**CROP PROTECTION PROGRAMME**

# Project Title: Development and promotion of wild rice management strategies for the lowlands of southern Tanzania

## R8477 (ZA0688)

# FINAL TECHNICAL REPORT

## Start date – End date
## (1 APRIL 2005 - 31 January 2006)

J. Mbapila (to August 2005)
N. Kibanda (from September 2005)

**Kilombero Agricultural Research and Training Institute**
**Ifakara, Tanzania**

**Date FTR completed____31st January 2006**

**"This publication is an output from a research project R8477 within the Crop Protection Programme funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID"**

**Contents**



.

**Dedication:** This report is dedicated to the memory of Jacob Mbapila who passed away in August 2005. He had led CPP funded work on the management of wild rice in Tanzania since 2001. The partnerships with extension staff in Ifakara and Kyela districts and at Ruvu and Dakawa irrigation schemes leading to demonstration of weed management practices resulted from his foresight and energy.

**RESEARCH TEAM**

**Tanzania Department of Research and Development**

**Kilombero Agricultural Research and Training Institute, Ifakara**
Dr. Jacob Cuthbert Mbapila (Plant Entomologist and Project Leader – deceased August 2005)
Mr Nkori John Kibanda (Plant Breeder and Project Leader from September 2005)

**Sokoine University of Agriculture, Morogoro**
Dr Joseph P. Hella (Agricultural economist)

**Natural Resources Institute, UK**
Dr Charles R. Riches (Weed Scientist/Agronomist)

This report has been prepared by Dr Charlie Riches (NRI) with inputs from Mr Nkori Kibanda (KATRIN) and Dr Joseph Hella, Sokoine University of Agriculture.

## Executive Summary

**Project Purpose:** This was the same as for work undertaken from 2002 to 2005 by project R8198 of which the current project was a 10 month extension. Activities were designed to develop and promote strategies for the management of wild rice (*Oryza longistaminata* and *O. punctata*) so farmers can increase lowland rice productivity on infested land in Tanzania.

**Research outputs:** A further series of field demonstrations were completed at 18 floodplain sites infested by the perennial wild rice *Oryza longistaminata* in four villages of Kilombero and Kyela districts. Pre-plant application of the herbicide Round Up (active ingredient glyphosate) and use of a basal fertiliser both significantly increased grain yield of the recently introduced aromatic rice cultivar TXD 306. Herbicide use achieved season long suppression of wild rice. Use of glyphosate was also provided effective control of the annual *O. punctata* in both transplanted and direct dry-seeded rice. Participatory budgets developed with farmer groups indicated the use of both fertiliser and herbicide to be cost effective. The land tenure system in Kyela was investigated with members of two village communities. Land ownership in the district is skewed and approx. 70% of households gain access to lowland rice fields via short term tenancies. Rented land tends to be less productive than land kept for cultivation by landowners, being of poorer fertility with greater infestations of wild rice. The perception in the community is that tenants are less likely to invest in improved production practices through fear of loosing use of fields to landlords. It was concluded that land owners are most likely to adopt herbicide for wild rice management initially and the district council needs to consider the needs of the community rather than individuals when planning promotion of production enhancing inputs for floodplain rice. A training manual covering improved rice production practices, including management of wild rice, was produced. Training courses for farmers, extension officers and village leaders were held in four locations.

**Contribution of the project towards DFID's development goals:** There is a steady increase in demand for rice both within Tanzania and the region. Adoption of wild rice management will allow farmers to increase productivity on infested fields and benefit from the market opportunities to raise household incomes. At the same time labour inputs for weeding will be reduced allowing growers to allocate the time saved to other income generating activities.

## Background

Rice is the second most important cereal crop in Tanzania after maize and the majority of rice farmers depend on it both for food and as a cash crop. However, highly competitive annual and perennial wild rices have been identified as one of the major constraints to rice production on lowlands in southern Tanzania. The problems caused in smallholder rice production by wild rice are widespread in Africa (Johnson *et al.* 2000[1]). Smallholder farmers may abandon seriously infested fields causing severe problems for affected households and having a wider impact on the local economy. Kanyeka[2] (1994) reported that wild rices were also a reason for low yields on the large parastatal farms in Tanzania. Due to low profitability substantial portions of these enterprises have subsequently been handed over to smallholder farmers but the problems of wild rice persist with current agronomic practice.

CPP project R7345 identified control methods for the annual *O. barthii* and perennial *O. longistaminata* in W. Africa, predominantly by using pre-pant application of the herbicide

[1] Johnson D E, Riches C R, Kayeke J, Sarra S, Tuor, F A. (2000) Wild rice in sub-Saharan Africa: its incidence and scope for improved management. FAO Global Workshop on Red rice Control, 30 August - 3 September 1999, Cuba. pp 87-94

[2] Kanyeka Z L (1994) Country Paper - Rice in Tanzania: Production and Research. Presented at Eighteenth Session of the International Rice Commission, Rome, Italy, 5-9 September 1004.

glyphosate (Round Up) (Tuor *et al*. 2001[3]). Subsequently R8198 (2002-5) has evaluated the use of the herbicide with farmer groups for *O. longistaminata* control on two floodplain areas and against *O. punctata* on two ex estate farms in Tanzania. Drought reduced the extent of the trials programme in 2002. From work with 33 farmer groups during the 2004 season the major observations were:

- At Ruvu and Dakawa rice farms there is insufficient irrigation to maintain flooded conditions. In this situation farmers report *O. punctata* control with one application of glyphosate before seeding. As they depend on hired labour for weeding they see the use of herbicide as a labour saving practice.
- Farmers estimate that an application of glyphosate to *O. longistaminata* re-growth prior to seeding rice reduces subsequent in-crop weeding time by 50% in areas of dense wild rice infestation. Furthermore surviving wild rice is much easier to pull up on plots that had been sprayed. Farmers assess this as a profitable option as the income from less than one bag of rice is sufficient to purchase enough herbicide to treat one acre.
- Through these studies, participating farmers ranked the use of herbicide first in terms of weed reduction and yield performance, compared to mechanical methods, during field days held in June and July 2004.
- R8198 has implemented farmer group work in collaboration with village extension officers (VEOs) from district agricultural teams (Department of Agricultural Extension). The project has facilitated training for VEOs and lead farmers from each target area in modern rice production at the Kilimanjaro Agricultural Training Centre. A leaflet and poster outlining wild rice management was prepared for use in future extension programmes.

