extension offices to reach large number of the community. A draft video has been produced documenting the use of green manure to improve soil fertility and to reduce the impact of *Striga* on the rice crop to allow wider dissemination of the technology.

Contribution of Outputs to Project Goal: Use of the legume/rice rotation has been evaluated and shown to have a potential for adoption over a large areas of Tanzania not only where *Striga* is a problem, but also in areas with poor soil fertility. This is especially useful for resource poor farmers who cannot afford to purchase inorganic fertilizer. As a result of the

project farmers in participating villages have begun to adopt the use of the green manure on a large scale, *Striga* infestation has decreased, and the yield decline in rice, identified by farmers as a major cause for concern, has been reversed. The project has demonstrated the value of using a range of partnerships, including research, extension and schools to promote knowledge on improved agricultural practices. Extension materials have been produced that can be used elsewhere in the country to support promotion of cereal/legume rotations that improve farm productivity and incomes.

Striga infested field –Kyela 2004

Background

Upland rice is an important cash crop in many areas of eastern and southern Tanzania, including Morogoro Rural and Kyela districts (Riches, 1999[1]). Under continuous cultivation, rice yields have been in decline in recent years. This is associated with falling soil fertility and an increase in infestation by the parasitic witchweed, *Striga asiatica*. In order to tackle this problem a group of researchers and extensionists have been undertaking trials in two villages in Kyela. Working with farmer groups in Kyela since 1996 (CPP project R7564) it has been demonstrated that up to 60% reduction in *Striga* numbers and 45% increase in rice yield can be achieved by applying urea fertiliser (Mbwaga, 2001[2]). Although the farmer groups involved in the on-farm trials described how they had learnt through this work that *Striga* infestation is associated with low soil fertility they also indicated an unwillingness to adopt the use of urea as a widespread practice. This is largely due to a lack of liquidity for fertiliser purchase. Although a seasonal credit programme was available in Kyela, operated on a group basis through the district agricultural extension programme, many farmers considered the terms to be unfavourable. In particular loans were repaid at harvest time when rice grain prices were low. Another approach to managing *Striga* was therefore needed.

The green manure species *Crotalaria ochroleuca,* called Marejea in Kiswahili, has been grown for many years at St Benedicts Abbey, Peramiho, southern Tanzania, where it is used to maintain the fertility of organic gardens. At Peramiho, this *Marejea* grows up to 2 m in height and has been found to be fairly drought tolerant, recovering well when rain returns. When broadcast as a sole crop growth is vigorous so that weeds is suppressed. This provides a clean entry for the subsequent crop. Seed obtained from Peramiho was distributed to the two farmer groups in Kyela by the research team and was planted at few sites by participating farmers in 2000. A number of farmers were familiar with *Marejea* as it had been included in on-farm trials undertaken in Kyela in a number of years before by Uyole Research Institute in the Southern Highlands. For example according to farmers in Njugilo village a team from Uyole was active in Kyela in 1989-90 seasons. They are also aware of on-farm trials in near by Mbula village, which are said to have been operational in about 1996 for four seasons. These looked at using *Marejea* in rotation with upland rice. However the farmers view is that this was “just an experiment” and there seems to have been limited farmer participation and no follow up promotion. It is also understood that there had been little reporting of these field activities. Although farmers had expressed interest in testing the species further, no seed was supplied. Farmers were very impressed by the growth of the plots planted in 2000 by Project R7564, especially those placed on what was judged by the community to be poor, worked out land. Farmers took particular interest in one site where the farmer had planted sufficient *Marejea* to allow a comparison in 2001 of rice growth following the green manure compared to that following rice. Farmers observed that no *Striga* emerged on the plot previously sown to *Marejea*. This yielded 2100-kg ha^{-1} rice compared to 1000 kg where no fertiliser was used and 1600 and 1900-kg ha^{-1}

---

[1] Riches C R (Ed.) 1999 *Striga distribution and management in Tanzania*. Proceedings of a stakeholder workshop, Dar es Salaam, 8-9 December 1999. Natural Resources Institute, University of Greenwich, UK.

[2] Mbwaga A M 2001 *Striga* research activities in Central, Eastern, Lake and Southern Highlands Zones of Tanzania: on-station and 0n-farm trials for 2000-01 season. Ilonga Agricultural Research Institute, Tanzania.

respectively where 25 and 50 kg N ha^{-1} had been applied. At a field day held in Kyela May 2001 and at results and planning meeting for 2001/2002 season in November 2001, both held in Kyela, farmers picked out the green manure plots and requested further support to test the use of Crotalaria more widely.

Following village seminars conducted by Ilonga staff 33 farmers requested seed of Crotalaria to plant in the 2002 season. The District Agricultural and Livestock Development officer and village based extension officers held a farmer's day for non-participating farmers and arranged a farmer exchange visit, with farmers from participating communities in Itope/Busale and Kilasilo villages visiting each others fields.

The process of farmer evaluation of green manure, which was initiated by the research team, has subsequently become farmer driven. This has been built on to implement a new project (R8194) designed to promote the use of the green manure Crotalaria for improving the fertility of Striga infested upland rice fields. This project was led by Ilonga Agricultural Research Institute and funded by DFID until March 2005. The project undertook field demonstration and other promotional activities in two districts of Tanzania – Kyela district in Southern Highlands Zone and Matombo division, Morogoro Rural district in Eastern Zone. In addition to Ilonga, local partners included district agricultural extension and primary school education staff, the NGO INADES Formation Tanzania, which specialises in community analysis and empowerment, a soil fertility specialist from Mlingano Agricultural Research Institute and a social economist from Sokoine University of Agriculture. The Natural Resources Institute, UK, assisted with developing protocols for monitoring farmer involvement in the demonstration work, development of the field programme and dissemination materials.

The project used two routes to promote the soil fertility enhancement for Striga management. The major focus was formation of farmer groups, which undertook on-farm demonstrations used as sites for field days. In addition there was interaction with teachers at village primary schools in both districts. Awareness of the Striga problem and of methods to improve soil fertility was included in agricultural primary school science classes. Supporting training materials including posters and leaflets were prepared according to the needs.

Information on the use of *Crotalaria* in Tanzania

Crotalaria ochroleuca, an annual legume from Africa commonly known as Marejea, or sunnhemp, has emerged as a promising under exploited crop. Vol 3. No.1 of the ILEIA Newsletter reported on this promising legume. Recently, Fr. Gerald, a Benedictine missionary in Tanzania published a manual on Sunnhemp, which covers the many beneficial characteristics of this plant.

Among sunnhemp's many uses are the following: green manure, nitrogen fixation, weed suppression, livestock forage, and pest control. Farmers in Tanzania have found tillage easier in fields where sunnhemp has been grown and incorporated into the soil, due to improved soil texture. These farmers can plough their fields before the rains, giving crops the benefit of the full rainy season, improving their chances of a successful harvest. Sunnhemp's deep root system aerates the soil and increases water infiltration. The deep roots also retard soil erosion.

Nitrogen fixing rhizobium associated with these roots, fix atmospheric nitrogen normally unavailable to plants. Professor M. P. Salema of Sokoine University of Agriculture, Morogoro, has isolated superior kinds of rhizobium for improved nodulation on sunnhemp. By inoculating their seeds with the rhizobium farmers can now increase their production. Nitrogen that has been fixed by the soil rhizobium is made available to crops by composting sunnhemp or turning it into the soil in situ. The organic matter added to the soil also improves soil moisture retention and texture. Cut sunnhemp can be used as a mulch to suppress weed growth and to control erosion. Ultimately the sunnhemp mulch will decompose, adding nitrogen to the soil to benefit succeeding crops. Sunnhemp's low carbon to nitrogen ratio causes it to decompose readily, quickly adding nutrients to the soil. Sunnhemp, unlike most nitrogen fixing legumes, performs well on poor and acidic soils. For this reason farmers in Tanzania have used sunnhemp to revitalise weedy or infertile fields

In addition to its soil improving qualities, sunnhemp also controls weeds. Under appropriate conditions sunnhemp establishes quickly and grows abundantly, thus out competing weeds. If planted densely, sunnhemp prevents weed growth in the first year, and reduces subsequent weed growth for the following 1-3 years. Sunnhemp can out compete couch grass (Digitaria SP) but not blackjack (Bidens pilosa). Over the course of 3 years sunnhemp eventually out competes stargrass (Cynodon SP) in paddies.

Cultivation of Sunnhemp: Experienced sunnhemp farmers mix 10 kg of seed for each 0.5 hectare to be planted with sand or dry soil at the ratio of 1: 2 litres to assure a proper planting density (plants spaced 10-15 cm apart). Above ground growth is slow initially, as the plants develop deep roots. Eventually sunnhemp reaches a height of two meters or more, and flowers appear three or four months later. Sunnhemp does not re-seed itself, since its pods stay closed after the seeds have matured, even protecting them for months into the rainy season. After six months the plants begin to senesce. The stems, however may persist for as long as eight or nine months, and will develop new leaves when cut one foot above ground, or when eaten by animals.

Other Uses of Sunnhemp: Sunnhemp can be grown as a fodder crop. Farmers in Tanzania have found that sunnhemp can constitute 60% of their cattle's feed. The stems that are left over are mixed with manure to compost them. Chicken will eat any part of the sunnhemp plant except for the seeds. One acre can yields up to 100 to 300 kilos of seeds; one kilo seed sells at 600/shillings in Tanzania. Some farmers let their cattle graze sunnhemp for one hour a day if they do not want to harvest the seed. Sunnhemp can also be used to feed tilapia.

It is also known from the literature and experimental results from Project R7564 that *Crotalaria* stimulates germination of *Striga* seed and it is not a host hence causing suicide germination of the seed.

Ilonga Agricultural Research Institute had, since 1995, been evaluating a number of recently developed pigeon pea cultivars. These are resistant to the soil borne wilt disease, *Fusarium udum*, which is widespread in East Africa. Promising cultivars had been introduced to farmers in Kyela in villages participating with project R7564. Pigeon pea is planted in this area but farmers had reported yields to be generally low. The crop is well known to have potential for increasing soil fertility and enhancing yields of following cereals (e.g. MacColl, 1989[3]) and trials demonstrated the potential of the new cultivars in Kylea. The crop was therefore included in the legume/rice rotations demonstrated by project R8194 as an alternative to *Crotalaria* as it provides an economic grain yield and contributes nitrogen and phosphorous to the system.

Project purpose

The project purpose:

> Soil fertility management strategies were validated and promoted, to reduce infestations of the parasitic weed *Striga asiatica* and increase yields of resource poor farmer's upland rice crops

The specific objectives

- The use of legumes – *Crotalaria* or pigeon pea to increase soil fertility was promoted so that the impact of *Striga* on rice/maize yields was reduced and yields of rice/maize increased. A reduction in the impact of *Striga* on rice/maize would contribute greater yields and income for households, whose major source of livelihood is agriculture.
- Publications of information sources to support the promotion of green manures in rice based systems were to be prepared and validated

Research Activities

Research partnerships: Building upon the work of project R7564 the project continued to take a farmer centred approach with majority of activities implemented through farmer research groups. To do this the project brought together agronomists, weed scientists, pathologists and agricultural economists of the Department of Research and Development, INADES Formation Tanzania and Sokoine University of Agriculture in Tanzania, and Natural Resources Institute UK with district extension staff from both Kyela and Morogoro rural districts.

***Research sites*:**

Research work was undertaken at two locations, one in Kyela, which is mainly rice, based farming system and a second one in Matombo Morogoro rural district, which is based more on maize system (Figure 1). All demonstration plots were done on farm using farmer research groups starting with two of those established by project R7564 and from there new ones were established at both sites.

Kyela district in Southern Highlands Zone

Rice is generally recognised as a very important crop in Kyela. The *Striga* research process has evolved quickly in this area at least partly in response to the enthusiasm of extensionists and farmers. A study of conditions in Kyela was carried by a combined team from ICRA (International Centre for development oriented Research in Agriculture) and Uyole ARI (1994[4]). Part of the study involved a survey of 123 respondents across

---

[3] MacColl, D. 1989. Studies on maize (*Zea mays*) at Bunda, Malawi. II. Yield in rotation with legumes. *Experimental Agriculture*, **25**: 367-374.