On the floodplains of Kyela district and the Kilombero valley *O. longistaminata* is most dominant on sites identified by the communities as having the deepest water and most fertile soils i.e. where the potential for rice is greatest. Farmers participating in trials in 2004 planted locally available rice varieties, generally the widely grown and variously names “Supa, Supa India, Kilombero”. This tall variety is competitive with weeds but has few tillers, lodges and has a relatively low yield. The earlier maturing and high yielding aromatic variety TXD 306 has recently been released and is in high demand from farmers. This non-photoperiod sensitive cultivar with maturity of 130 days is however, a semi-dwarf that is less competitive than the traditional types currently grown. TDX 360 therefore needs relatively good weed management and good water conditions. In consultation with farmers the project agreed to establish demonstrations of improved rice production in 2005, using TXD 306 on Round Up treated land. Sites were established with farmer groups at each location in January 2005. However, with the project due to end in March there would have been no opportunity to monitor the effects of recommended practices on rice productivity. CPP therefore agree to provide funds for a further 10 months to ensure completion of on-going field work and to further promote the wild rice management practices.

**Project Purpose**

The project purpose addressed the CPP output “Promotion of Strategies to minimise impact of target pests in rice-based land-water interface systems, for benefit of poor people”. This was the same purpose as for R8198 (2002-2005) for which the work described in this report was a 10 month extension.

The specific objectives were:

1. Demonstrate an improved management package for production of TXD 306 using glyphosate for wild rice suppression;

[3] Tuor F A, Gyasi K O, Terbobri P, Sarra S, Hamadoun A, Janowski M, Johnson D E (2001). Incidence, yield losses and some control measures for wild rice in West Africa. Proceedings of the Brighton Crop Protection Conference – Weeds, 2001, BCPC, Farnham, UK, 889-894.

2. Prepare a training manual covering rice production in wild rice infested area and train trainers;
3. Assess implications of land tenure on adoption of productivity enhancing technology in Kyela district where most cultivate land on short leases.

## Research Activities

***Research partnerships*:** Demonstration, dissemination**/**training activities in Tanzania were co-ordinated by the Kilombero Agricultural Training and Research Institute. Demonstration/trials were established with farmer groups in collaboration with village agricultural extension officers and district team members from Kilombero and Kyela district councils, Dakawa and Ruva irrigation schemes. Dr Joseph Hella provided support from Sokoine University to access economic benefit of improved rice management practices and to investigate land tenure arrangements in Kyela. Dr Riches (NRI) assisted with on-farm demonstration design and monitoring.

***Research sites***: Fieldwork continued with farmer groups formed in 2002 by project R8198. Demonstrations on land infested by the perennial wild rice *Oryza longistaminata* were undertaken on the floodplains of the Kilombero valley (Eastern Agricultural Zone) and floodplain of Lake Nyasa in Kyela district (Southern Highlands Zone). Work to demonstrate practices to increase the productivity of annual wild rice infested land (*O. punctata)* was continued in Morogoro region, Eastern Zone in Dihombo village and on fields recently allocated to smallholders at Dakawa and Ruvu, two irrigated farms previously operated by a parastatal farming concern. The cropping systems and existing farmer practices in these areas were discussed in the final technical report for project R8198 (Mbapila, 2005[4]).

**Activities undertaken by output**

**Output 1. Appropriate rice management practices for fields dominated by wild rice demonstrated and promoted.**

**Demonstrations of improved rice production practices:** Demonstrations with four plots were established with farmer groups on *O. longistaminata* and *O. punctata* infested land at the sites shown below.

| | **District** | |
|---|---|---|
| ***O. longistaminata*** | **Village** | **Demo plots** |
| **Kyela** | Kilwa | 4 |
| | Ngonga | 5 |
| **Kilombero** | Lumemo | 4 |
| | Michenga | 5 |
| ***O. punctata*** | | |
| **Mvomero** | Dakawa | 3 |
| | Dihambo | 4 |
| **Bagamoyo** | Ruvu | 4 |

Four plots were planted at each site with rice cultivar TXD306. For *O. longistaminata* infested sites these were:

[4] Mbapila J.C. 2005 Development and promotion of wild rice management strategies for the lowlands of southern Tanzania R 8198 (ZA0517). Final Technical Report for Project R8198. Ifakara, Tanzania: Kilombero Agricultural Training and Research Institute.

- Farmer practice tillage (plough twice with oxen, broadcast seed and harrow in Kyela; plough once by tractor, broadcast seed two weeks later and harrow in Kilombero), no fertiliser
- Farmer practice tillage (plough twice with oxen and harrow in Kyela; plough once by tractor and harrow in Kilombero), 80 kg $ha^{-1}$ urea fertiliser applied as a split dose at tillering and panicle initiation;
- Glyphosate 4 l $ha^{-1}$ applied to wild rice re-growth after one ploughing with harrowing before planting approx. two weeks later, no fertiliser;
- Glyphosate 4 l $ha^{-1}$ applied to wild rice re-growth after one ploughing with harrowing before planting approx. two weeks later, fertiliser applied.

For in-crop weed control 2,4-D amine was applied at dose of 2.5 l $ha^{-1}$ product to all plots at 21 days after sowing. Hand weeding was also undertaken at 21 and 42 days to remove wild rice.

For *O. punctata* infested sites practices were similar to the above to provide a combination of herbicide and fertiliser use. However practices used varied from location to location.

At Ruvu all field were transplanted in 2005. Land was ploughed by tractor and glyphosate applied at 3 l $ha^{-1}$ to newly germinated wild rice. Plots were subsequently transplanted and 2,4-D applied at 21 days. Water control here allows farmers to apply irrigation for the transplanting process and to reduce water levels for herbicide application.

At Dakawa plots were also ploughed by tractor and glyphosate applied at 3 l $ha^{-1}$ to newly germinated wild rice. Rice was then broadcast seeded and land harrowed. The infrastructure here does not allow farmers to drain water from their fields and many plots were damage after heavy rain. Yields were only obtained from one site.