[4] ICRA/ Uyole ARI (1994) A dynamic farming system: The case of Kyela district. Working document Series 37, Tanzania. ICRA, Wageningen, The Netherlands.

seven villages (five on the flood plain and two in higher areas). This provided the following background information:

- Kyela district -est. pop 159, 000 (1994); densely populated (est. 203 people/ sq. km in 1994)
- High rainfall - annual average 2726 mm (1972-93).

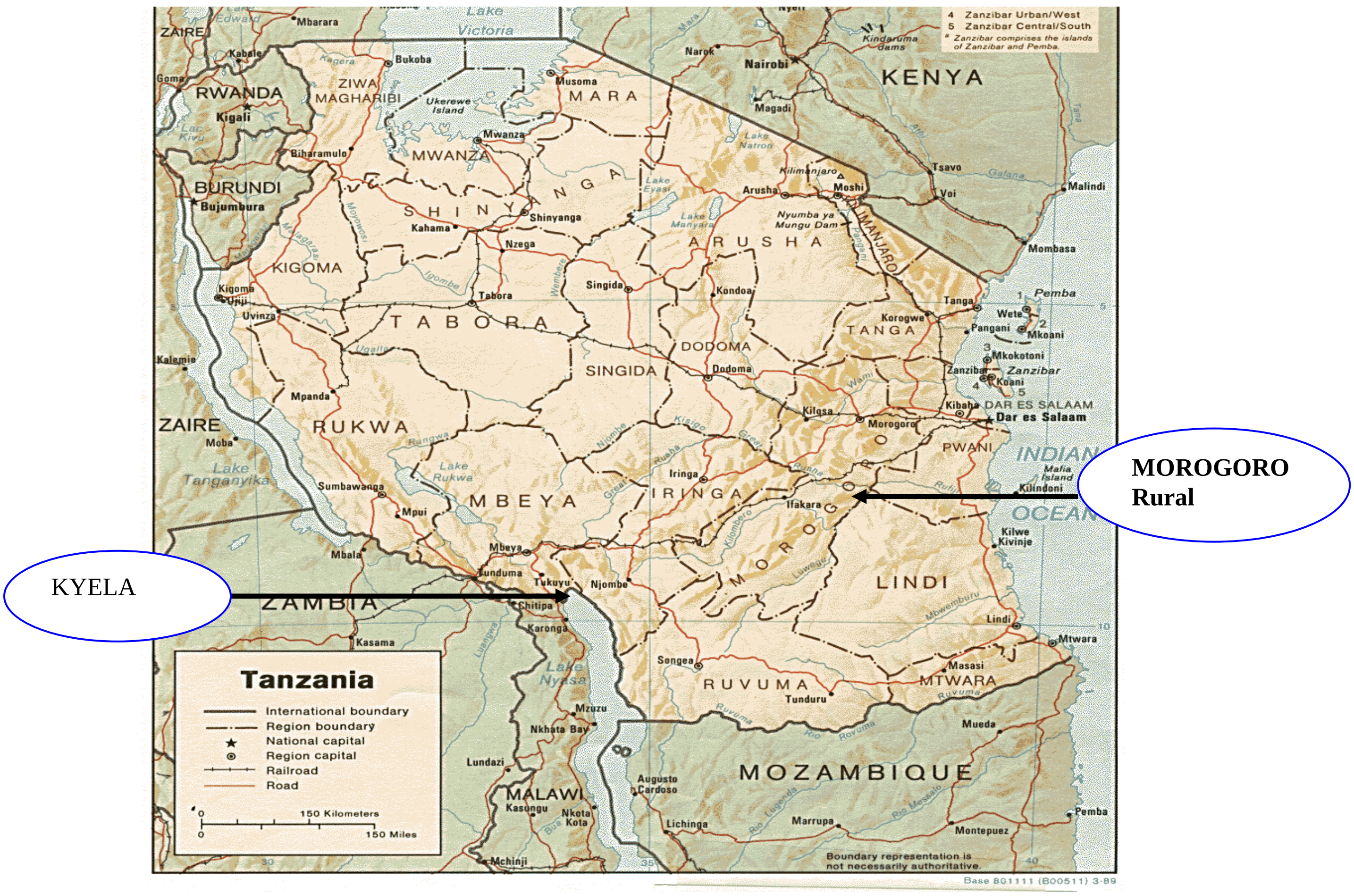


Figure 1: Map of Tanzania showing location of the study locations

- Kyela district can be broadly divided into flood plain (with high, middle & low benches) and higher land. Large areas of the flood plain are prone to flooding.
- Soils
  Flood plain: alluvial, poorly drained with high clay content;
  Higher land: weathered red clay; leached and acidic.
- Crops- household land allocation: rice (44%); home garden e.g. banana, cocoa (28%); other e.g. sweet potato/cassava (16%); maize (6%). Rice most favoured crop in Kyela - food and cash income.

Livestock - cattle numbers in decline. Pig and poultry are increasing.
The District Extension Service has divided Kyela district into four agricultural ecological zones. According to Mr Mwambungu (DALDO) there is a total of 20 extension staff working at division, ward or village level in the district.

Some Farmer perceptions

Fertility status varies between villages (generally decreasing moving from flood plains to higher land). Weeding is the most laborious task. Manure is associated with increase in weeds (5-15% of respondents). Weeds in general, particularly on the floodplain, considered a major constraint on rice production

Farmers classification of soils

In the higher areas, the ICRA study reports two main soil types *Kibumba* and *Ntitu*.

Local name	Kibumba	Ntitu
USDA classification	Ferrasols/ luvisols	Fluvisols
Location	Slopes	Valley bottoms
Colour	Red	Black
Texture	Clayloam	Clay
Water holding capacity	Poor	Good
Crops	Cassava, groundnuts, sweet potato, pigeon pea, bambaranut	Rice, maize
Fertility rank	2	1

Farmer knowledge

A high proportion of farmers have knowledge (through use) of chemical fertilisers and animal manure.
Discussions with farmers during studies undertaken by the DFID Striga project indicate farmers have little knowledge of *Striga* biology but associate it with declining soil fertility. The name for *Striga* in Kinyakusya is Kyumika

Upland Rice production practices

Cultivation- Ox ploughing (a male activity) is used by 70% of households across land types but by only 46% in upland areas. Other farmers use hand hoes.
Planting on both lowland and upland areas is by broadcasting over 2-3 months (to spread labour demand). Upland rice is planted in late December to early January, usually grown as a monocrop. Some farmers plant a sparse stand of pigeon pea within the rice.
Weeding is predominantly a female responsibility. 20% of respondents in the ICRA survey had used herbicides, most probably on lowland areas.
Harvesting of panicles in undertaken with a sickle.

Soil fertility management

Chemical fertilizer 54% of respondents have used at some time BUT following the national Economic Structural Adjustment Programmes, district sales of fertilizer (tonnes) by two main suppliers have fallen:

	KYERECU	RTC	TOTAL
1992	200	69	269
1993	2.5	25	27.5

Current use, based on discussions with farmer groups is thought to be low.

Up until recently there was high dependency on credit made available through IFAD project.
Crop Rotation- upland: 63% of respondents; Floodplain: 36%
Fallowing- practised by 50% of respondents - average period of 2 years.
Crop residues- grazed by cattle; used for thatch; burnt; Incorporated.
Rice fields: Hand hoe - residues burnt
Ox plough - incorporated

Animal manure
29 - 43% of respondents 'use ' animal manure but actual areas treated are thought to be small.

Constraints

Chemical fertilizer
The high price is generally considered as the major problem.
Response (Kg/ Ha) to fertilizer varies with location e.g.

	Without	With
Higher area (Lema)	198	395
Floodplain (Itungi & Mababu)	1186	1580

Difficulty with the credit conditions associated with the IFAD project reduces the attractiveness of this route into fertiliser purchase. These include the need for group membership and particularly the need to re-pay the loan at harvest time when rice prices are low (has been 250% variation in farm gate price for paddy over season).

Animal manure
Insufficient quantities and the distance to fields constrain widespread use of animal manure.

Time to walk to fields (minutes)

	Flood	High
Rice	45	55
Maize	30	15
Cass/SP	15	7

Some negative perceptions are associated with increased weed growth following use of manure.

Matombo Division, Morogoro Rural district in Eastern Zone

Morogoro Rural district has a population of about 600,000 and is to be spilt in two becoming Mvomero district in the north (4 divisions) and Morogoro Rural in the South (6 divisions). Matombo lies to the south in the area of the Uluguru Mountains. A study by Bhatia and Ringia (1996[5]) provides some useful background to the Uluguru mountain area. PRAs were carried out in 11 villages, one of which was Kiswira (one of the project villages).

[5] Bhatia Z. and Ringia O. (1996) Socio-economic survey of selected villages in the Uluguru mountains, Tanzania. Uluguru slopes planning project Report No. 3. A joint project between Government of the United Republic of Tanzania, the European Union and the Royal Society for the Protection of Birds.

The Uluguru mountain area in general is relatively densely populated (more than 150-persons/ sq. km) and has a high rate of population increase (up to 6.5% per annum). The area is most inhabited by Waluguru people whose livelihoods are based on crop production – particularly maize, beans and rice and, from selling vegetables and fruits to urban markets. The mountains rise from about 300m at the coastal plain to 2638m. Rainfall varies from 900m at Morogoro municipal to 1200-3100m on the drier western slopes to 2500-4000 m on the eastern slopes. There are generally two rainy seasons with the long rains (*Masika)* usually from February to June and the short rains (*Vuli*) October-January. The forests on the Ulugurus are considered to be one of the top priorities for biodiversity conservation in Africa, as well very important as river catchment areas, maintaining a humid climate and preventing soil erosion. There is a long history of external interventions aiming to conserve natural resources in the area.

Deforestation and other resource degradation are attributed to land scarcity. The system of land ownership at the time of the study was based on lineage systems, which is reported to lead to inequitable distribution, land scarcity and poor land management. Some families suffer from land shortage; others hold land, which is not being used. Some farmers are tenants, paying in cash or kind, and they are restricted from practising permanent land development, including planting of trees. According to Bhatia and Ringia (1996), Kiswira was identified as a special case where the land for the village is leased from the Catholic mission (dating back to the time of Tanzania's villagization programme). Under this arrangement all trees planted belong to the mission and a percentage of any produce (*ngoto*) from the farms also has to be paid to the mission. A diverse range of crops is grown for food and cash in a number of cropping systems (see below).

Season/ type of shamba	Long rains (*Masika*)	Short rains (*Vuli*)	Dry season (*Kiangazi*)
Hilly/ forest fields (*Mwituni*)	Maize/ rice relay (upland rice) Vegetables, potatoes, yam, cassava Bananas	Maize/rice relay Banana, beans Yam, potato	Woodlots Banana
Home gardens (*Jaladani)*	Intensive agro-forestry, banana, fruit trees, multi-purpose trees, beans, peas, livestock, maize, sweet potato	Maize and beans Banana and multi-purpose trees Small livestock	Agroforestry Multipurpose trees and banana
Valley bottoms (*bustani*)	Maize and rice Banana Beans	Maize/ rice relay Agroforestry	Irrigated/ residual moisture crops: Vegetables, maize, beans
Lower plains (*makondeni)*	Maize and cow pea Sorghum and cassava	Early maturing maize, cowpea, pigeon pea	Grass/ bush fallow

Inter-cropping is common. Maize is produced in all zones, but is not sufficient to meet food needs. Low yields are attributed to low soil fertility, low yielding local varieties, pests and diseases, particularly vermin. Rice appears to be cited as a food crop rather than a cash crop. Weeds in general are cited as a problem (growing fast in response to the favourable climate) and difficult to control, although *Striga* is not specifically mentioned in the report.

Shifting cultivation is still commonly practised although fallow periods are generally much reduced and in some areas land is cultivated continuously. The majority of farmers practise flat cultivation with contours constructed using grass, shrubs and trees. Bench terraces and other soil conservation practices are unpopular and are considered unproductive, labour intensive and less effective in erosion control than indigenous practices. Minimum or zero tillage is often practised especially on hilly fields. Hand hoes are the main tools for cultivation. Due to the presence of weeds, fire is used in many places to facilitate land preparation.