At Dihombo there is no irrigation or drainage infrastructure. Farmers rely on rain and field may become flooded after crop emergence. Tillage here is all by hand hoe. The second hoeing is used to pulverise the soil to produce a seedbed for broadcasting rice. On the demonstration plots glyphosate was applied at 3 l $ha^{-1}$ to newly germinated wild rice at 21 days after the second hoeing and rice was subsequently broadcast onto moist soil.

The plots acted as demonstrations for each village. Extension workers used these for field days.

**Training of trainers:** Experiences gained by the project since 2002 were brought together in a training manual. This included information on a range of improved rice production practices in addition to wild rice management. Training courses for lead farmers, extension workers, village and ward leaders were undertaken in the four areas in which the project has been working

### Output 2. Influence of land-tenure on adoption of improved rice management in Kyela District understood.

**Study in two communities cultivating floodplain land:** Unlike in the majority of Tanzania where farmers have customary rights to cultivated land, the situation in Kyela is complicated by a skewed distribution of land-ownership. Previous discussion with farmers here suggested that the majority gain access to floodplain rice land by short-term rental contracts. A study was therefore undertaken by Dr Hella (Sokione University) to provide a greater understanding of the land inheritance and ownership system in Kyela in order to assess possible implications for future adoption of improved rice management practices. Discussions were undertaken with community members and a questionnaire was used to collect opinions on access to land and likely adoption of improved practices including wild rice management. The methodology is described in detail in Appendix 1.

**Research outputs**

**Output 1. Appropriate rice management practices for fields dominated by wild rice demonstrated and promoted.**

**Effect of herbicide and fertiliser on rice performance at *O. longistaminata* infested sites**

Although plots were planted predominately as demonstrations the opportunity was taken to analyse available data. Initially an analysis was carried out to explore possible relationships between rice performance and geographic location by district as farmers in Kilombero use tractor ploughing for land preparation while in Kyela ox-drawn ploughs are used. The two districts are also likely to be different climatically being in different regions of the country. Mean rice yield was significantly higher ($p = 0.018$) at trial sites in Kilombero (3217 kg $ha^{-1}$) compared to in Kyela (2472 kg $ha^{-1}$ S.E.D. $\pm$ 305 with 56 d.f.). However there was no interaction between either herbicide or fertiliser application and district. Data was therefore re-analysed by including districts with farm sites as block effects. Rice mean grain yield was significantly increased by both herbicide ($p < 0.001$) and fertiliser ($p < 0.001$) and there was no interaction between these inputs ($p < 0.638$). Highest yields were achieved when both herbicide and fertiliser had been applied (Table 1). Median yields were more than doubled by using herbicide and fertiliser in each district (Table 2).

**Table 1:** Effect of pre-planting application of 4 l $ha^{-1}$ glyphosate and fertiliser on rice yield (kg $ha^{-1}$). Means for nine sites in each of Kilombero and Kyela districts in 2005.

| | **Fertiliser** | |
|---|---|---|
| **Herbicide** | **Nil** | **Applied** |
| No glyphosate | 1854 | 2644 |
| Glyphosate | 2987 | 3894 |
| S.E.D. (51 d.f.) | 174 | |

**Table 2:** Rice yields (kg $ha^{-1}$) at trial sites in Kilombero and Kyela districts, 2005.

| | **No Herbicide No Fertiliser** | **No Herbicide Fertiliser** | **Herbicide No Fertiliser** | **Herbicide Fertiliser** |
|---|---|---|---|---|
| **Kilombero** | | | | |
| Mean | 2393 | 2917 | 3420 | 4138 |
| Median | 1700 | 2050 | 2350 | 3550 |
| S.E. Mean | $\pm$ 521 | $\pm$ 599 | $\pm$ 687 | $\pm$ 681 |
| **Kyela** | | | | |
| Mean | 1314 | 2372 | 2553 | 3650 |
| Median | 1080 | 2100 | 2400 | 3850 |
| S.E. Mean | $\pm$ 170 | $\pm$ 283 | $\pm$ 343 | $\pm$ 350 |

Glyphosate application resulted in significant suppression of *O. longistaminata* (Table 3.) so that the number of shoots during the rice seedling stage was reduced by more than 60% ($p < 0.001$). Season long suppression was observed with significantly less wild rice re-growth being recorded on herbicide treated plots at harvest ($p<0.001$).

**Table 3:** Effect of glyphosate application on mean number of *O. longistaminata* shoots $m^2$ at 21 and 35 days after rice emergence ($log_e$[count+1]) and on biomass of re-growth at rice harvest (kg per plot). Data mean of 9 sites in each of Kilombero and Kyela districts in 2005. Figures in brackets are actual count means.

| | **No. $m^2$ 21 DAE** | **No. $m^2$ 35 DAE** | **Kg per 100 $m^2$ at harvest** |
|---|---|---|---|
| No glyphosate | 2.4 (2.7) | 2.91 (24.8) | 3.21 |
| Glyphosate | 0.7 (1.4) | 0.6 (2.7) | 0.82 |
| S.E.D. (17 d.f.) | 0.18 | 0.25 | 0.54 |

**Effect of herbicide and fertiliser on rice performance at *O. punctata* infested sites**

All rice at Ruvu was transplanted during 2005. Mean rice yields were higher on plots treated with glyphosate (Table 4), but not significantly so ($p = 0.113$). Fertiliser application was however a significant benefit ($p = 0.012$). All wild rice was removed by a hand weeding undertaken at 21 days after sowing and at this time there were significantly less on herbicide treated plots ($p = 0.003$, Table 5). Further emergence of the weed followed but numbers and biomass remained lower on treated plots through to harvest ($p = 0.009$, Table 5). Although the main effect of herbicide on yield was not significant, probably due to removal of all plants at 21 days, transplanting and a weak "F" test with only four sites, the reduced wild rice population considerably cut labour requirement for weeding, according to farmers.