Most households in the Ulugurus experience shortage of cereal food, particularly maize. Households supplement home produced maize with maize imported from Kilosa and Iringa districts. During the PRA constraints (Bhatia and Rinia 1996) were identified and prioritised in seven villages. 18 major constraints were identified: Communications, Hospital/health, Land scarcity, Mine ownership, Education/schools, Lack of milling machines, poor upbringing of youth, clean and safe water, lack of markets, poor agriculture/forest extension, vermin, poor village leadership, deforestation, unemployment, high cost of agricultural inputs, corruption of officials/leaders, lack of credit facilities and pests and diseases. In Kiswira village the top 6 constraints were ranked as Hospital/ health, Lack of milling machines, Vermin, Clean and safe water, Communications, Lack of markets. Loss of soil fertility due to shorter fallows was specifically mentioned in the Kiswira PRA. Manure is not used because of insufficient livestock. Villagers are discouraged from erosion control practices such as planting 'kaskas' because they feel this would reduce land availability for cropping even further.

In Morogoro rural district there are 235 villages and 132 extension staff outside the district HQ. The aim is to have at least one extension officer in each ward.

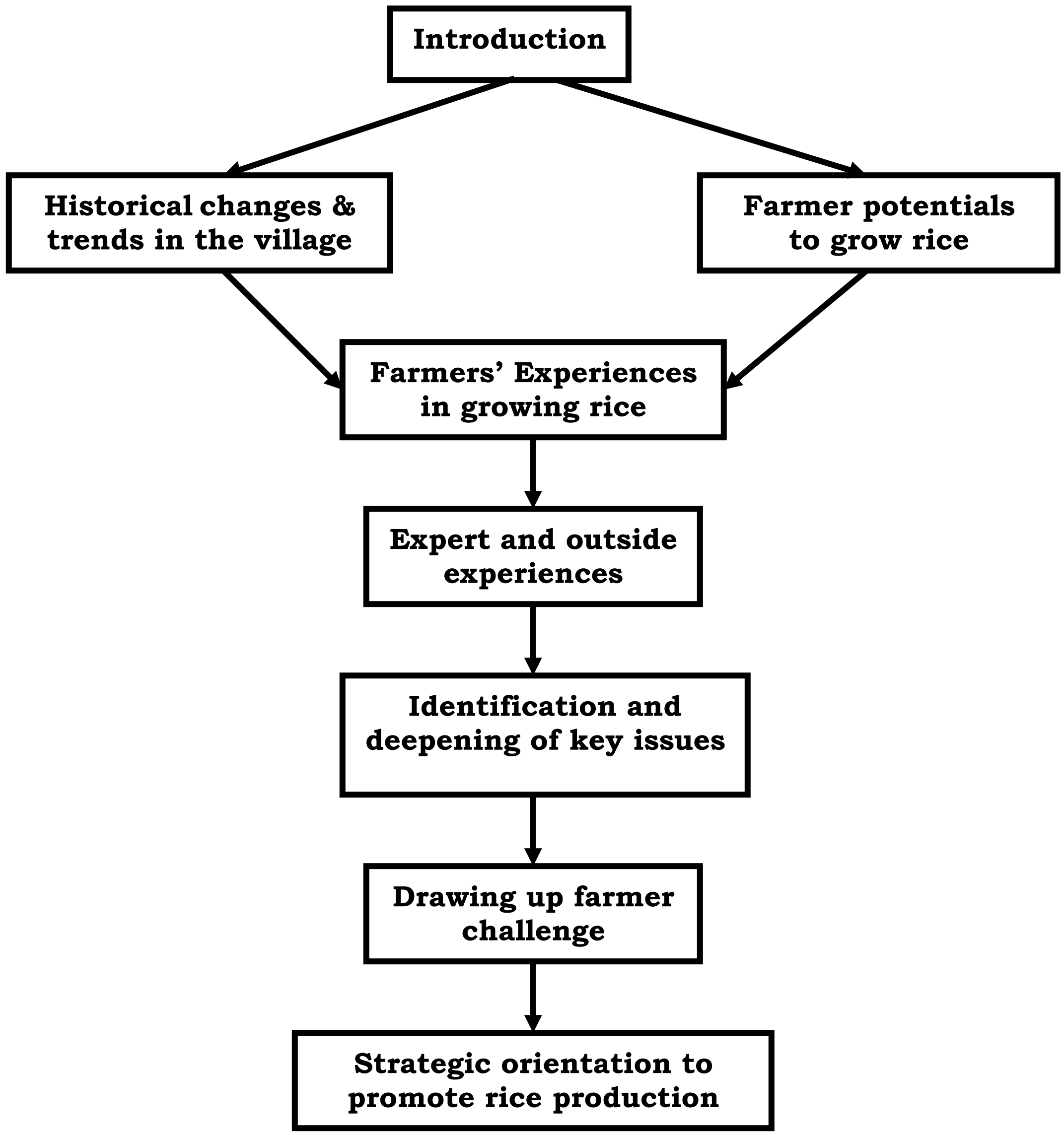
Output 1

Participatory evaluation and promotion of green manures used in rotation with rice on Striga infested soils

Farmer research group establishment, **Context analysis and baseline survey**

During the life of the project activities were conducted in 13 villages (eight in Kyela and five in Morogoro rural). High incidences of parasitic weed *Striga,* low soil fertility and marked decline in rice production were main reason for choosing these sites. Initial seminars were held in Kilasilo, Itope, Sinyanga, Konjula (Kyela), Kiswira and Kibangile villages (Matombo) at the beginning of the project to strengthen existing groups (in Kilasilo, Itope) and to form new groups. INADES Formation staff led participants in a Context analysis with the objective of assisting farmers to understand their situation so that they can fully understand the challenge ahead of them and to set strategies to alleviate the situation (see Working paper No. 2, 2003). The process followed with farmers at context analysis workshops is shown in the diagram below.

Context analysis workshop process



Subsequently, in October 2004 seven new groups were formed in Ushirika, Ngana, Kasumulu, Kandete, in Kyela and in Konde, Mtombozi, Gozo villages , in Morogoro Rural districts. During these seminars staff from the extension office opened the meetings. There then followed a discussion on the crops grown, and identification of production constraints. Following this Staff from Ilonga made a presentation on the economic importance of Striga, biology, possible control options and options for improving soil fertility. A possible lay out for demonstrations were discussed and farmers willing to be involved were facilitated to form a group and to vote for group leaders. Also examples were given for successful villages, which have already adopted the use of green manure to improve soil fertility and control of Striga.

District	Village	Group membership 2003 – 2005	Demonstration plots 2003 -2005
Kyela	Kilasilo,	26	22
	Sinyanga	13	13
	Itope	16	10
	Ushirika	10	10
	Ngana	10	10
	Konjula	10	8
	Kasumulu	10	10
	Kandete	10	10
Matombo	Kiswira	16	12
	Kibangile	23	16
	Konde	21	21
	Matombozi	20	20
	Gozo	17	17
Total		189	179*

* These are number of plots which scientists were able to visit and evaluate

Methodology for participatory technology evaluation

Demonstration plots

At initial village seminars a presentation was conducted on *Striga* biology, control and options for improving soil fertility. Planning sessions were then held with each farmer group. A possible lay out for demonstrations were discussed and farmers willing to be involved were facilitated to form a group and to vote for leaders of the group. Existing *Striga* research groups in Itope and Kilasilo from Project R7564, who already had plots of *Crotalaria*, were updated on the new project and plans were agreed for coming seasons. During discussion with farmers it was agreed to incorporate *Crotalaria* and pigeon pea into the demonstration plots. Pigeon pea variety Mali, known to be resistant to fusarium wilt was used.

It was agreed that on each farm where a demonstration was established there would be three plots, side by side of *Crotalaria*, disease resistant pigeon pea and rice/maize. All plots were planted to rice or maize in the following season. During mid-season evaluations group members in the villages visited all the sites in their respective accompanying the multidisciplinary project team. Each of the host farmers described his demo plot. Farmers were encouraged to discuss what they observed so far during the season. This included the advantages and disadvantages of growing green manure, or pigeon pea in rotation as compared to continuous rice or maize cropping. Further group meeting were held to develop participatory budgets to compare rotations to normal farmer's usual practice. Farmer perceptions, experiences and lessons learnt were systematically monitored and recorded during the monitoring tours, which included, participating farmers, extension staff and research partners.

Soil samples were collected from plots previously under green manure and from those of continuous rice to identify the status of the soil fertility and to find out the contribution of green manure to soil fertility. This was done in two villages Kilasilo and Itope in Kyela and from the other location will be reported in phase two of the project.

Associated trials on use of green manures
Post-graduate student Juma Kayeke undertook field work on the use of green manures for increasing rice productivity on *Striga* infested soil in Kyela during the period this project was operational. Project staff provided advice on his trials and he was also provided with some financial support to work in Kyela. Two replicated trials were undertaken on land borrowed from farmers in Itope and Kyela villages. In these trials the effect of a range of legumes, including *Crotalaria*, either applied as mulch or incorporated at flowering on subsequent rice yield and *Striga* emergence was assessed. The residual effect of the green manure in a second season of rice cropping was also examined.

Output 2

Identification, preparation and publication of information sources to support promotion of green manure in rice based farming system

Farmer exchange visits and field days
Exchange visits involved exposing farmers from villages not previously participating in this work to the activities in villages where activities had been established under R7564 (Kilasilo and Itope in Kyela). These visits provided a learning experience and encouraged farmer to farmer discussion of the *Striga* problem and potential solutions. Farmers who were already using the legume/cereal rotation showed their plots to visitors and described what they had learnt and their future plans. These discussions motivated visitors to begin testing the suggested practices in their own villages. Taking a selection of farmers and extension workers from Matombo to Kyela in 2003 was a particularly important component of introducing the rotations to Matombo. It became clear that the visits contributed to farmer "learning by doing". Explaining an agronomic practice, including rotation for *Striga* management, has limited impact. The exchange visits allowed farmers to question others already using the rotation and to learn from their experiences. The visits are descried in detail in Working paper No. 4, 2003.

Summary of farmer exchange visits 2003-2004

	Village		Number of visitors	
Date	**Visitors from:**	**Village visited:**	**Farmers**	**Extension**
22 May 2003	**Kiswira & Kibangile**	**Kilasilo**	**29**	**4**
23 May 2003	**"**	**Itope**	**29**	**4**
24 May 2003	**Sinyanga, Konjula**	**Kilasilo & Itope**	**17**	**2**
27 May 2004	**Kilasilo & Itope**	**Kiswira**	**10**	**8**
28 May 2004	**Kilasilo & Itope**	**Kibangile**	**10**	**8**

Summary of field days held 2003-2004

Date	Village field day held	Farmers	Extension
14 June 2003	Kilasilo	35	5
19 May 2004	Kiswira	36	4
20 May 2004	Kibangile	80	4
14 June 2004	Kilasilo	35	9

Promotion through primary schools

To initiate involvement of agricultural primary school teachers as a pathway of technology promotion, three workshops were held in the two project sites following discussions with district education officials. The aim was to explore the possibility of incorporating the knowledge on *Striga* biology and control in the school agricultural sciences curriculum. The idea was to make use of schools as centres of education for the surrounding community by demonstrating of growing green manure and the impact of this on *Striga* and rice. Activity plans were drawn up with teachers and meetings held with them twice per season. Each school developed a programme to teach pupils about *Striga* management through songs, poems, plays and traditional dances. Schools also set up demonstration plots. It is believed that if you educate a school child you have educated three people that is pupil, mother and father.

Preparation of extension material

Information collected during the project was compiled into extension resources – a leaflet, a poster and a video.

Research outputs

Output 1: *Participatory evaluation and promotion of green manures used in rotation with rice on Striga infested soils*

Context analysis: This was conducted in the initial six villages of the project; 4 in Kyela and 2 in Matombo. Through this participatory context analysis farmer goals for the project were established and this led to the establishment of farmer led demonstrations.

A full detail of the process has been presented in working paper N0. 2 (2003). The main finding included the following:

Key social and traditional issues

- ►Rice (Kyela)/maize (Matombo) were the main staples and used as food during celebrations
- ►High incidence of rice theft has increased in the last few years
- ►Collective farming (through ujamaa) among social groups is no longer being practised

Key environmental concern

- ►Decline in soil fertility
- ►Increase of Striga and *Ramphicarpa fistulosa* (for Kyela) problem
- ►Drought, inadequate and uneven rainfall distribution during the season
- ►Serious deforestation, drying of rivers and disappearance of wild animals

Key economic concern

- ►Rice and maize yields have declined from 20 bags to 1-2bags per acre respectively

- ►High in put prices and low prices for agricultural produce
- ►Limited marketing opportunities, usually dominated by middlemen, who offer very low prices for rice.
- ►Land scarcity due to population pressure, average land per household was estimated to be 2 acres.

Yield performance of Rice/Maize following Green manure (*Crotalaria*/pigeon pea) rotation Kyela-Matombo, 2003/2004 season

The results following green manure varied among farms, villages and locations. This was due to management practised by individual farmers, soil variation, intensity of *Striga* infestation in the field and climatic differences. Generally the rotation of green manure with cereals increased the yields of cereals significantly. The addition of ground phosphorous rock did not improve the yield of rice, indeed it was observed to have a negative effect. The possible reason for poor rice performance after application of phosphorous rock is that immediately after it had been applied there was no moisture in the soil for more than two weeks, hence it affected the vegetative growth of the rice crop. Full details of crop performance have been presented in project working papers No.7 (2003) and No. 8 (2004).

Kyela: During 2003 season farmers in Kilasilo and Itope who had participated with project R7564 had reached the second season for growing rice on plots which had previously been planted to Marejea (19 sites) or pigeon pea (4 sites) (Table 1&2). At both villages the rice yield from plots following green manure was significantly higher than rice following rice. The poorest yield was obtained from continuous rice. At Itope the rice yield increase following *Marejea* was 134.8% and rice after pigeon pea was up by 21.7% (Table 1). The rice yield increase during 2003 season at Kilasilo due to *Marejea* was 88.9% and due to pigeon pea was 207.4% (Table 2).
During 2003 more farmers and villages joined the project and planted legumes. These plots were test cropped with rice in 2004 (Tables 3-7). Highest grain yield of rice was obtained from plots following Marejea and the poorest grain yields were from those plots under continuous rice. The *Striga* infestation was also much reduced on plots under green manure. Previous soil analysis indicated soils to be very low in phosphorous so Mijingu phosphate Rock was added at some sites in an attempt to top enhance the value of green manuring. A good response was observed especially at Itope village, where the yield increase was 500% as compared to control (Table 3). From Kilasilo village, phosphate was not very much effective because after its application there was a prolonged dry spell which affected the crop and the yield increase was 75% as compared to without phosphate, which was 70% both with reference to the control (Table 4). Similar results were obtained at Konjula and Sinyanga villages, where the yield of rice following Marejea increased by more than 70% as compared to plots of continuous rice (Tables 5 & 6). The yield ranged from 0.2 to 6t/ha. Table 7 shows the summary of results of continuous rice after rice and rice after Marejea/pigeon pea for 2003 and 2004 seasons, where the yield of rice after Marejea/pigeon pea was much higher than rice following rice by 1.2 – 2.1 folds respectively.

Replicated trials in Kyela:
Trials undertaken by Kayeke[6], comparing different manures on improvement of soil fertility and reduction of impact of *Striga* on the rice crop confirmed the value of *Crotalaria*. The highest yield of rice was obtained from plots which were under *Crotalaria* in the previous season, followed rice grown after locally found weeds *Cassia obtusifolia* and *Mimosa invisa.* A yield increase of more than 100% was recorded for rice in rotation with *Crotalaria* compared continuous rice at both trial sites (Table 8). This response of rice was obtained when the green manure was either incorporated after flowering or cut down and left on the soil surface as mulch. However no effect of the legume was observed in a further season of rice cropping suggesting that farmers will need to alternate rice and a legume in the long term to maintain high yields. *Crotalaria* on these trial plots produced a mean of 4.3 tonnes ha^{-1} shoot dry matter and an additional 0.35 tonnes ha^{-1} of root containing 3.4% and 0.35% nitrogen, equivalent to 147 kg ha^{-1} N.

Matombo: In Kiswira, the plots planted to green manure or maize in 2003 were all planted with maize variety TMV-1 in 2004 season. Highest maize yield was recorded from plots following pigeon pea but this was not statistically significant as compared to the yields after Marejea (Table 9). The lowest maize yield was observed from plots which were under continuous maize. The maize yield increase due to pigeon pea was 160%, while that due to Marejea was 140% as compared to the continuous maize. The maize yield ranged from 0 to 2.4t/ha (Table 9).
At Kibangile village some farmers planted rice following green manure while others planted maize. Highest maize yield was observed from plots following *Marejea* and the least maize yields were harvested from continuous maize plots. Compared to the control, the yield increase due to *Marejea* was 120% and due to pigeon pea was 80 % (Table10). For those plots that were planted with rice, the highest yield was obtained from plots which were under Marejea in the previous season followed by rice after pigeon pea. Yield increase due to Marejea as compared to continuous rice was 126% while due to pigeon pea was 87% (Table 11).

Table 1: Yield performance of rice following green manure rotation Itope village, 2003

	***Striga* count/$25m^2$**			**Grain yield kg/$25m^2$**		
Sites	***Rice after rice***	***Rice after Crotalaria***	***Rice after pigeon pea***	***Rice after rice***	***Rice after Crotalaria***	***Rice after pigeon pea***
Rehema Mwalaba	48	18	0	-	9.5	-
Laison Kayuni	0	2	0	-	6.0	-
Y. Kayuwi	0	0	0	-	1.5	-
Mbalangwe	0	0	0	-	4.5	-
Mwema Hamisi	8	0	5	2.5	9.0	2.5
A. Mwakitubwa	0	0	0	-	3.0	3.0
Mwang'onda	12	5	0	2.0	4.0	-
Mean	**9.7**	**3.6**	**0.7**	**2.3**	**5.4**	**2.8**
Yield increase %				**0**	**134.8**	**21.7**
Range	**8-48**	**0-18**	**0-5**	**2-2.5**	**1.5-9.5**	**2.5-3.0**

[6] Kayake Mohamed, J. 2004. *Evaluation of potential green manure and plant extracts for control of Striga asiatica on upland rice in Kyela, Tanzania*. PhD Thesis, Morogoro: Sokoine Ubiversity of Agriculture.

Table 2: Yield performance of rice following green manure rotation Kilasilo village, 2003.

Sites	*Striga* count/25m²			Grain yield kg/25m²		
	Rice after rice	***Rice after Crotalaria***	***Rice after pigeon pea***	***Rice after rice***	***Rice after Crotalaria***	***Rice after pigeon pea***
Mwandenuka	1.0	1	0	0.5	6.0	-
Mwamundela	181	160	86	4.5	8.0	9.5
Mwakalinga	1300	82	0	1.5	4.5	-
Mwakatage	0	18	0	2.0	4.0	-
Kandonga	2100	396	0	3.5*	2.5**	-
Mwaipopo	15	5	1	2.5	10.0	7.0
Mwaseba	126	31	0	3.0	4.0	-
Frora Samwilo	77	103	0	3.0	6.5	-
Mbonge	-	-	-	-	-	-
Mwandenuka 2	63	177	0	2.1	3.0	-
Sankey	396	704	0	3.5*	3.5	-
Isumo	15	47	0	4.0	7.0	-
Mugogo	2	0	0	2.2	2.5	-
Mean	**356.3**	**143.7**	**7.3**	**2.7**	**5.1**	**8.3**
Yield increase %				**0**	**88.9**	**207.4**
Range	**0- 2100**	**0 -704**	**1 – 86**	**0.5 – 4.0**	**2.5 – 10.0**	**7.0-9.5**

** planted rice variety Supa India, *planted rice variety Zambia

Table 3: Yield performance of rice grown in rotation with green manure Itope Village – Kyela district 2004

Treatment	**with phosphate rock**	**Without phosphate rock**	
	Rice yield (t/ha)	***Striga* count 12 WAP/25m2**	**Rice yield (t/ha)**
Crotalaria - Rice	1.2	5	1.78
Rice – Rice	0.2	21	1.75
G. Mean	**0.68**	**12.8**	**1.76**
S.E.	**0.49**	**8.6**	**0.55**
Range	0 – 4	0 – 70	0 – 4
Yield increase (%) on *Crotalaria* plot	**500**		**1.7**

Table 4: Yield performance of rice grown in rotation with green manure Kilasilo Village – Kyela 2004:

Treatment		**Rice yield with phosphate rock**	**Rice yield (t/ha) without phosphate rock**
Crotalaria - Rice		1.4	1.7
Pigeon pea - rice		1.1	1.1
Rice – Rice		0.8	1.0
G. Mean		**1.09**	**1.28**
Range		0.0 – 3.2	1.28
Yield increase (%)	***Crotalaria***	**75**	**70**
in plots of	**Pigeon pea**	**38**	**10**

Table 5: Yield performance of rice grown in rotation with green manure Konjula –Kyela 2004:

Treatment	***Striga* count 12WAP/25m2**	**Rice yield (t/ha)**
Crotalaria – Rice	2.5	2.3
Rice – Rice	6.0	1.3
G. mean	**4.25**	**1.78**
S.E	**0.98**	**0.74**
Range	2-10	0.2-6.0
Yield increase (%) on *Crotalaria* plot		76.9

Table 6: Yield performance of rice grown in rotation with green manure Sinyanga –Kyela 2004:

Treatment	***Striga* count 12WAP**	**Rice yield (t/ha)**
Crotalaria – Rice	0	0.9
Rice – Rice	2	0.5
G. mean	**0.8**	**0.68**
S.E	**0.54**	**0.09**
Range	0 – 3	0.4 – 1.0
Yield increase (%) on *Crotalaria* plot		**80**

Table 7. *Upland rice yields for continuous rice and rice in rotation with C. ochroleuca or pigeon pea on demonstration plots in Kyela District in 2003 (n = 13) and 2004 (n = 15)*

	Upland rice yields ($kg\ ha^{-1}$)	
Previous crop	2003	2004
Rice	1024	1141 ± 233
Crotalaria	2138	1968 ± 327
Pigeonpea	-	1340 ± 227
SED (12 df)	270	

Table 8: The yield performance of rice planted in rotation with green manure Kyela 2004 (replicated trial)

Village		*Crotalaria*. ochruleuca	*Cassia obtusifolia*	*Mimosa invisa*	Rice followed rice
Kilasilo		**2.8t/ha**	2.6t/ha	2.0t/ha	1.3t/ha
Itope		**2.8t/ha**	2.3t/ha	2.0t/ha	1.2t/ha
Yield increase (%)	Kilasilo	**115.4**	100	53.8	-
	Itope	**133.3**	91.7	66.7	-

Source: Kayeke, J. M, (2004) Evaluation of the potential of green manure and plant extracts for the control of witchweed (*Striga* asiatica L. Kuntze) in upland rice in Kyela, Tanzania: Thesis SUA, Morogoro, Tanzania 2004Thesis SUA, 2004.

Table 9: Yield performance of maize grown in rotation with green manure Kiswira Village –Matombo 2004:

Treatments		**Maize yield (t/ha)**
Crotalaria – maize		1.2A
Pigeon pea - maize		1.3A
Maize – maize		0.5B
G. Mean		**0.98**
S.E.		**0.21**
Range		0 – 2.4
Yield increase (%) on plots of	***Crotalaria***	**140**
	Pigeon pea	**160**

Numbers followed by the same letter do not differ significantly ($p \leq 0.5$)

Table 10: Yield performance of maize grown in rotation with green manure Kibangile – Matombo 2004:

Treatments		**Maize yield (t/ha)**
Crotalaria – maize		2.2
Pigeon pea - maize		1.8
Maize – maize		1.0
G. Mean		**1.67**
S.E.		**0.35**
Range		0.4 – 2.8
Yield increase (%) in plots of	***Crotalaria***	**120**
	Pigeon pea	**80**

Table 11: Yield performance of rice grown in rotation with green manure Kibangile – Matombo 2004

Treatments		Maize yield (t/ha)
Crotalaria – rice		6.8
Pigeon pea - Rice		5.6
Rice – rice		3.0
G. Mean		**5.13**
S.E.		**1.46**
Range		2.4 – 10t/ha
Yield increase (%) on plots of	***Crotalaria***	**126**
	Pigeon pea	**87**

Soil fertility monitoring

The soil analysis undertaken at ARI Mlingano, indicated that pH of Kyela soils ranged from medium acid (pH 5.4) to very strongly acid (pH <5.0) with the latter category forming about 90% of the samples (Table 12). As expected for soils with very low pH, the exchangeable acidity (exchangeable Al + H) was fairly high. A very strong negative correlation between pH and exchangeable H was observed. The exchangeable acidity was dominated by exchangeable H. The aluminium saturation as a measure of toxicity is calculated by dividing exchangeable Al by the sum of exchangeable bases and exchangeable Al. The results indicate Al saturation was low and was not likely to pose any limitation to rice production. The content of soil organic carbon was moderate while that of total nitrogen and available phosphorus was in most cases low. All soils had low contents of Ca, Mg and Na but medium to high levels of exchangeable K.