**Table 4:** Effect of pre-planting application of 3 l $ha^{-1}$ glyphosate and fertiliser on rice yield (kg $ha^{-1}$). Means for four sites at Ruvu in 2005.

| | **Fertiliser** | |
|---|---|---|
| **Herbicide** | Nil | Applied |
| No glyphosate | 1594 | 1919 |
| Glyphosate | 1714 | 2328 |
| S.E.D. (9 d.f.) | 213 | |

**Table 5:** Effect of glyphosate application on mean number of *O. punctata* shoots $m^2$ at 21 and 35 days after rice emergence ($log_e$[count+1]) and on biomass of re-growth at rice harvest. Data mean of 4 sites at Ruvu in 2005. Figures in brackets are actual count means

| | **No. $m^2$ 21 DAE** | **No. $m^2$ 35 DAE** | **g $m^2$ at harvest** |
|---|---|---|---|
| No glyphosate | 2.13 (8.2) | 1.72 (6.9) | 112 |
| Glyphosate | 1.14 (2.3) | 0.92 (1.6) | 45 |
| S.E.D. (9 d.f.) | 0.24 | 0.38 | 20 |

Although demonstrations were established at four sites at Dakawa continuing problems with the drainage system resulted in three farmers loosing their crops due to flooding after heavy rain early in the season. Yield data were taken from two sites at Dihombo village. Rice was broadcast planted at both Dakawa and Dihombo and data were combined. Although application of glyphosate increased mean rice yield, (Table 6) this effect was not significant ($P = 0.116$). Use of fertiliser did increase rice yield significantly ($p = 0.007$). At Ruvu, there was no interaction between the two inputs ($p = 0.123$), however, there was a significant reduction in the number of wild rice observed at 21 days (Table 7) after sowing and in weed biomass at harvest ($p < 0.001$ and $p = 0.015$ respectively).

**Table 6:** Effect of pre-planting application of 3 l $ha^{-1}$ glyphosate and fertiliser on rice yield (kg $ha^{-1}$). Means for Dakawa (1 site) and Dihambo (2 sites) in 2005.

| | **Fertiliser** | |
|---|---|---|
| **Herbicide** | Nil | Applied |
| No glyphosate | 725 | 1867 |
| Glyphosate | 1442 | 1875 |
| S.E.D. (6 d.f.) | 279 | |

**Table 7:** Effect of glyphosate application on mean number of *O. punctata* shoots $m^2$ at 21 and 35 days after rice emergence ($log_e$[count+1]) and on biomass of re-growth at rice harvest. Data mean of 3 sites at Dakawa and Dihambo in 2005. Figures in brackets are actual count means.

| | **No. $m^2$ 21 DAE** | **No. $m^2$ 35 DAE** | **g $m^2$ at harvest** |
|---|---|---|---|
| No glyphosate | 2.80 (16.1) | 2.55 (12.1) | 114 |
| Glyphosate | 1.23 (2.6) | 1.04 (2.1) | 9 |
| S.E.D. (6 d.f.) | 0.22 | 0.20 | 31 |

**Participatory economic analysis of production practices**

Meetings were held after harvest with members of the groups that had carried out demonstrations to determine the economic benefit of improved rice management practices from the point of view of growers. Approx. 20 group members accompanied by village government leaders and village agricultural extension officers attended each meeting. Three rice management options were considered:

Option I - no use of recommended technologies, i.e. local seed, no herbicide or fertiliser;
Option II - improved seed (TXD 306),recommended fertiliser dose, no herbicide;
Option III - improved seed, recommended fertilizer and herbicides (Round Up and 2, 4-D)

Group participants indicated the costs of all inputs needed to produce rice under each option and calculated returns based on their estimates of the yields achievable from using each option. It should be emphasised that these were not the yields measured on the demonstration plots and reported above. The gross margins that were derived are shown in Tables 8 to 11. Comparative analysis of gross margin (profit/loss) across the study districts is presented in Figure 1. Use of recommended practices (options II and III) appears to be more profitable than existing practices in all districts. Highest profit was recorded at Ruvu (Bagamoyo) and lowest at Kyela. Low yield from existing practices (option I) resulted in a loss in all districts except Ruvu. Despite higher costs for purchased inputs, cost of production per bag of rice harvested was lowest when both fertiliser and herbicide are used.

**Table 8:** Gross margins for rice production on *O. longistaminata* infested land at Lumemo and Michenga villages in Kilombero districts, Morogoro region

| Activity per acre | Option I | Option II | Option III |
|---|---|---|---|
| **Land Preparation** | | | |
| (i) Land clearing | | | |
| (ii) Land plowing | 25,000 | 25,000 | 25,000 |
| (iii) 1st harrowing | 20,000 | 20,000 | 20,000 |
| (iv) 2nd harrowing | - | - | - |
| **Planting** | | | |
| (i) Broadcasting | 20,000 | - | - |
| (ii) Dibbling/Transplanting | - | 12,000 | 12,000 |
| (iii) Cost of seeds | 5,000 | 5,000 | 5,000 |
| **Weeding** | | | |
| (i) Hand weeding | 30,000 | 30,000 | - |
| (ii) 2nd hand weeding | 20,000 | 20,000 | 10,000 |
| (iii) 3rd hand weeding | 10,000 | 10,000 | - |
| (iv) Herbicide | | | |
| - Round up | - | - | 24,000 |
| - 2,4 D Amine | - | - | 4,500 |
| (v) Herbicide application charge | - | - | 4,000 |
| (vi) Sprayer rent charge | - | - | 3,000 |
| **Fertilizer (Urea)** | | | |
| (i) Cost of fertilizer | - | 25,000 | 20,000 |
| (ii) Cost of fertilizer application | - | 3,000 | 3,000 |
| **Bird scaring** | 30,000 | 30,000 | 30,000 |
| **Harvesting** | | | |
| (i) Harvesting the crop | 15,000 | 15,000 | 15,000 |
| (ii) Gathering and heaping | 5,000 | 5,000 | 5,000 |
| (iii) Beating and threshing | 15,000 | 15,000 | 15,000 |
| (iv) Storage bags | 2,500 | 8,000 | 30,000 |
| (v) Transport cost | 5,000 | 5,000 | 12,500 |
| **TOTAL** | **202,500** | **228,000** | **238,000** |
| **Total harvest (Bags/acre)** | *5 bags* | *16 bags* | *25 bags* |
| **Revenue (20,000*bags)** | **100,000** | **320,000** | **500,000** |
| **Profit/(loss)** | **-102,500** | **+92,000** | **+262,000** |
| **Cost of production per bag** | **40,500** | **14,250** | **9,520** |