Effects of green manuring

In most of the cases green manure plots had a lower pH, lower contents of organic carbon, total nitrogen and available phosphorus compared to unmanured plots. Green manuring, however, increased levels of exchangeable H and K in most of the fields while the effects on other exchangeable bases was variable.

The general soil characteristics have shown that, apart from nitrogen, very low levels of available phosphorus could still limit productivity. For example legumes, even when suitably inoculated, will not grow well unless soil nutrients are available. The main nutrient required in Tanzania is phosphorus. Low pH will also limit productivity.

An improvement of the soil N status by green manuring was not achieved for most of the sites. The time of planting cereal and the time of incorporation of the green material were not consistent for all the farms. These two factors have great influence in the success of green manuring as a nitrogen source. From work conducted by (Kayeke 2004) at the same villages, the maximum release of nutrients by *Crotalaria* was during the first 4 weeks after rice planting, while maximum release of the nutrients from the roots occurred after 8 weeks. This means the time of soil sampling was done too early to detect the change in fertility.

In most of the sites, incorporating Marejea and pigeon pea showed some form of nutrient immobilization causing N deficiency early during crop growth. Sakala et al. (2000[7]) also reported that senesced cajanus biomass have a short period of N immobilization despite having a narrow C/N ratio. Immobilization of nutrients delays their release to the rice crop but later the green manures are mineralized and make the nutrients available to the crop for uptake. This early season N deficiency has not been shown to reduce yield. In fact, the final yields in our trials were higher on green manured plots.

Green manure should be ploughed under when still in their active growth stage. If ploughed under too early, leaching of nitrogen is likely to occur as decomposition is facilitated and nitrates tend to be washed out. Besides the bulky organic matter will be greatly reduced by the time its effectiveness is most needed and C/N ratios will be low. Thus, benefits for succeeding crops will be limited. If a green manure crop is ploughed in too late in the season or in a too mature state, the decomposition process may not have proceeded enough before the planting of the succeeding crop. Also if the green manure has a low N content (high C/N ratio) may cause an N-deficiency which may result to stagnation in growth of the crop and thus depressed yields. Despite the negative effects of green manuring on soil properties, very low *Striga* counts were recorded in manured plots during the latter part of the season. The yields of cereals were recorded high in plots following green manure. The next round of soil sampling and analysis will be done 4-6 weeks after planting to confirm if the green manures are mineralized after this period to release the nutrients for crop uptake. It is also recommended to include the application of P in the form of Minjingu Phosphate Rock. It is very effective in acid soils and because of its high Ca content it will also ameliorate soil acidity

[7] Sakala, W.D., Gadish, G, Giller, K.E. (2000). Interactions between residues of maize and pigeonpea and mineral N fertilizers during decomposition and N mineralization. Soil Biology and Biochemistry, 32: 679-688.

Table 12 : Effect of green manuring on soil properties Itope and Kilasilo Villages

Farmer	**Treatment**	Soil properties										
		PH		OC	**Total N**	**Available P mg/kg**	**Exchangeable bases (me/100g)**				**Exch. Al Meq/100g**	**Exch. H Meq/100g**
		H_20	**KCl**	**%**	**%**		**Ca**	**Mg**	**K**	**Na**		
Abdala	Control	5.4	3.4	1.91	0.18	3.31	2.13	0.7	0.88	0.6	0.58	2.09
	Marejea	4.75	3.4	1.76	0.16	2.42	0.73	0.8	0.98	0.04	0.38	3.5
Mwema	Control	4.7	3.4	1.77	0.16	2.16	1.77	0.71	1.14	0.05	0.16	2.60
	Mbaazi	4.63	3.4	1.51	0.14	1.36	1.77	0.73	0.75	0.06	0.82	2.93
	Marejea	4.5	3.4	1.78	0.16	1.30	1.73	0.57	0.75	0.05	0.08	3.12
Yusufu	Control	4.73	**3.5**	**1.78**	**0.17**	1.09	2.23	0.73	0.8	0.06	0.33	2.08
	Marejea	4.53	**3.47**	**2.25**	**0.21**	0.83	0.93	0.83	1.69	0.06	0.12	3.05
Asajenie	Control	**4.73**	**3.57**	**2.24**	**0.21**	4.08	5.57	0.8	1.21	0.07	0.20	1.75
	Marejea	**4.73**	**3.7**	**2.24**	**0.21**	2.83	1.63	0.77	1.43	0.07	0.1	1.88
Rehema	Control	4.77	3.53	2.13	0.2	8.36	1.17	0.7	0.88	0.09	0.12	2.61
	Marejea	4.9	3.77	2.06	0.20	4.08	2.23	1.17	1.03	0.08	0.21	0.43
Mng'and a	Control	4.83	3.7	2.18	0.21	10.7	1.32	3.8	0.8	1.00	0.06	0.90
	Mbaazi	4.77	3.67	2.05	0.19	1.48	3.03	0.9	1.36	0.06	0.2	1.03
	Marejea	4.67	3.63	2.15	0.21	0.90	3.83	0.9	0.82	0.09	0.53	1.06
Hamisi	Control	5	**3.6**	**1.77**	**0.16**	0.64	2.17	0.87	1.06	0.06	0.1	1.00
	Marejea	4.87	**3.6**	**1.83**	**0.17**	0.24	2.33	0.83	1.17	0.03	0.11	1.62
Lyson	Control	4.8	3.17	1.63	0.15	1.64	1.9	0.4	0.96	0.09	0.15	2.38
	Marejea	4.63	3.17	1.54	0.13	2.41	1.53	0.6	0.57	0.05	0.17	3.03
Kayuni	Control	4.87	3.17	1.71	0.16	1.50	1.8	0.83	0.83	0.07	0.09	2.63
	Marejea	4.8	3.2	1.59	0.14	0.94	1.97	1	0.47	0.04	0.07	2.12
M'tage	Control	5.3	3.87	2.31	0.21	5.51	5.8	1.13	1.79	0.07	0.12	0.3
	Marejea	4.67	3.3	1.81	0.16	3.19	1.1	0.7	0.89	0.04	0.06	3.20
M'ndela	Control	4.63	**3.23**	**1.85**	**0.17**	1.25	1.5	0.6	0.75	0.04	0.07	3.31
	Mbaazi	4.67	**3.3**	**2.23**	**0.2**	3.98	2.4	1.2	0.18	0.07	0.13	1.71
	Marejea	4.7	**3.23**	**1.97**	**0.19**	2.75	1.67	0.97	0.73	0.05	0.15	2.62
Isumo	Control	4.97	3.4	1.81	0.16	2.20	1.47	0.9	0.71	0.10	0.15	2.07
	Mbaazi	4.97	3.43	1.46	0.13	0.71	1.87	0.87	0.82	0.10	0.07	2.10

M’popo	Control	4.7	3.43	1.94	0.18	1.12	1.57	0.03	0.59	0.03	0.14	3.25
	Mbaazi	**4.77**	**3.5**	**2.15**	**0.2**	**1.61**	**1.67**	0.93	0.72	0.05	0.1	2.94
	Marejea	4.73	3.33	1.7	0.15	1.48	1.5	0.8	0.8	0.03	0.10	4.04
M’seba	Control	5.1	**3.4**	**1.18**	**0.10**	**0.78**	**1.1**	0.77	0.29	0.12	0.03	3.74
	Marejea	4.53	**3.4**	**1.41**	**0.12**	**1.12**	**1.47**	0.7	0.31	0.07	0.07	4.01
Sunkey	Control	4.7	**3.47**	**1.56**	**0.13**	2.00	1.17	0.7	0.55	0.06	0.07	4.89
	Marejea	4.63	**3.53**	**2.1**	**0.16**	0.98	1	0.47	0.68	0.04	0.05	3.63
Mwalinga	Control	4.9	3.6	1.64	0.14	1.54	0.97	0.67	0.76	0.05	0.12	3.02
	Marejea	4.73	3.5	1.25	0.10	1.46	1.1	0.7	0.81	0.05	0.6	3.94
Mboge	Control	5.17	2.37	1.41	0.12	0.94	1.13	0.83	0.85	0.04	0.21	1.85
	Marejea	5.27	3.6	1.12	0.1	1.29	1.9	0.83	0.94	0.07	0.34	1.01

Marejea = *Crotalaria*, Mabaazi = pigeon pea

Economic analysis on the use of green manure in rotation with cereals

In the mid 70's and early 80's the use of Marejea was very much emphasised by the government. The seed of Marejea was distributed to many regions of the country through regional/district agricultural extension offices with the hope that it could be distributed to farmers. There was however little adoption. To learn more about the advantages and disadvantages of using the green manure a participatory analysis was conducted in participating villages. The objectives of this study were to

- assess the advantages and disadvantages of growing manure in the 1st season followed by rice as compared to growing rice in the 1st and 2nd season;
- rank the performance of legumes used in the demos;
- assess the profitability of the legume/rice rotation with farmers.

The methodology used was an indoor workshop where farmers made contribution from questions and answers**.**

- Farmers reflected and listed the advantages and disadvantages of opting to grow manure in the first season followed by rice as compared to that of continuous growing rice.
- Farmers listed all the legumes they used and ranked them by comparing their performance
- Farmers translated the costs and income from the two options of the inputs and outputs so that they could to be able to tell which one is more profitable than the other.

The workshop was conducted one day per village except for Sinyanga and Konjula; these villages were combined for one day due to logistic problems of getting to Konjula village. Other villages involved in this exercise were Itope, Kilasilo in Kyela and Kiswira and Kibangile in Matombo-Morogoro rural districts.

Sinyanga and Konjula villages: The facilitator introduced the topic on identification of advantages and disadvantages of growing manure in the first season. The farmer's responses were as summarised in the Table13.1. The effect of *Crotalaria* on rice yield was observed in the following season.

Table 13.1.Advantage and disadvantages of growing *Crotalaria* in the first season followed by rice in the second season.

Season	Advantages	Disadvantages
1st Season *Crotalaria*	1.There was a hope of improving soil fertility 2.Seeds for *Crotalaria* and pigeon pea were harvested 3.Weed infestation was reduced	1. Missing rice harvest that season 2.Abussed by neighbouring farmers that they are crazy of growing weeds that have no value 3.More labour was used in land preparation sowing and harvesting 4.More cost was involved on the above activities
2nd Season Rice Vs *Crotalaria*	1.Rice yield has improved/increased	1.The price dropped due to increased production hence increasing supply 2.More labour was required for

	2.*Striga* infestation has been reduced	harvesting 3. More food was given out to others as gift if harvest increases due to improper planning of use of the harvest

At this stage farmers were able to realise some benefits of using green manure although none could quantify the benefits. It was noted also that, if no proper planning is done, increased crop harvest may lead into misusing the household resources such as over drinking.

Ranking the performance of *Crotalaria* and Pigeon pea as observed from the Demo plots: The legumes used in the demo plots were compared to each other by scoring against the farmers ranking criteria. If the legume performed best in a certain criteria it got a score of 3 and if its performance was average then it scored 2 and if performance was poor then it scored 1. The scores were agreed by all workshop participants after a short reflection, questions and answers. Results are presented in Table 13.2.