**Table 9:** Gross margin analysis for rice production on *O. longistaminata* infested land at Ngonga (Ligombo) village in Kyela district

| No. | Activity per acre | Option I | Option II | Option III |
|---|---|---|---|---|
| **1.** | **Land Preparation** | | | |
| | (i) Land clearing | 500 | - | - |
| | (ii) Land plowing | 20,000 | 20,000 | 20,000 |
| | (iii) 1st harrowing | 15,000 | 15,000 | 15,000 |
| | (iv) 2nd harrowing | 15,000 | 15,000 | 15,000 |
| **2.** | **Planting** | | | |
| | (i) Broadcasting | 10,000 | 10,000 | - |
| | (ii) Dibbling/Transplanting | - | - | 50,000 |
| | (iii) Cost of seeds | 10,000 | 10,000 | 10,000 |
| **3.** | **Weeding** | | | |
| | (i) Hand weeding | - | - | 11,000 |
| | (ii) Herbicide | - | - | 6,000 |
| | - Round up | - | - | 5,000 |
| | - 2,4 D Amine | - | - | 2,000 |
| | (iii) Fertilizer application | - | - | 20,000 |
| | (iv) Sprayer rent charge | - | - | 30,000 |
| **4.** | **Fertilizer (Urea)** | | | |
| | (i) Cost of fertilizer | - | 20,000 | 20,000 |
| | (ii) Fertilizer application | | | |
| **5.** | **Bird scaring** | 30,000 | 30,000 | 30,000 |
| **6.** | **Harvesting** | | | |
| | (i) Harvesting | 10,000 | 10,000 | 10,000 |
| | (ii) Threshing | 3,000 | 7,000 | 12,000 |
| | (iii) Storage bags | 1,800 | 4,200 | 7,200 |
| | (iv) Transport cost | 3,000 | 7,000 | 12,000 |
| | **Total** | **168,300** | **198,200** | **240,000** |
| | Total harvest (Bags/acre) | *3 bags* | *7 bags* | *12 bags* |
| **7** | Revenue (40,000 * bags) | 120,000 | 280,000 | 480,000 |
| | **Profit/loss** | **-48,300** | **+81,800** | **+239,800** |
| | **Cost of production per bag** | **56,100** | **28,314** | **20,016** |

**Table 10:** Gross margin analysis for rice production on *O. punctata* infested land at Dihombo village in Mvomero district

| No. | Activity per acre | Option I | Option II | Option III |
|---|---|---|---|---|
| **1.** | **Land Preparation** | | | |
| | (i) Land clearing | 20,000 | 20,000 | 20,000 |
| | (ii) Land plowing | 20,000 | 20,000 | 20,000 |
| | (iii) 1st harrowing | 15,000 | 15,000 | 15,000 |
| | (iv) 2nd harrowing | | | |
| **2.** | **Planting** | | | |
| | (i) Cost of seeds | - | - | |
| | (ii) Costs of seeding/transplanting | 4,000 | 4,000 | 4,000 |
| | (ii) Nursery preparation | 5,000 | 5,000 | 5,000 |
| | (i) Broadcasting | - | - | - |
| | (ii) Dibbling/Transplanting | 24,000 | 24,000 | 24,000 |
| | (iii) Cost of seeds | | | |
| **3.** | **Weeding** | | | |
| | (i) 1st Hand weeding | 24,000 | 24,000 | - |
| | (ii) 2nd hand weeding | 20,000 | 20,000 | 20,000 |
| | (iii) 3rd hand weeding | 8,000 | 8,000 | - |
| | (iv) Herbicide | | | |
| | - Round up | - | - | 9,000 |
| | - 2,4 D Amine | - | - | 5,000 |
| | (v) Herbicide application charge | - | - | 3,000 |
| | (vi) Sprayer rent charge | - | - | 3,000 |
| **4.** | **Fertilizer (Urea)** | | | |
| | (i) Cost of fertilizer | - | 30,000 | 30,000 |
| | (ii) Cost of fertilizer application | - | - | 2,000 |
| **5.** | **Bird scaring** | 30,000 | 30,000 | 30,000 |
| | Guard hut construction | 5,000 | 5,000 | 5,000 |
| **6.** | **Harvesting** | | | |
| | (i) Harvesting the crop | 40,000 | 40,000 | 40,000 |
| | (iii) Beating (and threshing) | 15,000 | 15,000 | 15,000 |
| | (iv) Storage bags | 4,000 | 7,500 | 15,000 |
| | (v) Transport cost | 12,000 | 22,500 | 45,000 |
| | (vi) Arrangements of bags in store | 1,600 | - | - |
| | **TOTAL cost** | **247,600** | **290,000** | **310,000** |
| | **Total harvest (Bags/acre)** | **8bags** | **15 bags** | **30bags** |
| | **Revenue (25,000*bags)** | **200,000** | **375,000** | **750,000** |
| | **Profit/loss (Revenue – Cost)** | **-47,600** | **+85,000** | **+440,000** |
| | **Cost of production per bag** | **30,950** | **19,333** | **10,333** |

**Table 11:** Gross margin analysis for rice production on *O. punctata* infested land at Ruvu irrigation scheme in Bagamoyo district

| No. | Activity per acre | Option I | Option II | Option III |
|---|---|---|---|---|
| **1.** | **Land Preparation** | | | |
| | (i) Land clearing | 20,000 | 20,000 | 20,000 |
| | (ii) Land plowing | 25,00 | 25,000 | 25,000 |
| | (iii) 1st harrowing | 15,000 | 15,000 | 15,000 |
| | (iv) 2nd harrowing | | | |
| | (v) Field leveling | 15,000 | 15,000 | 5,000 |
| | (iv) Cleaning irrigation channels | 12,000 | 12,000 | 13,000 |
| **2.** | **Planting** | | | |
| | (i) Cost of seeds | - | 13,500 | 5,000 |
| | (ii) Costs of seeding/transplanting | - | - | - |
| | (ii) Nursery preparation | - | 3,750 | 1,000 |
| | (i) Broadcasting | - | - | - |
| | (ii) Dibbling/Transplanting | 25,000 | 45,000 | 45,000 |
| | (iii) Cost of seeds | | | |
| **3.** | **Weeding** | | | |
| | (i) 1st Hand weeding | 25,000 | 25,000 | - |
| | (ii) 2nd hand weeding | 15,000 | 15,000 | 10,000 |
| | (iii) 3rd hand weeding | - | 15,000 | **-** |
| | (iv) Herbicide | | | |
| | - Round up | - | | 9,000 |
| | - 2,4 D Amine | - | - | 5,000 |
| | (v) Herbicide application | - | - | 5,000 |
| | (vi) Sprayer rent charge | - | - | - |
| **4.** | **Fertilizer (Urea)** | | | |
| | (i) Cost of fertilizer | - | 36,000 | 36,000 |
| | (ii) Cost of fertilizer application | - | 2,000 | 2,000 |
| **5.** | **Bird scaring** | 20,000 | 20,000 | 20,000 |
| | Guard hut construction | - | 6,000 | 6,000 |
| **7.** | **Harvesting** | | | |
| | (i) Harvesting the crop | 25,000 | 25,000 | 25,000 |
| | (ii) Gathering and heaping | 10,000 | - | 20,000 |
| | (iii) Beating | 15,000 | 15,000 | 15,000 |
| | (iv) Storage bags | - | 12,000 | 24,000 |
| | (v) Transport cost | - | 26,000 | 30,000 |
| | **TOTAL** | **222,000** | **306,250** | **365,250** |
| | Harvest (bags) | *12 bags* | *20 bags* | *40 bags* |
| **9** | Revenue (25,000 * bags) | 300,000 | 500,000 | 1,000,000 |
| | **Profit/loss** | **+78,000** | **+193,750** | **+634,750** |
| | **Cost of production per bag** | **18,500** | **15,312.50** | **9,131.25** |

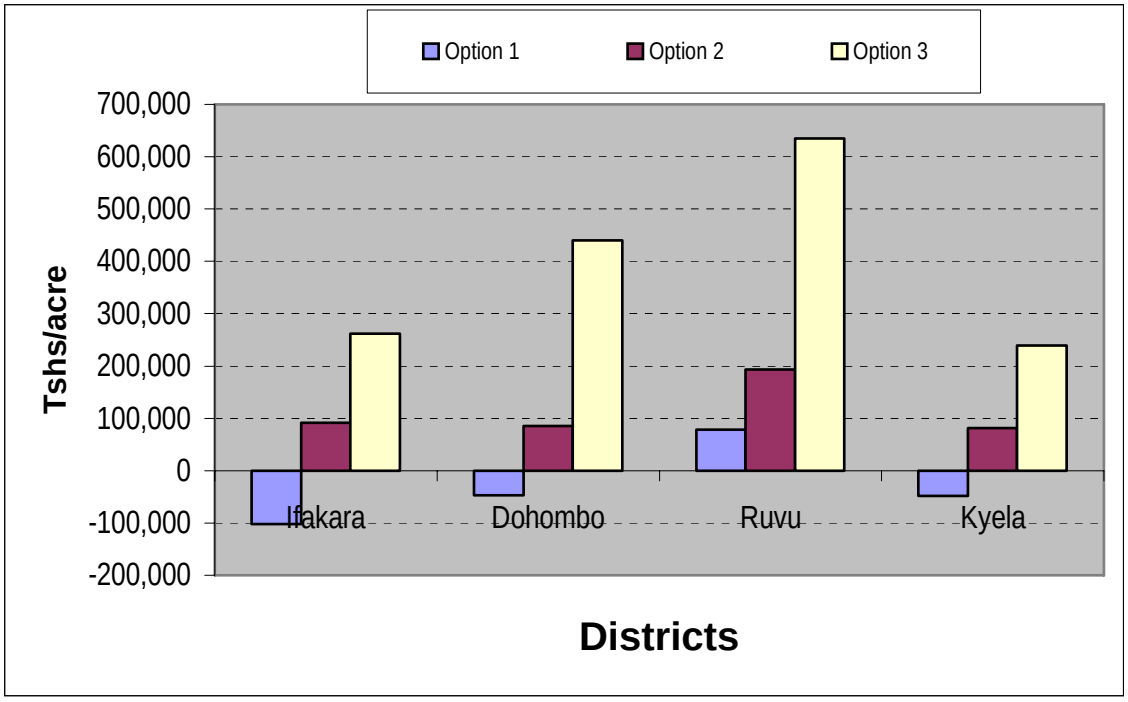



Figure 1: Gross margin (Tshs) accrued from one acre of rice based on three input options at Ifakara (Kilombero), Dihombo (Mvomero), Ruvu (Bagamoyo) and Kyela (Kyela). Option 1 - farmer practice; option 2 – improved seed and fertiiser; option 3 – improved seed, fertiliser and herbicide.

Rational producers may be expected to always aim at maximizing profit, utility or strive to produce at the lowest cost possible. This can be achieved by adopting **option III** which recorded the highest possible gross margins in all study locations. Currently the majority of producers in the study villages use the practices under option I including planting low yielding rice of Supa India cultivar type. The costs of producing rice using existing practices derive largely from "non-cash" inputs. For example, much of the land worked by farmers is held under customary, village or communal tenure arrangements and farms are mainly worked by family labour (often unpaid). Farmers do not therefore always perceive farm labour to have a monetary cost. However when the true costs, including a realistic opportunity cost for labour, were discussed, farmer were surprised that in many cases they experience losses. Training farmers on a business approach to their rice enterprise, particularly with increasing opportunity to supply a growing urban market, will lay a foundation for adoption of improved practices. It is important however, for inputs to be available near to farms, at the time farmers market rice and therefore have cash available.

**Field days at demonstration plots**

Field days were held at demonstration sites in Kilombero district and at Ruvu irrigation scheme during the last week of May 2005 when rice was at grain filling stage. Seven farmers with two village extension workers and one village chairman from Kyela district joined 46 farmers, two extension workers and village leaders from three communities in Kilombero for a field day at Kilombrero distfrict sites. Radio and newspaper reporters were also present. The Ruvu field day brought together 58 farmers from the irrigation scheme, one from Dakawa irrigation scheme and six from Dihambo village. Village leaders from each community and an extension officer also attended. During the tour of demonstration sites farmers were asked to select the best treatment based on visual assessment for the management of wild rice. Farmers were most impressed by the performance of rice on plots to which both glyphosate and urea fertilizer had been applied.

**Farmer Training**

Training of farmers was undertaken at four locations during January 2006 prior to the onset of rains and the rice planting season. At all sessions participants included 101 rice farmers (project participants and non-participants), 2 agricultural input stockiest, 3 extension staff (village/ward and district), 2 village chairpersons and 3 ward executive officers from Lumemo and Michenga in Kilombero district, Dihombo/Dakawa in Mvomero district, Ruvu in Bagamoyo district and Kilwa and Ngonga in Kyela district.

The training was divided into theoretical and practical sessions. The theoretical part concentrated on introducing farmers to improved rice production practices for increased rice grain yield while the practical part emphasised the management of wild rice and other weeds in lowland rice using *Glyphosate* and 2, 4 D Amine. The practical session also addressed herbicide application procedures, handling and storage

To support continued training a Swahili training manual (Annex 1), with colour pictures and diagrams was developed and 120 copies were distributed to the District councils, village extension staff and rice farmers. Other copies will be sent to the Kilimanjaro Agricultural Training Institute (KATC), Moshi Tanzania. The manual focuses on profitable rice production with special emphasis on use of Glyphosate (Round up) herbicide for wild rice management.

Topics covered in the manual are;

- Production constraints - Insect pests (e.g. stem borers and gall midge), diseases (Rice Yellow Mottle Virus (RYMV) and blast diseases) and high infestation levels of weeds including wild rice; poor soil and water management; low yielding cultivars;
- Advantages and disadvantages of available cultivars;
- Recommended fertiliser doses and ways to increase fertiliser use efficiency;
- Rice establishment and spacing;
- Weed control including use of herbicide for wild rice management;
- Safe, effective application, storage and handling of herbicides. Includes spray mixing and application

After the training session farmers were given opportunity to share experience with others and made a number of observations:

**Project participating farmers said: -**

- They have started managing their farms with less labour due to application of Glyphosate and 2, 4 D Amine herbicides

- They have started returning to fertile fields that had been infested by wild rice and now manage these by using glyphosate;
- When *Glyphosate* and *2, 4 D Amine* herbicides are applied with an application of urea fertilizer rice grain yield is significantly increased
- They plan to expand from the current 0.5-1.0 hectare to at least 1.5 hectares per farmer using improved practices;
- They plan to undertake other economic activities using the time saved from extensive weeding in their rice fields.

**Non-project participating farmers: -**

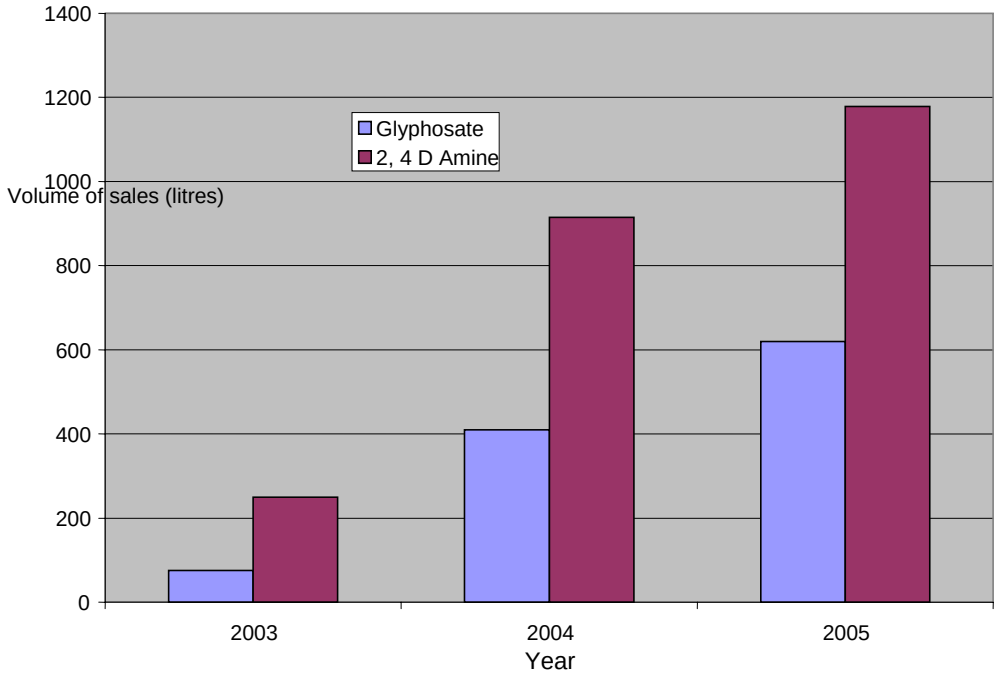
- Training session had educated them on how to control wild rice that has been a problem for many years;
- Start practicing the technology by copying from project participating farmers;
- Suggested that knowledge on wild rice management should be extended to other areas where research trial was not conducted.

**Herbicide sales**

Three stockists of agricultural inputs including pesticides, based in Ifakara (Kilombero district) were asked to provide details of herbicide sales during the period the project has been active. Sales of both 2, 4-D amine and glyphosate (Round Up) have increased annually since 2003 (Figure 2). While the use of 2,4-D was already known by some farmers for control of broadleaf weeds and sedges sales increased from 250 litres to 1,178 litres in 2005. The supply of glyphosate increased from 75 litres to 620 litres.

All stockiest complained of lack of capital to maintain sufficient stocks to supply the customers' demand. Very few farmers claim to go outside Ifakara town to search for similar products.

Figure 2: Variation in volume of sales of herbicide products in Kilombero district from 2003-2005



**Output 2. Influence of land-tenure on adoption of improved rice management in Kyela District understood**.

Information collected during discussions with members of two communities in Kyela is summarised in Appendix 1. The Nyakyusa clan that lives in Kyela is a patrimonial society with land inheritance through the male line. Farmland is owned by no more than 30% of households as a result of allocations made by the chief to leading families following the conquest of the area by the Nyakyusa in the 19th century. This skewed ownership has persisted. The profound structural changes to asset ownership, including nationalisation and the Ujamaa movement were never implemented or recognised by the Nyakyusa. As a result the majority of households access rice land by short-term rental contracts, usually limited to two crop seasons. The tenure situation is further complicated by the widely held perception that land-owners may terminate or refuse to renew contracts for rice plots on which tenants achieve a good yield and cultivate these themselves. Although not "ground-truthed" data collected in the study suggests strongly that tenants are allocated land with the densest wild rice infestations and poorest soil fertility. Participants in the study agreed that:

- landowners are most likely to adopt technologies that improve rice yields;
- tenants are least likely to undertake investments that improve yield in the long-term as this will increase the productive potential of the land to the ultimate benefit of the land owner.

However farmers who have been exposed to project activities have seen the benefits of wild rice management and fertiliser use and through participatory budgeting undertaken in 2004 realised that they need to also consider the value of their labour, invested in rice farming. There is also a need for wider understanding in the community of the benefits that increased investment can bring to individual households.

This study suggests that district council agricultural and village development officials need to further engage with communities in Kyela to assess the potential for improving rice output from a community, rather than individual perspective. Landowners, up to 30% of households are most likely to adopt improved technology, including herbicide for wild rice management, first. The question remains as to what happens to land of tenants where wild rice is brought under control. Although the demonstrations show that wild rice suppression is season long, there is re-growth and additional inputs are likely to be needed each year. The need for continued herbicide application year on year will only become apparent as increasing numbers of farmers use the technology. On view emerging from the study is that tenants may be prepared to invest in herbicide and/or fertiliser to maximise output in at least the first season of a rental contract. This is more likely to be the case with extension input to demonstrate the technology and impact on household labour productivity. An alternative scenario is that land-owners may continue to keep the best plots to them selves but to increase areas planted they would need to hire labour. What ever the outcome it is clear that the land tenure issue needs to be considered by the district council when developing promotion activities aimed at improving lowland rice productivity in Kyela.

**Contribution of Outputs to developmental impact**

During the 10-month extension to the project, fieldwork has demonstrated with farmers that a package of wild rice control and fertiliser use with the improved cultivar TXD 306 will enhance productivity of floodplain and irrigated rice systems in Tanzania. Application of glyphosate to wild rice re-growth prior to seeding rice allows wild rice infested land to be cultivated profitably. This includes previously abandoned land often on areas with the deepest water and highest soil fertility that have the highest potential for rice production. The combination of wild rice suppression by glyphosate and in-crop weed control with 2, 4-D reduces subsequent in-crop hand weeding time by 50%, a saving in labour welcomed by growers. Extension material produced by the project provides farmers with the knowledge to use herbicides safely and

effectively. Recent projections indicate that demand for rice in sub-Saharan Africa will grow at 2% per year over the next three decades with imports of milled rice reaching 5.91 million MTs, some 27% of consumption. At the rice farm gate price the cost of treating one ha with glyphosate is covered by the sale of just 130 kg paddy. This approach to wild rice management therefore provides farmers with an opportunity to reduce labour costs while increasing rice output to benefit from increasing market demand for rice in Tanzania. The training manual, along with the leaflet and poster produced in 2004 provides extension material on which district council extension managers or NGOs can base future promotion of wild rice control. Increased understanding of the land tenure situation on the Kyela floodplain will assist extension staff target dissemination of improved rice production practices.

## Follow-up indicated/planned

The extension materials produced by the project have already been distributed to district council agriculture teams in wild rice infested areas. Further assistance with training of trainers at district level and of lead farmers will reinforce key messages delivered at project run training sessions. It will be particularly important to provide knowledge on herbicide use in rice to the wider farming community to avoid the crop damage that currently results from application of inappropriate products sourced from street traders, particularly in Kyela. There are currently few herbicide suppliers in the areas the project has been working. Thought needs to be given to securing supplies for farmers and providing stockists with the knowledge to advise farmers on effective weed management.

**PUBLICATIONS SUMMARISING RESULTS FROM R8477 -** see Annex 1 on CD for electronic copy.

## Conference Papers

Riches, C.R., Mbwaga, A.M., Mbapila, J., Ahmed, G.J. (2005). Improved weed management delivers increased productivity and farm incomes from rice in Bangladesh and Tanzania. *Aspects of Applied Biology 75: Pathways out of Poverty*. 127-138.

### Extension materials

Uzalihaji wa Kilimo bora cha Mpunga wa Mabondeni wenye tija unaozingatia matumizi ya viua gugu, hasa kwenye punga pori Tanzania. Mwongozo wa Maafisa Ugani, 2005. *('Profitable Lowland Rice Production with special emphasis on Herbicide application on wild rice management in Tanzania. A guide to Agricultural Extension Staff in Tanzania. November, 2005* Published by Kilombero Agrocultural Research an dTraining Institute, Ifakara, Tanzania..

Video kwa ajili ya mbinu bora za uangamizaji punga pori/punga zeze katika kilimo cha mpunga wa mabondeni, siku ya wakulima, 2005. (A *Field day documented Video on Wild Rice Management Practices in Tanzania, 2004*)

### Newspaper article

28th May 2005 Mwananchi Newspaper.*Siku ya wakulima- tukio la kuwaelimisha mbinu bora za kilimo cha mpunga kwa wakulima wadogo wadogo katika vijiji vya Dakawa na Ruvu*" (*Farmers field day- A way small-scale farmers learn more on rice production technologies at Dakawa and Ruvu..*

**Radio Programmes**

29th May 2005 Radio Tanzania *Siku ya wakulima wadogo wadogo wa mpunga wa Dakawa na Ruvu* (Farmers' Field day for small-scale rice farmers at Dakawa and Ruvu)