Table 13. 2: Ranking of the two legumes *Crotalaria* and pigeon peas against each other

Criteria	***Crotalaria***	**Pigeon pea**
1.Can be used as food	1	3
2.Reducing ability of weed infestation	3	2
3. Can be used as fire wood	1	2
4.Potential to improve soil fertility	*	*
5.Ability to germinate in the field	3	2
6.Easiness to plant	3	1
7.Easiness in harvesting	1	3
8.Resistance to insect attack	2	1
9.Yield (amount of grain seed)	3	2
10.Prices of the seed after harvesting	3	2
11.Marketability of the harvested seed	1	3
12.Availability of seed	1	2
13.Can be used as forage	2	3
Total	**24**	**26**
Ranking	**2**	**1**

* : *Not observed in the first year*

Results from Table 13.2 showed that pigeon pea was ranked higher than *Crotalaria* meaning that farmers preferred using pigeon pea as compared to *Crotalaria*. An exercise followed to cost the inputs and outputs of the two options of which one was continuous growing rice in the 1st and 2nd season. The second option was growing legume in the 1st season followed by rice in the 2nd season. The market prices used in costing the inputs and out puts were those prevailing at the time of the workshop.

Table 13.3 Cost of input and income of a trial compared to control

Rice after rice				Rice after *Crotalaria*			
	1st season	**2nd season**	**Total**		**1st season**	**2nd season**	**Total**
Out puts Harvested one tin of rice in the plot (A price of one tin was 2500 Tshs.)	2500	2500	5000	Outputs Selling seed 47kg of *Crotalaria* @ 600/=. Harvested 1.9 tins of rice @ 2500	28200	- 4750	28 200 4750
Total output			5000	Total output			32950
Inputs Fertiliser in the plot Urea/DAP	750	750	1500	Inputs *Crotalaria* seed 1kg@600/=	600		600
Herbicide application	550	550	1100	Rice seed 1kg		200	200
Storage bags	150	150	300	Storage bags	150	300	450
Man-days Slashing	240	240	480	Man-days Slashing	240	120	360
Ploughing	750	750	1500	Ploughing	750	750	1500
Harrowing	500	500	1000	Harrowing	0	500	500
Broadcasting	500	500	1000	Broadcasting	0	500	500
Rotavating	280	280	560	Rotavating		2	480
Racking	280	280	560	Racking	0	0	0
Weeding	400	400	800	Weeding	0	2000	2000
Bird scaring			8882	Bird scaring	0		4320
Harvesting Cutting	350	350	700	Harvesting Cutting	0	350	350
Collecting	200	200	400	Collecting	0	200	200
Shelling and winnowing	500	500	1000	Shelling and winnowing	500	500	1000
Carrying to home	200	200	400	Carrying to home		1000	1000
Total cost			**20 182**	**Total Cost**			**13 460**
(Output - input) Loss			**-15182**	***(Output - inputs) Profit***			***+19 490***

- The plot size was 10m x 30m
- The unit price used for seeds was Marejea Tshs 600/=, herbicide 7 000/=, fertilizer 15000/= for a 50kg bag), rice was 2500/=.
- Unit man-day/ hour used was Tshs 240/=
- Yield ratio refer TABLE 7

Results in Table.13.3 showed that, it is more profitable to grow rice after *Crotalaria* than rice after rice as rice yield increased by 1.9fold. The rice yield increased because of soil fertility improvement through incorporation of Marejea and also costs such as weeding are cut down due reduction from weed infestation. These results exposed farmers to a situation that enabled them to decide confidently what to grow in order to reach their main objective of improving rice production. Farmers confidently decided to improve rice production by growing green manures.

Itope village

14.1: Advantage and disadvantages of growing *Crotalaria* in the first season and rice after *Crotalaria* in the second season Itope-Kyela

	Advantages	Disadvantages
1st Season *Crotalaria*	1.Selling of *Crotalaria* seed 600/= per kg 2. Weed infestation was reduced. 3.Some farmers were attracted to the trial and they asked questions to the participating farmers 4. There was a hope of fertility improvement 5. Pigeon pea was a good source of protein food *6. Striga* was not found in the field	1. Rice was not produced in the first season 2.Laughed by neighbouring farmers by growing non food crop 3.*Crotolaria* was easily washed by heavy rain water when broadcasted 4.*Crotolaria* was eaten by cattle 5. Harvesting *Crotalaria* was a hard work
2nd Season Rice Vs *Crotalaria*	1.Rice yield was improved 2.*Striga* infestation was reduced 3.Soil fertility was improved 4.Weed infestation was reduced 5.Only light weeding was needed and done once	1.The price of rice was lower than the price of *Crotalaria* 3. More rice was given out to others as gift

At this stage farmers were able to realise some benefits of using legumes although none could quantify the benefit. It was noted also that, if no proper planning was done, increased crop harvest may lead into misusing of household resources.

Ranking performance of *Crotalaria* against pigeon pea

Results from the Table 14.2 show that *Crotalaria* was ranked higher than pigeon pea, indicating that farmers liked growing *Crotalaria* as a rotation crop than pigeon pea.

Table 14.2: Ranking of the two legumes *Crotalaria* and pigeon peas against each other Itope - Kyela

Criteria	*Crotalaria*	Pigeon pea
1.Can be used as food	1	3
2. Can be used as fire wood	2	3
3.How better is the selling price	3	1
4. Can be used as forage	3	1
5.Easiness to carry planting operation	3	1
6.Reduced number and burden of weeding	3	1
7.Easiness to germinate	3	1
8.Easiness to harvest	1	2
9. Increased yield of rice	3	2
10.Resistance to diseases and insects	3	1
11.Cost of inputs involved	1	3
12.Reduction of *Striga* infestation	3	2
Total	**29**	**21**
Ranking	**1**	**2**

Economic analysis was carried to compare rice after rice and rice after *Crotalaria*. After ranking of the legumes, it followed the exercise of costing the inputs and outputs of the two options. One was continuous growing rice in the 1st and 2nd year and the second option was of growing legume in the 1st followed by rice in the 2nd year. The costing was done basing on the market price at the time of the workshop in Tanzanian Shillings.

Table 14.3. Cost of income and input of growing green manure as compared to continuous rice crop Itope - Kyela

Rice after rice				**Rice after *Crotalaria***			
Materials	1st season	2nd season	Total	Materials	1st season	2nd season	Total
Out puts Rice yield 1tin @ 2500 Tshs.	2500	2500	5000	Outputs *Crotalaria* seed sold 47kg @ 600/= Selling Rice 1.9 tins @ 2500	28200	4750	28 200 4750
		Total output	**5 000**	**Total output**			**32950**
Costs Man-days Slashing	1500	1500	3000	Costs Man-days Slashing	1500	0	15000
Ploughing	1000	1000	2000	Ploughing	1000	1000	2000
Harrowing	1000	1000	2000	Harrowing	1000	1000	2000
Rotavating	500	500	1000	Rotavating	60	1000	1060
Weeding	2000	2000	4000	Weeding	0	1000	1000
Bird scaring	26hrs	26hrs	12480	Bird scaring	0	6240	6240
Harvesting Cutting	500	500	1000	Harvesting Cutting	5040	1000	6040
Collecting	240	240	480	Collecting	0	240	240
Shelling and winnowing	240	240	480	Shelling and winnowing	480	240	720
Carrying to home	500	500	1000	Carrying to home	0	500	500
Storage bags	150	150	300	Storage bags	250	300	550
		Total Costs	**27 740**			**Total Costs**	**21 850**
(Out put – costs) Loss -ve			**22 740**	**(Out put- Costs) Profit +VE**			**11 600**

- The plot size was 10m x 30m
- The unit price used for rice seeds was Tshs 600, unit price for rice produce was 2500/=.
- Unit man-day hour used was Tshs 240/=

Kilasilo village

Farmers were asked to give the advantages and disadvantages of growing *Crotalaria* in the first season followed by rice crop in the second season. In addition, they were required to point out the advantages and disadvantages of growing rice after legume in the second season. The budgetary economic analysis was also done in a participatory way. The responses are as summarised in Table 15.1 below.

Table 15.1. Advantage and disadvantages of growing *Crotalaria* in the first season and rice after *Crotalaria* Kilasilo - Kyela

	Advantages	Disadvantages
1st Season ***Crotalaria***	1.Selling of *Crotalaria* seed 600 per kg 2.Reduction of weed infestation 3.Firewood was obtained after shelling *Crotalaria* seed 4. There was a hope fertility improvement 5. *Crotalaria* was also used as forage	1. No rice was produced 2.Laughed by neighbouring farmers by growing non profitable plants in their rice field 3.Fear that *Crotalaria* can not improve soil fertility
2nd Season Rice Vs *Crotalaria*	1.Rice yield was improved 2. *Striga* infestation was reduced. 3. Soil fertility was improved. 4. Weed infestation was reduced. 5.Only light weeding was done once	1.The price of rice was lower than the price of *Crotalaria* 2. More time was used for buzzing and drinking. 3. More rice was given out to others as gift. 4.More second marriages occur

Ranking the performance of *Crotalaria* against pigeon pea

Farmers were asked to rank the legumes used in the demonstration, *Crotalaria* and pigeon pea and the results were as shown in the following Table 15.2

Table 15.2 Ranking *Crotalaria* against Pigeon pea Kilasilo - Kyela

Criteria	*Crotalaria*	Pigeon pea
1.Food	1	3
2. Fire wood	1	3
3.Price of seed	3	1
4.Reduction of number weeding	3	1
5.Reduction of weed	3	1
6.Easiness to carry planting operation	3	1
7.Easiness to get seed	2	3
8.Germination	3	1
9.Easiness to harvest	2	3
10. Increase rice yield	3	2
11.Resistance to diseases and insect attacks	3	1
12.Market	1	3
13.Control *Striga* infestation	3	2
14.Attracting thieves	1	3
Total	**33**	**28**
Ranking	**1**	**2**

The results from Table15.2 above indicated that *Crotalaria* was ranked higher than pigeon pea, meaning that farmers preferred to use *Crotalaria* than pigeon pea

Table 15.3 Income (Out put) and Cost (input) for growing *Crotalaria* as compared to rice after rice Kilasilo - Kyela

Rice after rice				Rice after *Crotalaria*			
	1st season	2nd season	Total		1st season	2nd season	Total
Out puts Harvested Rice 1tin @ 2500	1.5 Tins (3500)	1.75 Tins (4375)	7 875	Outputs Selling seed 23 kg @ 600 Rice 1.9 tins @2500	13800	 4750	13800 4750
Total output			**7875**	**Total output**			**18550**
Costs – Inputs Fertiliser TSP 74.6 & Urea 896 Seed 4x500 x2			3284 4000	**Costs –** Inputs Fertiliser Seed	0 600	0 200	0 800
Ploughing	895	895	1790	Ploughing	895	895	1790
Harrowing	600	600	1200	Harrowing	600	600	1200
Broadcasting	600	600	1200	Broadcasting	200	600	620
Weeding	2239	2239	4478	Weeding	0		
Harvesting Cutting	520	520	1040	Harvesting Cutting	520	3920	4440
Collecting, shelling and winnowing	980	980	1960	Shelling and winnowing	2205	980	3185
Carrying to home	200	200	400	Carrying to home	200	400	600
Storage bags	150	150	300	Storage bags	150	300	450
Total Costs			**19652**	**Total Costs**			**13 385**
Loss (Output – Costs)			**(-)11777**	**Profit (Output- costs)**			**(+) 5165**

- *The plot size was 10m x 30m*
- *The unit price used for rice seeds was Tshs 3000, unit price for rice produce was 2500.*
- *Unit man-day hour used was Tshs 240*
- *Unit price of Crotalaria seeds 600 per kg*
- *Yield ration refer Table 7*

By growing green manure a farmer gets a profit of 5165/= but on the other hand when he/she grows rice both in the 1st and 2nd season he/she ends up getting a loss of 11,777/= Tz shillings. Farmers realised that green manure improved soil fertility hence rice production and reduced impact of *Striga* on rice crop.

Kiswira village - Matombo

Kiswira and Kibangile village grow more maize than rice and at the time of the workshop, they had already made an exchange visit to Kyela.

The responses of farmers during evaluation of growing manure for the whole season without growing a crop instead green manure are summarised in the following Tables

Table 16.1: Advantage and disadvantages of growing *Crotalaria* in the first season Kiswira - Matombo

	Advantages	Disadvantages
1st Season ***Crotalaria***	1.*Striga* was not found in the field	1. Missing rice harvest in that season
	2.Many villagers asked many questions about the technology	2.Abussed by neighbouring farmers to be crazy for growing weeds that have no value
	3.Pigeon pea was harvested for food	3. The area for crop production was reduced
	4. *Crotalaria* seeds were also harvested for future use	

Table16.2. Advantage and disadvantage of growing pigeon pea and *Crotalaria* Kiswira – Matombo

Advantages	Disadvantages
1.The soil become friable and easy to cultivate	Extra labour was required for incorporating *Crotalaria* in the soil
2. Soil fertility increased, good crop stand	
3. Number of weeding has been reduced	
4.Neighbours are attracted	
5.*Striga* has been reduced	
6. Pigeon pea can be harvested more than one season	

Then a ranking was done to compare *Crotalaria*, Pigeon pea and *Pueraria spp* performance in the Demo plots

Table 16.3. Ranking the performance of three legumes in Demo plots Kiswira - Matombo

Criteria	*Crotalaria*	**Pigeon pea**	***Pueraria spp***
1. Fertility improvement	3	2	-
2.Ability to reduce *Striga*	3	2	3
3. Ability to improve yield	3	2	-
4.Reduction of weed	3	2	-
5.Easiness to get seeds	1	3	3
6.Easines to germinate	3	2	1
7.Ability to reduce soil erosion	3	2	1
8.easiness to sow seeds	3	2	1
9.Marketing	3	2	1
10.easy to harvest	2	3	-
11.Easiness to plough under	1	3	-
12.Other uses	2	3	-
13.Storage after harvesting	3	1	-
14.Disease and insect resistance	3	1	-
15.draught resistance	1	3	-
Total	**37**	**33**	**13**
Ranking	**1**	**2**	**3**

Results showed that *Crotalaria* was ranked highest followed by pigeon pea, meaning that farmers preferred to use *Crotalaria in* rotation with cereal crop than the other two legumes.

Table 16.4: Cost analysis of inputs and outputs Kiswira - Matombo

Maize after maize				**Maize after *Crotalaria***			
	1st season	**2nd season**	**Total**		**1st season**	**2nd season**	**Total**
Out puts Maize yields in kgs @ 200 Tshs	4kg 800/=	4kg 800/=	1600/=	*Crotalaria* seeds @ 600/=/kg Maize	7kg 4200/=	9.6kg	4200 1920
Total			**1 600**	**Total**			**6120**
Inputs				Inputs			
1. Maize seeds	300	300	600	*Crotalaria* seeds	150		150
				Maize seeds		300	300
2.Manpower Slashing	300	300	600	Slashing	600	600	1200
Ploughing	300	300	600	Ploughing	600	600	1200
Planting	360	360	720	Planting	720	0	720
2weedings	960	960	1920	One weeding	-	240	240
Harvesting	240	240	480	Harvesting	240	480	720
Shelling	240	240	480	Shelling	240	240	480
		Total	**5400**			**Total**	**4710**
		Outputs – inputs = - (Loss)	**- 3800**			**Outputs – inputs = (Profit)**	**+1410**

- The plot size was 10m x 50m
- Unit man-day hour used was Tshs 240
- Yield ratio refer Table 9

The yield data was included in the calculation after the crop was harvested from Table 9, hence results in Table 16.4 showed that it was more profitable to grow maize after *Crotalaria* than maize followed maize because *Crotalaria* improved soil fertility and yield of maize increased by 2.4folds. In addition, costs such as weeding were cut down since weed infestation in maize was reduced by the previous green manure crop. These results exposed farmers to a situation that enabled them to decide confidently what to grow in order to improve their maize production.

5.0: Kibangile village.

Table.17.1. Advantages and disadvantages of growing *Crotalaria/*Pigeon pea in the first Season, Kibangile - Matombo

	Advantages	**Disadvantages**
1st Season ***Crotalaria***	Harvesting pigeon pea	There was no rice/maize crop
	Harvesting *Crotalaria* seeds	Laughed and abused by others
	Reduced weeding	Reduced area under cultivation

Table 17. 2. Advantages and disadvantages of legumes used in Kibangile – Matombo

Advantages	Disadvantages
Rice is grown where soil was very poor	Incorporating *Crotalaria* in the soil was a tedious job
Maize/rice yield is expected to be higher	Harvesting *Crotalaria* seeds was a very tiresome operation
Reduced weed infestation and weeding	
Striga has been controlled	
The soil was easy to cultivate	
There were signs of improved soil fertility, the soil colour turn black	

Table 17.3. Ranking the performance of the two legume crops, Kibangile - Matombo

Criteria	*Crotalaria*	Pigeon pea
1.Soil fertility improvement	3	2
2.*Striga* control	3	3
3.Weed control	3	2
4.Improvement of soil Structure/texture	3	2
5.Maize/rice yield improvement	3	2
6.Easiness to sow seeds	3	1
7.easiness to germinate	3	1
8.Seed availability	1	3
9.Marketing	1	3
10. Other uses	1	3
11.Resistance to diseases and insect pests	2	1
12.Draught tolerant	2	3
13.easy to store	3	1
14.Soil erosion control	3	2
15.Easiness to harvest	1	3
Total	**35**	**32**
Ranking	**1**	**2**

From the results Table 17.3 *Crotalaria* ranked higher than pigeon pea, this means farmers preferred to use *Crotalaria* than pigeon pea.

Table 17.4. Cost analysis of inputs and outputs for growing maize/rice after *Crotalaria* Kibangile .

Maize/rice after maize/rice				**Maize/rice after *Crotalaria***			
Crop	**1st season**	**2nd season**	**Total**	**Crop**	**1st season**	**2nd season**	**Total**
Out puts Maize yields	3kg	3kg	2400	*Crotalaria*/maize seeds		6.6kg	2640
Total			**2400**	**Total**			**2640**
Inputs				Inputs			
1. Maize seeds	2kg@600/= 1200			Crotalaria & maize seed	1kg x 600/= = 600/= 1kg x 600/= = 600/=		
Slashing	6hrsx 214/hr x2 seasons/ 23.04 =112/=			Slashing	6hrsx214x2seasons /=112.00		
Ploughing	12hrs x 2x214/23.04 =222/=			Ploughing	1/4hrsx214x2 seasons = 107.00		
Planting	2hrx 214 = 428			Planting	1/4hrs x214 +1hrs x214 =497.00		
2weedings	12hrs x 214/= x 2 seasons/23.04 = 445/=			One weeding	6hrsx214/23.04= 55.70		
Harvesting	2hrs x 2season x 214/= =856			Harvesting	6hrsx214x2 seasons/23.04 =111.50		
Shelling	1hrs x 2seasonsx214/= = 428/=			Shelling	1hrsx214x2= 428.00		

Total	**3692**	**Total**	**2511.20**
Loss (Outputs – inputs)	**-1292**	**Profit (Outputs – inputs)**	**+128.80**

- *The plot size was 35m x 5m*
- *Unit man-day hour used was Tshs 214*
- *600/= price of maize and Crotalaria seed per kg*
- *One acre has 23.04 plots of 35m x 5m*
- *Yield after Crotalaria ratio refer to Table 10.*

From results presented in Table 17.4, it was more profitable to grow maize/rice after *Crotalaria* than maize/rice after maize/rice. The reason was that maize yield had increased due to improved soil fertility by using *Crotalaria* in rotation by 2.2fold. In addition, costs such as weeding were minimized since weed infestations in crops following *Crotalaria* were, according to farmers, reduced significantly.

Summary from economic analysis: The results, based on farmers experiences, indicate that growing green manure in rotation with cereals, results in higher cereal yields. A farmer will have excess grain and higher income from crop sales from the rotation option as compared to growing continuous rice after rice or maize. Farmers identified an increase in cereal yield due to the green manure, which improves soil fertility and reduces the impact of *Striga.* In addition, costs for weeding are reduced because weed infestation in cereal plots following Marejea are less.

Output 2: Identification, preparation and publication of information sources to support promotion of green manure in rice based farming system.

Farmer exchange visits and Farmer field days

These were key activities for increasing farmer awareness of the *Striga* problem and of the option of using legume rice rotations. The farmer field days and exchange visit approaches involved farmers from one location to another in a different location/field with a specific theme of a study in mind. In this regard, farmers in the problem area visited their counterparts who had a greater experience in managing the problem through fields (sites) visits. This approach of technology dissemination helped to promote better farming by providing an opportunity for farmers to see and discuss the best techniques with one another and with technical specialists. This also creates a situation in which informal contracts and learning could take place. It also encouraged the host farmers to play a prominent role in discussion and explaining the particular technology in question. The exchange visits and field days conducted in the two projects areas of Kyela and Matombo led farmers to increase sizes of their plots planted with *Crotalaria* from less than an acre to more than an acre. The demonstration sites increased up to 117 and 122 in Kyela and Matombo respectively. There was an increased demand for farmer produced *Crotalaria* seed. Kyela farmers sold 240 kg in 2003 season and in the 2004 season they sold more than 400 kg of *Crotalaria* seed to neighbouring farmers and other districts like Muheza and Matombo.

Farmers evaluating rice performance following Crotalaria, Kyela 2003

Schools: A partnership was established between researchers, extension and teaching professionals at each project site to determine how knowledge of the *Striga* biology and control using green manure could be incorporated into primary school agricultural sciences curriculum. A training workshop was held for two days at each site involving 15 schools from Kyela and 6 schools from Matombo as shown on the following tables below and the details are presented in Working paper No.5 (2003)

Kyela primary schools involved with the project and their activities 2003-2004.

Activity	Lema	Kandete	Ngamanga	Nduka	Nkuyu	Lema[2]	kisale	Mbogela	Lugombo	Lukwego	Kyela	KCM	Lusungo	Kasumulu	Mbula
Choir								√						√	√
Poems	√			√	√	√	√			√		√			
Drama				√											
Traditional dance		√									√		√		
Demo plots	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Matombo Primary schools involved with the project and their activities 2003-2004

	Kibangile	Konde	Mlono	Matombo	Mkumbo	Gozo
Choir	√	-	-	√	√	-
Poems	√	√	√	√	√	√
Drama	√	√	-	-	-	-
Tradional Dance	√	-	√	-	-	-
Demo plots	√	√	√	√	√	√

The teachers were briefed on the biology and *Striga* control options by using learning tools, which included posters showing *Striga* biology and integrated control options, leaflets and a *Striga* manual. The outcome of the workshop was an agreed strategy for the incorporation of awareness and control of *Striga* into school curriculum, the spread of this knowledge to other schools and the community surrounding the schools. In a follow up workshop teachers gave a highly positive account of their experiences of incorporating awareness of *Striga* biology and control into their school curriculum. Different teaching methods were described including lecturing, using of real objects in classroom situation (*Striga* plant), drama, songs, plays and field demonstrations.

Participants of the Primary school teachers Workshop, Kyela 2004

It was then agreed that the processes and methodologies adopted by teachers were appropriate and the key activity during the extension of the project during 2005-06 will be to document these activities in the form of a video tape, which can be broadcasted on school children programme run on Tanzania Television and to prepare a teaching manual on *Striga* biology and control options in Kiswahili for teachers, extension staff and progressive farmers.

In both Matombo and Kyela, a monitoring and evaluation committee (consisting of District Agricultural extension officer, District Education officer, Ward executive secretary, Ward Education officer) has been established to monitor the implementation of the activities in participating primary schools.

Information dissemination

Leaflet: A leaflet "Rutubisha Udongo na Dhibiti Viduha kwa kutumia Marejea" (Improve soil fertility and control *Striga* by growing *Crotalaria*) has been produced (see Annex 3) 2000 copies have been printed and a large number of them have been distributed to farmers in farmer research groups, extension staff, primary schools participating in the project and to farmers purchasing *Crotalaria* seed.

Poster: Posters have shown to be effective tools to reach many farmers, because they are displayed at public locations like in schools, hospitals villages, ward and district offices. 500 posters were produced and to date half of these have been distributed to primary schools, project villages and to districts.(see Annex 3)

Radio programme: On 06 December 2004 discussion with District Commissioner from Kyela district on the importance of *Crotalaria* to improve soil fertility and control of *Striga* was broadcast by Radio Tanzania. On 7th December interviews with Itope farmers on the use of *Crotalaria* was aired on the Radio Tanzania with a good feeder back through telephone calls. A special programme on the use of *Crotalaria* in Kyela was broadcast on 16 and 20th December each for half an hour on Radio Tanzania.

Video tape: A draft video tape on the use of *Crotalaria* is available but needs further editing. A final version will be completed during phase II of this project. This will be broadcasted on Tanzania Television and Sokoine University Agriculture Television. It will also be available for promotion meetings at village level.

Contribution of Outputs to developmental Impact

The project was designed to validate and promote practices to reverse the trend of 30 and 70% decline in rice yields over the past 20 years as witchweed levels have increased. There is strong market demand for quality aromatic rice in Tanzania so farmers in affected areas of Kyela and Matombo districts, are keen to reverse the decline in yield. Through facilitation by R8194 and interaction with district extension, farmers have realised the importance of improving the fertility of *Striga* infested land; hence they have increased the area of cultivation of legumes keeping enough seed for themselves and selling or giving surplus to neighbours, family and friends. Farmers can not afford the high cost of inorganic fertilisers so have opted for rice-legume rotations that are low-cost and sustainable. Participatory analysis undertaken by the project with farmer groups had demonstrated that by use of rotation farmers can improve soil fertility and reduce the impact of *Striga* on cereal crop yields resulting in higher income from rice and, in Matombo, from maize. Dissemination of knowledge of the link between low soil fertility, *Striga* and poor crop yields and of how to improve crop management is the key to farmer adoption of legume/cereal rotations. The project has demonstrated how a combination of knowledge sources and learning opportunities can support this process.

District councillors attending field days and district extension staff have become increasingly aware of the demand from farmers for knowledge about this practice. District officers are responding by using project sites for field days. Farmer to farmer extension and dissemination of *marejea* and pigeon pea seed is a key aspect of promotion of the rice-legume rotation. This can be enhanced by formation of farmer groups, farmer led demonstrations and field days facilitated by the district council. This work has also demonstrated how primary schools can also contribute to dissemination of knowledge about agricultural practices, a process now being embraced in both Kyela and Matombo. The project has also provided leaflets, a poster and a video as learning tools that can be used in future by extension service providers in Tanzania.

How will the outputs be made available to intended users?

Farmers have started producing *Crotalaria* seed to give to neighbours or to sell to other farmers. Shops for selling the seed have been set up by farmers in Kilasilo village during the 2004 season. District, Zonal and National agricultural shows, will offer a good forum for selling the Marejea seed produced by farmers, with assistance from extension staff.

R8194 has been an enabling project assisting district council extension teams to promote the use of rice/maize-legume rotation on *Striga* infested land. The project has been extended for a further 10 months during 2005 and will continue this approach and working with primary schools. District extension and schools are the major providers of knowledge to communities in Kyela and Matombo. Meetings will be held with managers of the extension and education departments to review progress since 2002 and to plan further up-scaling in 2005-2006 crop seasons and beyond. Already, during 2004 extension offices in both districts facilitated involvement of farmers from new villages and wards in field days. Project staff will work with extension to bid for district council funds for holding further field days and facilitating farmer exchange visits in coming seasons. Further distribution and use of leaflets, posters and a training video through village extension officers and schools will also be budgeted for. Kyela district council has already provided funds to pay for transport used by the village extension officer who is based in Kyela, to allow him to evaluate project trials.

PUBLICATIONS SUMMARISING RESULTS FROM R8194

Annex 1: Working Papers and workshop proceedings – see CD attached

1. MBWAGA, A. M, RICHES, C.R and LAMBOLL R.I. (2003): Enhancing productivity of upland rice on *Striga* infested soils: Village meetings to design the demos Programme Kyela-Matombo. Project Working Paper No. 1, 29pp.
2. P. LAMECK and A. MBWAGA: (2003). Enhancing productivity of upland rice on *Striga* infestedsoils: Context Analysis for four villages in Kyela and two villages in Matombo-Morogoro ruraldistricts Project Working Paper No. 2, 44pp
3. A. MBWAGA, C. RICHES (2003): Monitoring Demonstrations of soil fertility enhancing practices Kyela and Matombo-Morogoro rural districts . Project Working paper No. 3, 23pp.
4. A. MBWAGA, C. MASSAWE, J. KAYEKE (2003). Farmers Exchange Visits Report,

Relevance and Lessons, Kyela district, Mbeya region. Project Working Paper No. 4, 30pp

5 .MBWAGA et al (2003)**:** Incorporation of Awareness and Control of *Striga* in the school Curriculum, Project Working Paper No. 5, 46pp.

6. HELLA, JP and MBWAGA, AM, (2004) Enhancing Productivity of Upland Rice on *Striga* Infested soils in Kyela and Matombo: Some findings of socio-economic baseline study. Project Working Paper No. 6, 24pp.

7. MBWAGA *et al (2004*). Planning workshop in Matombo and Kyela for 2003/04 season*.* Project *Working Paper No. 7, 25PP*

8. MBWAGA, A.M. & RICHES, C.R. (2004), Achievements in 2004 season on promotion ofgreen manure to increase soil fertility and control *Striga* in Kyela and Matombo districts. Kilosa, Tanzania: ARI Ilonga, Project Working Paper No. 8, 46 pp

ANNEX 2: Conference Papers – see CD attached

HELLA, JP. MBWAGA, AM., LEY,G. and RICHES, C.(2003). Rural development strategies through farmer groups and farmer oriented research: A case study, A paper presented at the Pre-IAAE conference, 13-15 August, 2003, Durban South Africa

ANNEX 3: Extension materials – seed CD and video tape attached

MBWAGA et al (2004): A Leaflet titled “Rutubisha Undongo na Dhibiti Viduha kwa Kutumia Marejea”

MBWAGA et al (2005): Posters about “Dhibiti Viduha kwa kurutubisha udongo ukitumia Marejea”

ARI Ilonga 2005: A video tape: “Matumizi ya jamii ya mikunde kurutubisha mashamba na kudhibiti kiduha”

ANNEX 4: Radio programmes

ANON (2003) Striking back as *Striga* II. An interview with Dr. C. Riches, collaborator in R8194, by AGFAX-Wren Media. November 2003, Duration: 3’06 Transcript sent to 40 radio stations in Africa (G)

ANON (2004) Interview with Itope farmers in Kyela on the use of *Crotalaria*’ which was broadcasted on radio Tanzania and

ANON (2004) Special programme on the use of *Crotalaria* in Kyela was aired each for half an hour on radio Tanzania on 16^{th} and 20^{th} December

OTHER REFERENCES

Mbwaga A M 2001 *Striga* research activities in Central, Eastern, Lake and Southern Highlands Zones of Tanzania: on-station and 0n-farm trials for 2000-01 season. Ilonga Agricultural Research Institute, Tanzania.

MacColl, D. 1989. Studies on maize (*Zea mays*) at Bunda, Malawi. II. Yield in rotation with legumes. *Experimental Agriculture*, **25**: 367-374.

ICRA/ Uyole ARI (1994) A dynamic farming system: The case of Kyela district. Working document Series 37, Tanzania. ICRA, Wageningen, The Netherlands

Riches C R (Ed.) 1999 *Striga distribution and management in Tanzania*. Proceedings of a stakeholder workshop, Dar es Salaam, 8-9 December 1999. Natural Resources Institute, University of Greenwich, UK.

Riches, C. (2003). Integrated management of Striga species on cereal crops in Tanzania. Final Technical Report (R7564/ZA0369), Natural Resources Institute, University of Greenwich, UK.
Sakala, W.D., Gadish, G, Giller, K.E. (2000). Interactions between residues of maize and pigeonpea and mineral N fertilizers during decomposition and N mineralization. Soil Biology and Biochemistry, 32: 679-688.

R8194 Project Logical Frame

Narrative Summary	Indicators of Achievement	Means of Verification	Risks and Assumptions
Goal			
The goal is given by DFID **Livelihoods of poor people improved through sustainably enhanced production and productivity of RNR systems.**	*To be completed by Project Manager*	*To be completed by Project Manager*	*To be completed by Project Manager*
Purpose			
Promotion of strategies to minimise impact of target pests in rice-based Land-Water interface cropping systems, for benefit of poor people	***To be completed by Project Manager***	*To be completed by Project Manager*	*To be completed by Project Manager*

Outputs			
1.0 Evaluation, and promotion of green manures used in rotation with rice on *Striga* infested soils accomplished	1.1 3 and 2 farmer groups established in Kyela and Matombo districts respectively for the 2003 cropping season.	1.1 Project reports	Widespread drought which prevents significant numbers of farmers planting a demonstration.
	1.2 Use of the green manure demonstrated at least 30 on farm sites in Kyela and 20 sites in Matombo over 2003-5 crop season	1.2 Project reports	Withdrawal of extension staff from collaborating in this project.
	1.3 At least a total of 100 farmers exposed to the technology through field days and seminars in each season. With assumption that each participating farmer brings a new farmer	1.3 Project reports	
	1.4 Yield of rice for participating farmers increased from average 1 t/ha to 2.0 t/ha end of the project	1.4 Monitoring reports	Extreme weather conditions or pest infestation may reduce yields
	1.5 Technology positively evaluated by farmers according to their criteria	1.5 Monitoring reports	
2.0 Information sources to support promotion of green manures in rice based farming systems prepared, validated and published	2.1 Information resources developed, tested and duplicated. Drafts tested by farmers by August 2004 At least 2000 copies of a farmer information leaflet provided to extension by end July 2005.	2.1 Draft leaflets available	
	2.2 Information resources under use by extension programmes in Kyela and Matombo during 2005 season. .	2.2 Leaflets available in final form	

Activities			
1.1 Seminars to introduce farmers to project and confirm or form new farmer groups in each area.	1.1 3 in Kyela and 2 in Matombo in October 2002	1.1 Project reports	Sickness of team member prevents them from participating in seminars.
1.2 Selection, design and establishment of demonstration sites with farmer groups in 2003 season	1.2 50 sites planted by end 01/03	1.2 Project reports	Adverse weather conditions such as a delay to the on-set of the rains, delays establishment of demonstrations or reduces number of sites.
1.3 Mid-season and harvest field days for farmers and group evaluations	1.3 Group evaluation across members sites and field days for other farmers at one selected site per group prior to harvest completed	1.3 Evaluation reports and monitoring of field days reported.	
1.4 Selection of and establishment of demonstration sites with farmer groups in 2004 season	1.4 Rice test crops planted at 50 sites by 01/04	1.4 Project reports	
1.5 Mid-season and harvest field days for farmers and group evaluations	1.5 Group evaluation across members sites and field days for other farmers at one selected site per group prior to harvest completed	1.5 Evaluation reports and monitoring of field days reported.	
1.6 Farmer-exchange visits	1.6 Matombo farmers visit Kyela in 05/03	1.6 Monitoring of feed back from farmers reported	
1.7 End of season meetings with farmers	1.7 In June/July each season	1.7 Monitoring report completed on farmer feedback at meetings	
2.0 Identification of information needs for different stakeholders	2.0 Discussion with stakeholders up to 04/03	2.0 Plan in place to design information sources and agreed by 06/03	
2.1 Design of information strategies for different stakeholders	2.1 Leaflets suitable for extension, farmers and schools drafted for testing by 10/03	2.1 Copies of drafts printed and circulated to stakeholders for evaluation	
2.2 Testing and validation of strategy	2.2 Information leaflets, posters etc evaluated with stakeholders during 2004 season	2.2 Evaluation reports available on information sources by 07/04 to allow refinement of information ready for printing from 01/05	
2.3 Final preparation, and distribution of information resources for different stakeholders.	2.3 At least 2000 copies of Leaflets etc printed and distributed to relevant areas of Tanzania by 06/05	2.3 Verification that copies of final information resources are with stakeholders in final project report.	

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)

This was a promotional project, which from the beginning it was agreed with CPP that a biometrician was not needed in this project, however the few analysis done a simple ANOVA was applied.

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:

Name (typed):

Position:

Date: