Crop Protection Programme

Development and promotion of wild rice management strategies for the lowlands of southern Tanzania R 8198 (ZA0517)

FINAL TECHNICAL REPORT

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Executive summary:
Project Purpose: The project was designed to develop and promote strategies for the management of wild rice (*Oryza longistaminata* and *O. punctata*) and develop information and extension materials on wild rice control so farmers can increase lowland rice productivity on infested land in Tanzania.

Output 1 &2 *Management packages formulated for control of o. longistaminata and o. punctata in different ecologies and cropping systems in southern Tanzania; Management packages developed and promoted through on-farm and demonstration trials at four locations in southern Tanzania:* Seven farmer-research groups, with a membership from 128 households undertook demonstration trials on 32 wild rice infested farms. Participatory evaluation during field days and sensitization workshops involved more than 230 rice producers from seven villages within the project areas. Farmers identified the use of glyphosate before planting at the rate of 3 litres/ha for the control of annual wild rice (*O. punctata* on irrigated land) and 4 litres/ha for the control of perennial wild rice (*O. longistaminata* on rain-fed fields) as the best options for the management of these weeds. Post-emergence application of 2-4D at 21 days after germination was favoured to reduce labour inputs for in-crop weed control. Partial budget analysis undertaken with growers, district agricultural extension staff, village chairmen and ward executive officers demonstrated on the benefit of improving wild rice management. Income from rice production could be increased from a cost benefit ration of less than one (0.64) to 2.94 for farmers in Kyela, 3.25 for Dakawa and 4.93 for Ruvu farmers when glyphosate was used.

Significant increase in yield of more than 4t/ha over control have been achieved using glyphosate before planting and 2-4D at 21 days after crop emergence and has formed an added incentive to technology adoption

Output 3 & 4: Technologies and decision tools verified for control of *O. longistaminata and O. punctata; Extension materials prepared and disseminated.* Group members from Michenga and Lumemo villages in Kilombero set up, in addition to the experimental fields, demonstration plots on their own field to enable other farmers in the district copy the technology they have acquired. Due to involvement of different rice production stakeholders in seminars and field days, and following the deputy Minister for Agriculture visit to one of the trial sites, the supply of glyphosate has iincreased tremendously. More than 3500 litres of glyphosate have been purchased between November 2004 to February 2005 in areas where the project has been operating compared to less than 500 litres in 2003. To support promotion the project prepared a leaflet and poster (3000 and 1500 copies respectively). These have been distributed to extension teams and farmers.

Contribution of Outputs to Project Goal: Rice yields in glyphosate treated plots have been more than double those achieved by usual farmers practice and income from rice production substantially increased. The sustainability of the production system has been enhanced as farmers have realised that application of glyphosate to *O. longistaminata* regrowth or *O. punctata* seedlings prior to seeding rice allows wild rice infested land to be cultivated profitably. This previously abandoned land includes 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. Results from the project provide district council extension managers with an opportunity to consider how to incorporate wild rice management issues into future programmes.

Table of contents:

List of Tables:

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1. 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 weeds including highly competitive annual and perennial wild rice species (*Oryza punctata* and *O. longistaminata* respectively) have been identified as one of the major constraints to rice production on lowlands in central and southern Tanzania (Johnson *et al.* 2000). Wild rice is a cause of very low yields on large-scale farms (Kanyeka, 1994) and a major problem confronting small-scale farmers (Matthews et al., 1994). Wild rices are the only known alternative hosts for African Rice Gall Midge (ARGM) and are important hosts for Rice Yellow Mottle Virus (RYMV). RYMV (Bano et al 2001) and ARGM are important pests of rice in Tanzania and a number of West African countries including Nigeria, Burkina Faso, Mali, Sierra Leone and Guinea.

In Tanzania, lowland rice production is undertaken by large mechanised parastatal farms and by smallholders who cultivate either by hand or by oxen -drawn plough. O*. longistaminata* occurs widely in Kyela Kilombero and Mbarali districts - on rainfed floodplains farmed by smallholders. Control is by cultivation, removal of rhizomes by hand and hand weeding. Before the project little herbicides were used and some of the herbicides which were used, such as Tordon (picloram) and Gramoxone (paraquat) are not intended specifically for weed control in rice. The National Food and Agriculture Corporation (NAFCO) farms at Dakawa and Ruvu are infested by wild rices. *O. punctata* thrives on these irrigation schemes under a system of direct seeding of rice with poor water management and this has contributed to the collapse of schemes as large commercial operations. 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.

Annual and perennial wild rice (*Oryza*) species are difficult to control weeds since they are similar in appearance to cultivated rice in the vegetative stage, compete vigorously with the crop. CPP project R7345 studied control methods for the annual wild rice *O. barthii* and for O*. longistaminata* in Ghana, Mali and in glasshouse studies in the UK (Tuor et al. 2001), This work identified that pre-pant application of the herbicide glyphosate (Round Up) provides effective control of both annual and perennial wild rice. These studies were undertaken in close co-operation with farmer groups and successful strategies and methods of control for wild rice identified some of which, are also applicable in the Tanzanian situation. During R7345 field surveys were conducted in the south of the country around Mbeya, Kyela and Ifakara and the para-statal rice farms of Ruvu, Dakawa, M'Barali and Kapunga. A field experiment at the main rice station, KATRIN, Ifakara, confirmed that Tanzanian populations of *O. longistaminata* are effectively controlled by early season application of glyphosate prior to rice seeding.

Project R8198 (2002-5) was designed to evaluate the use of glyphosate as a component of improved rice management with farmer groups for *O. longistaminata* control on two floodplain areas and against *O. punctata* at Dhakawa and Ruvu. The project has through collaborative work in wild rice infested areas, developed and promoted improved control practices. Farmer participatory demonstrations of different improved control methods have been undertaken and extension information needed to support wild rice management have been developed. Through demonstrations, field days, training and seminars with rice production stakeholders, the results of improved management practices have reached a large number of farmers within a short period of time.

2. Project Purpose:

To develop and promote strategies for the management of wild rice (*Oryza longistaminata* and *O. punctata)* and develop information and extension materials on wild rice in Tanzania

3. Research activities:

3.1 Base line survey, interviews and formation of farmers research groups

Village meetings to introduce the project and form farmer research groups were held in Kilwa and Lungombo (Kyela), Lumemo and Michenga (Kilombero) in November 2002, Dakawa (Mvomero-Morogoro rural) in January and Ruvu (Coast) in February 2003. In all the villages except Ruvu, staff from the district agricultural extension service opened the meetings, which were later chaired by the respective village chairpersons. The meeting in Ruvu was opened by the chairlady of the Ruvu farmers association. Discussions were then held on the major constraints to rice production, methods of land preparation, major weeds in rice fields and control measures used by the farmers. After the discussions, farmers research groups were formed. Each group members democratically elected their own chairperson and a secretary. Household interviews were undertaken during the same period in four villages in Kyela, Four in Kilombero, two in Dakawa and one in Ruvu. Two villages in Kyela (Kajunjumele and Kingila) and two in Kilombero (Mbasa and Katindiuka) were also selected for household interviews. These were undertaken as a baseline survey to provide an understanding of current rice production practices and marketing.

3.2 Site selection; design an establishment of experimental/demonstration sites:

A total of twenty-three experimental sites were selected in collaboration with the farmer research groups formed in 2002/2003. However, by 2004 seven farmer-research groups, with a membership from more than 128 households undertook demonstration trials on 32 wild rice infested farms as shown in Table 1 below:

Table 1: number of research demonstrations trials conducted during the 2003 and 2004 season in Kyela, Kilombero, Mvomero and Coast

	Farmer group activity	
District	**2003**	**2004**

O. longistaminata	**Village**	**Members**	**Demo plots**	**Members**	**Demo plots**
Kyela	Kilwa	20	4	25	5
	Lungombo	20	4	25	5
Kilombero	Lumemo	20	4	25	5
	Michenga	20	4	25	5
O. punctata					
Mvomero-Morogoro Rural	Dakawa	28	7	32	8
Coast	Ruvu	20	4	25	5

3.3 Experimental treatments:

In 2003, a total of eight treatments were tested for the control of *O. longistaminata,* in Kilombero and Kyela while five treatments were formulated for *O. punctata* control at Ruvu and Dakawa.

The treatments for *O. longistaminata* at Kilombero and Kyela were:

1. Land ploughed, harrowed and rice seeds sown and covered + one hand weeding at 21 days after emergence DAE) (Farmers practice)
2. Land ploughed, harrowed and rice seeds sown and covered + 2-4D at 21 DAE and one hand weeding at 42 DAE.
3. Land ploughed, harrowed and rice seeds sown and covered + 2-4D at 21 DAE + one hand weeding at 42 DAE + sequential cropping of *Crotalaria juncia*
4. Land ploughed, harrowed and rice seeds sown and covered + 2-4D at 21 DAE + one hand weeding at 42 DAE + sequential cropping of Pigeon peas
5. Land ploughed, harrowed + 3l glyphosate at 20-30 cm tall *O. longistaminata* + broadcast soaked rice seed + 2-4D at 21 DAE + hand weeding at 42 DAE
6. Land ploughed, harrowed + 4l glyphosate at 20-30 cm tall *O. longistaminata* + broadcast soaked rice seed + 2-4D at 21 DAE + hand weeding at 42 DAE
7. No ploughing, apply 3l glyphosate to 20-30 cm tall *O. longistaminata* to broadcast seed without covering + 2-4D at 21 DAE + one hand weeding at 42 DAE
8. No ploughing, apply 4l glyphosate to 20-30 cm tall *O. longistaminata* + broadcast seed without covering + 2-4D at 21 DAE + one hand weeding at 42 DAE

The treatments for *O. punctata* were:

1. Plough + harrowing + 2 l glyphosate/ ha at 3 leaf stage *O. punctata* + broadcast soaked rice seed (no seed covering)+ 2-4D at 21 DAE + hand weeding at 42 DAE.
2. Ploughing + harrowing + 3 l glyphosate/ ha at 3 leaf stage *O. punctata* + broadcast soaked rice seed (no seed covering)+ 2-4D at 21 DAE + hand weeding at 42 DAE
3. Ploughing + harrowing + 2 l glyphosate/ ha at 3 leaf stage *O. punctata* + broadcast soaked rice seed (seeds covered) + 2-4D at 21 DAE + hand weeding at 42 DAE

4. Ploughing + harrowing + 3 l glyphosate/ ha at 3 leaf stage *O. punctata* + broadcast soaked rice seed (seeds covered) + 2-4D at 21 DAE + hand weeding at 42 DAE
5. Farmers' treatment, plough + harrow sow cover seed followed by one hand weeding.
6. Ploughing + harrowing + 2 glyphosate/ ha at 3 leaf stage *O. punctata* + Seed drill soaked rice seed + 2-4D at 21 DAE + hand weeding at 42 DAE
7. Ploughing + harrowing + 3 glyphosate/ ha at 3 leaf stage *O. punctata* + Seed drill soaked rice seed + 2-4D at 21 DAE + hand weeding at 42 DAE

In 2004, the treatments were modified following discussions held with rice production stakeholders during field days and workshops. The treatments for *O. longistaminata* were reduced from eight to five. And those for the control of O. punctata were reduced from five to three.

Treatments for *O. longistaminata* were:

1. No herbicide + one hand weeding at 21DAE (Farmers practice)
2. 2-4D at 21 DAE + one hand weeding at 42 DAE
3. 2-4D at 21 DAE + one hand weeding at 42 DAE + *Crotalaria juncia*
4. 2-4D at 21 DAE + one hand weeding at 42 DAE + pigeon peas and
5. 4l Glyphosate + 2-4D at 21 DAE + one hand weeding at 42 DAE

And those for *O. punctata* were:

1. No herbicide + one hand weeding at 21DAE (Farmers practice)
2. 2 l Glyphosate + 2-4D at 21 DAE + one hand weeding at 42 DAE
3. 3 l Glyphosate + 2-4D at 21 DAE + one hand weeding at 42 DAE

Although it was planned to evaluate the use of post-rice sowings of green manure or pigeon pea for suppression of wild rice re-growth this approach proved impractical. These species were established in Kyela in 2003 but it proved impossible to keep livestock off isolated plots. The floodplains in Tanzania are valuable for grazing during the dry season. Fields are unfenced and provide a communal resource. Any form of post-rice cropping on residual moisture would require costly fencing. Fertilizer in the form of Urea was applied to each plot at the rate of 80 kg N/ha. Stem counts of the wild rice were made from each plot at 21 DAE and at harvest from four 1m x 1m quadrats while fresh and dry wild rice biomass was determined at harvest. Studies to estimate the yield loss due to wild rice were conducted by measuring yield from each plot after harvest. One plot of each treatment was planted on each participating farm, providing replicate blocks to use in Analysis of variance.

In 2003 field days were organized at Kyela, Dakawa-Dihombo and Ruvu at the vegetative stage with the aim of involving farmers and other rice production stakeholders in selecting the best wild rice management strategies among the treatments tested. During the 2004 season, field days were conducted in all four districts at the ripening stage.

3.4 Training of participants:

Training programme for Key- farmers from Kilombero, Mvomero, Kyela and Bagamoyo Districts was conducted at the Kilimanjaro Agricultural Training Centre (KATC) from 22nd September to 3rd October 2003 (Appendix 3). The objective of the course was to enhance and improve skills and knowledge of the farmers so that they can increase productivity and operate their farms more efficiently and sustainably in terms of water management, rice production techniques and strengthening Irrigation Associations (IAs) or Co-operative societies/farmers groups.
Training on herbicide calibration and application was also provided to all participating farmers in all districts at a selected site to enable farmers to calculate and apply accurately the amount of herbicide required per unit area.

3.5 Workshops

Workshops were conducted in 2003 and 2004 involving more than 230 rice production stakeholders from seven villages within the project areas (Appendix 2). In 2003, the workshops were earmarked as a sensitization and awareness creating tool for rice production stakeholders on technologies being developed to manage wild rice infested fields and bridge the gaps between stakeholders and create a follow-up mechanism for efficient rice productivity in the participating districts. In 2004 the workshops aimed at mainly evaluating the treatments in terms of performance and economic benefits and look at ways of increasing the supply of glyphosate by input stockist. Participants were the district council officials as well as the middle level link staff who included the Division Executive Officers, Village Executive officers, Village Agricultural Extension Officers, input stockists and some of the participating farmers.

4. Project Outputs

Output 1 &2 ***Management packages formulated for control of O. longistaminata and O. punctata in different ecologies and cropping systems in southern Tanzania; Management packages developed and promoted through on-farm and demonstration trials at four locations in southern Tanzania***

4.1 Baseline survey

In total 100 respondents were interviewed. The majority (40%) was from Kyela district. Bagamoyo, Mvomero, and Kilombero districts each provided 20% of the respondents, About 80% of the farmers interviewed cultivate low land rice.

The average number of members per household was determined. Kyela district had a higher numbers of adults, children and those who can work in the farm (Table 2). Rice being labour intensive the proportion of members who can work in the farm has important implication for carrying out various farm operations since the main source of farm labour is family labour. Hired labour is used mostly for weeding except in Kilombero. Tractors, hired from machinery pools operated by the remaining estate managers, are used for land preparation at Ruvu and Dakawa. Some farmers in Kyela prepare their land by Oxen-driven ploughs while hoes are used elsewhere.

Table 2: Average household members

District	Average number Adults	Average number children	Average number of persons who can participate in farm operations
Kyela	3.2	4.1	3.2
Bagamoyo	2.0	2.4	1.9
Mvomero	1.7	1.2	1.1
Kilombero	1.6	1.9	1.5

The total area (acre) owned by respondents partitioned for a different crop is shown in Table 3. On average the area under rice is higher than for the other crops indicating the importance of the crop in these districts. More than 80% of the crop is lowland rainfed except at Ruvu and Dakawa where supplementary irrigation is sometimes provided. However the irrigation and drainage systems on these schemes lack maintenance making water difficult to manage on some fields. Areas under maize are highest in Mvomero and Bagamoyo but negligible at Kyela and Kilombero district. This ratio suggests the role of rice in farming system for the latter districts.

Table 3: Total area (acres) under different crops

District	**Total farm area**	**Total area under rice**	**Total area under maize**	**Total area under cassava**
Kyela	3.9	2.6	0.4	0.32
Bagamoyo	2.45	2.3	1.0	1.0
Mvomero	5.22	2.6	2.35	0.75
Kilombero	4.1	3.4	0.61	0.31

The total production of selected crops a year before the project started is shown in Table 4. Without considering area cultivated, the data indicate that production is low and varies from one district to another. Although the yields are very low, Kilombero, Mvomero and Bagamoyo districts recorded higher yields than Kyela.

Table 4: Average production of different crops per household

District	Maize (bags)	Cassava (bags)	Rice (bags)	Potato (bags)	Banana (bunch)
Kyela	3.7	2.4	7.6	2.6	55.3
Bagamoyo	5.5	-	17.3	-	-
Mvomero	9.6	31.5	20.4	-	-
Kilombero	3.6	2.2	24.0	3.0	15.0

A bag of rice is about 80 kg, maize, cassava and potatoes about 100 kg

In Kyela land preparation is undertaken in August, September, October and November. In Kilombero and Mvomero district the majority of farmers prepare land in November and December where as in Bagamoyo land preparation is done in January (Table 5).

Table 5: Months for land preparation (% farmers)

District	July	Aug	Sept	Oct	Nov	Dec	Jan
Kyela	7.5	55	15	2.5	20	-	-
Bagamoyo	-	-	10.5	-	21.1	15.8	52.6
Mvomero	-	-	-	-	10.0	85.0	5.0
Kilombero	50	-	-	5.0	40.0	45.0	5.0

As indicated in Table 6, 40% of the respondents cultivate their rice plots once. Single cultivation is common at Kilombero and Mvomero. In Kyela and Bagamoyo it is common to cultivate 3 to 4 times prior to planting.

Table 6: Number of times land is cultivated before planting rice (% farmers)

District	**1**	**2**	**3**	**4**
Kyela	0.0	0.0	70.0	30.0
Bagamoyo	0.0	17.5	27.5	40.5
Mvomero	60.0	35.0	5.0	0.0
Kilombero	100.0	0.0	0.0	0.0
Average	40.0	20	20	20

Planting time varies considerably. Planting starts in December and ends in March. Overall, more than 50% of farmers plant rice in January. In Kyela the majority plant in December where as at Mvomero and Kilombero planting is mostly done in January (Table 7).

Table 7: Planting time for rice (% farmers)

District	**December**	**January**	**February**	**March**
Kyela	50	27.5	20	2.5
Bagamoyo	15	40	40	5
Mvomero	10.5	84.5	5.3	0
Kilombero	40.0	60.0		

Weed is the most serious problem in rice production. Farmers mentioned about 11 weeds with slight variation across districts and villages within the same district. From the study *O. longistamina* is the most common weed in Kyela where as *O. punctata* is common in Bagamoyo and Mvomero. *Ipomoea aquatica* was also reported in Kilombero district. Based on proportion of respondents interviewed, *O. longistamina* is ranked highest followed by *O. punctata*. Weed control is mostly by hand weeding as reported by 72% of the respondents. Use of herbicides is reported by 28% of the respondents and it is more common in Kyela than other districts (Table 8). However, during field visits it was realized that most of the herbicides used in Kyela such as Tordon, Gramoxon* and Gesapax* are total weed killers and not suitable for control of weeds in rice fields. Indeed during 2004 farmers purchased herbicide from the market in Kyela only to find that their rice dies after spraying. The product turned out to be smuggled into the country from sugar cane estates in Malawi.

Table 8: Methods of weeding (% farmers)

District	**Hand**	**Herbicides**

Kyela	55.0	45.0
Bagamoyo	85.0	15.0
Mvomero	80.0	20.0
Kilombero	85.0	15.0
TOTAL	72.0	28.0

Up to 4 weedings undertaken by hand are common in the study area. In Kyela more than 50% of the farmers weed once where as at Kilombero and Mvomero about 60% reported to weed twice. In Bagamoyo weeding 3 to 4 times is common (Table 9)

Table 9: Weeding times (% farmers)

District	**1**	**2**	**3**	**4**
Kyela	57.6	42.4	0.0	0.0
Bagamoyo	10.5	57.9	26.3	5.3
Mvomero	15.8	63.2	21.1	0.0
Kilombero	0.0	90.0	10.0	0.0
Average	36.3	20.9	20.9	22.0

Time of harvesting depends on whether the variety grown is late or early maturing and also on the time (month) of planting. From the survey conducted in the four districts, farmers in Kilombero and Mvomero, though they plant late, harvest their crop earlier than farmers in Bagamoyo and Kyela districts (Table 10) probably because the majority of the farmers in Kilombero and Bagamoyo use early maturing varieties.

Table 10: Months when rice is harvested (% farmers)

District	**May**	**June**	**July**
Kyela	55	27.5	17.5
Bagamoyo	-	55.6	44.4
Mvomero	-	84.2	15.8
Kilombero	-	90.0	10.0

ln Kyela and Kilombero, about 50% of what is produced is sold while at Mvomero and Bagamoyo, 75% of what is produced is sold (table 11). This suggests that rice is equally an important food and cash crop in Kyela and Kilombero and more of a cash crop in Mvomero and Bagamoyo. Kyela has a diversified farming system with farmers also obtaining some income from the sales of palm oil and cocoa.

Table 11: Amount of rice consumed and sold

District	**Home use (Bags)**	**Sale (Bags)**
Kyela	5.5	4.6
Bagamoyo	1.8	2.2
Mvomero	7.1	14.1
Kilombero	13.6	12.8

4.2 Integrated management of wild rice

4.2.1 Management of *O. longistaminata* in Ifakara and Kyela.

The drought in 2003 limited fieldwork on the management of *O. longistaminata* to on-farm sites in Kyela District. By 21 days after sowing (DAS) application of glyphosate had significantly reduced the number of wild rice shoots ($P<0.001$) while harrowing of the seedbed at planting also contributed to the decrease in shoot number ($P=0.028$) (Table 12). In terms of comparison of treatments with usual farmer practice of sowing rice onto ploughed and harrowed land with one hand weeding at 21 DAS, glyphosate applications with harrowing at planting reduced wild rice shoot number significantly. The high rate of Roundup (4-l ha^{-1}) with no harrowing at planting also significantly reduced wild rice number. All practices reduced wild rice dry weight recorded at harvest compared to farmer practice. There is some evidence that 3l Roundup applied pre-planting resulted in a greater reduction overall ($p=0.055$). Rice grain yield was increased by use of Roundup with harrowing at planting. Overall, harrowing increased yield ($p=0.015$) and 3l Roundup was adequate to produce highest yields ($p=0.045$).

Table 12: Effect of weed management practices on *O. longistaminata* infestation. Wild rice number at 21 days after sowing, dry weight at harvest and rice yield means for 4, 3 and 3 farms respectively in Kyela in 2003. Wild rice counts square root with actual means in brackets.

	Wild rice			Rice yield
Weed management practice	No. m^2		Dry weight (g)	kg ha^{-1}
Farmer practice	6.02	(36.2)	2.4	0.50
Farmer practice + 2, 4-D	5.63	(31.7)	1.60	1.07
Pre-plant glyphosate (3 l ha^{-1})	4.53	(20.5)	0.35	1.50
Pre-plant glyphosate (4 l ha^{-1})	4.11	(16.9)	0.95	0.50
Pre-plant glyphosate (3 l ha^{-1}) + harrow	3.13	(9.8)	0.60	2.25
Pre-plant glyphosate (4 l ha^{-1}) + harrow	2.67	(7.1)	0.90	1.70
SED (all except FP + 2,4-D)	0.85		0.31	0.50
SED (FP + 2,4-D v others)	0.70		0.25	0.41
df	23		16	16

On the basis of these results and farmer comments it was decided to reduce the number of treatments tested in 2004. Harrowing was perceived as important to prevent birds and ducks eating pre-germinated rice seed prior to establishment, while post-emergence applications of 2,4-D reduced the labour needed for in-crop weed control. The effect of glyphosate application on wild rice shoot number was not apparent at 21 DAS. By the time of the second count at 130 DAS however use of the herbicide had led to a significant reduction in weed number compared to either farmer practice ($p<0.05$) or on plots where only a post-emergence application of 2,4-D had been used ($p<0.001$)(Table 13). Improved wild rice control by glyphosate did not effect rice establishment (Table 14) but did result in higher rice grain yield compared to farmer practice ($p>0.001$). A significant effect of the herbicide on wild rice biomass was still evident at harvest, with greater re-growth on non-treated plots.

Table 13: Effect of weed management practices on *O. longistaminata* infestation. Data from 7 and 10 farms in Kyela and Ifakara respectively in 2004. Weed count square root with actual means in brackets.

	Wild rice m^2				Harvest Fresh weight
Practices	**21 DAS**		2^{nd} count (130 DAS)		Kg 10 m^2
Farmer practice	3.88	(15.0)	3.98	(15.8)	4.40
2, 4 – D post-em.	4.01	(16.1)	4.77	(22.7)	5.26
Glyphosate pre-plant	3.65	(13.3)	2.88	(8.3)	2.29
SED (FP v 2,4-D)	0.45		0.45		0.77
SED (2,4-D v FP, Gly	0.37		0.37		0.63
df	66		53		52

Table 14: Effect of *O. longistaminata* management practices on rice plant populations and yield. Data from 7 and 10 farms in Kyela and Ifakara respectively in 2004. Rice counts square root with actual means in brackets.

Practices	Rice m^2		Yield kg ha^{-1}
Farmer practice	8.75	(76.5)	2161
2, 4 – D post-em.	9.01	(81.2)	2859
Glyphosate pre-plant	8.75	(76.5)	3586
SED (FP v 2,4-D)	0.67		398
SED (2,4-D v FP, Gly	0.55		325
df	66		51

4.2.2 Management of *O. punctata* at Dhakawa and Ruvu.

Seven treatments were compared in 2003 but yields were only available from one farm at Dhakawa and three at Ruvu irrigation scheme. No effect on rice yield was observed (Table 15). 2003 was a very dry year (appendix 1) that rice plants in most plots at Ruvu, Dakawa and Kilomero dried out before flowering stage.

Table 15. Effect of seven wild rice management treatments on rice yields. Means for one farm at Dhakawa and three at Ruvu in 2003.

Treatment	Yield kg ha^{-1}
Pre-plant glyphosate (2 l ha^{-1}) + 2-4D	2200
Pre-plant glyphosate (3 l ha^{-1}) + 2-4D	1770
Pre-plant glyphosate (2 l ha^{-1}) + 2-4D + (harrow)	2300
Pre-plant glyphosate (3 l ha^{-1}) + 2-4D+ (harrow)	2400
Farmer practice	2030
Pre-plant glyphosate (2 l ha^{-1}) + 2-4D + (seed drilling)	1930
Pre-plant glyphosate (3 l ha^{-1}) + 2-4D+ (seed drilling)	2020
SED	568
df	18

In 2004 two doses of glyphosate (2 and 3 l ha^{-1} Roundup) were applied to the flush of *O. punctata* seedlings emerging after ploughing following the first rains. The Roundup treatments resulted in significant reductions in wild rice numbers and dry weight (Table 16). The two doses were equally effective.

Table 16. **Effect of two doses of Roundup applied prior to seeding rice on *O. punctata* populations at Dhakawa and Ruvu irrigation schemes (means of four and three farms respectively). Data squares roots with actual means shown in brackets.**

	Wild rice m^2				Wild rice dry	
Treatment	1st count (21 DAS)		2nd count (130 DAS)		weight g m^2	
Farmer practice	3.43	(11.7)	1.75	(3.1)	4.22	(58)
Roundup 2 l ha^{-1}	1.96	(3.8)	0.96	(0.9)	3.35	(19)
Roundup 2 l ha^{-1}	1.67	(2.8)	0.80	(0.6)	3.24	(16)
SED	0.53		0.18		0.21	
df	12		11		11	

Rice stands established after use of Roundup were considerably higher than those on plots where farmer practice had been used although these differences were not significant (Table 17). Yields were however significantly higher on plots treated with the higher rate (3 l ha^{-1}) of herbicide (p=0.018).

Table 17. Effect of two doses of Roundup applied to prior to *O. punctata* on subsequent rice populations and grain yields at Dhakawa and Ruvu irrigation schemes (means of four and three farms respectively).

Treatment	Rice no. m^2	Grain yield kg ha^{-1}
Farmer practice	47.7	4909
Roundup 2 l ha^{-1}	74.1	5055
Roundup 2 l ha^{-1}	71.3	5921
SED	13.6	318
df	12	11

Output 3 & 4: Technologies and decision tools verified for control of *O. longistaminata and* O*. punctata; Extension materials prepared and disseminated*

4.3 Benefits of using glyphosate:

The cost of rice production, including the costs of land preparation, harrowing, planting, weeding, fertilizers, harvesting and transportation were calculated for each district during the workshops held in 2004. Rice market prices offered in each district that year were used. In all the districts, the cost benefit ratio was higher where glyphosate was used

than the farmers practice. Tables 18- 21 show the cost benefit ratios attained from each district.

Table 18: Economics analysis on the use of glyphosate for control of *O. punctata* in Bagamoyo (Ruvu) District

Treatment	Number of bags/ha	Cost of production (Tsh.)	Revenue (Tsh.)	Profit/loss (Tsh.)	Cost benefit ratio
Farmer practice	52.5	354000	1575000	1221000	3.45
2 l/ha pre-emergence glyphosate + 2-4D	62.5	353000	1875000	1522000	4.31
3 l/ha ha pre-emergence glyphosate + 2-4D	72.5	367000	2175000	1808000	4.93

* One bag sold at 30,000/= Tanzanian shillings

Table 19: The economics analysis on the use of glyphosate for control of *O. punctata* in Mvomero (Dakawa) District

Treatment	Number of bags/ha	Cost of production (Tsh.)	Revenue (Tsh.)	Profit/loss (Tsh.)	Cost benefit ratio
Farmer practice	32.5	358000	975000	617000	1.72
2 l/ha pre-emergence glyphosate + 2-4D	45	391000	1350000	959000	2.45
3 l/ha ha pre-emergence glyphosate + 2-4D	57.5	405000	1725000	1320000	3.26

* One bag sold at 30,000/= Tanzanian shillings

Table 20: The economics analysis on the use of glyphosate for control of *O. longistaminata* in Kilombero District

Treatment	Number of bags/ha	Cost of production (Tsh.)	Revenue (Tsh.)	Profit/loss (Tsh.)	Cost benefit ratio
Farmer practice	22.5	323000	675000	352000	1.09
Post emergence 2-4D	25	329000	750000	421000	1.28
4 l/ha pre-plant glyphosate + 2-4D	32.5	342000	975000	633000	1.85

* One bag sold at 28,000/= Tanzanian shillings

Table 21: The economic analysis on the use of glyphosate for control of *O. longistaminata* in Kyela District

Treatment	Number of bags/ha	Cost of production (Tsh.)	Revenue (Tsh.)	Profit/loss (Tsh.)	Cost benefit ratio
Farmer practice	25	457500	750000	292500	0.64
Post emergence 2-4D	32.5	377500	975000	597500	1.58
4 l/ha pre-plant glyphosate + 2-4D	45	242500	1350000	1107500	4.57

* One bag sold at 23,000/= Tanzanian shillings

On the basis of discussions held during the field days and from the workshops, glyphosate treatment at 3 l/ha for the control of *O. punctata* at Ruvu and Dakawa and the 4 l/ha for the control of *O. longistaminata* at Kyela and Kilombero were selected by farmers. Participants from the research groups indicated that, plots, which received glyphosate, reduced the workload of weeding since it required 50% less time to weed compared to plots not treated with glyphosate. Photographs of O. punctata and O. longistaminata are shown on appendix 4.

4.3 Dissemination of technologies developed

Seven farmer-research groups, with a membership from 128 households undertook demonstration trials on 32 wild rice infested farms. Participatory evaluation during field days and sensitization workshops involved more than 230 rice producers from seven villages within the project areas. Farmers identified the use of glyphosate before planting at the rate of 3 litres/ha for the control of annual wild rice (*O. punctata* on irrigated land) and 4 litres/ha for the control of perennial wild rice (*O. longistaminata* on rain-fed fields) as the best options for the management of these weeds. Post-emergence application of 2-4D at 21 days after germination was favoured to reduce labour inputs for in-crop weed control. Partial budget analysis undertaken with growers, district agricultural extension staff, village chairmen and ward executive officers demonstrated on the benefit of improving wild rice management. Income from rice production could be increased from a cost benefit ration of less than one (0.64) to 2.94 for farmers in Kyela, 3.25 for Dakawa and 4.93 for Ruvu farmers when glyphosate was used.

Significant increase in yield of more than 4t/ha over control have been achieved using glyphosate before planting and 2-4D at 21 days after crop emergence and has formed an added incentive to technology adoption. Group members from Michenga and Lumemo villages in Kilombero set up, in addition to the experimental fields, demonstration plots on their own field to enable other farmers in the district copy the technology they have acquired. Due to involvement of different rice production stakeholders in seminars and field days, and following the deputy Minister for Agriculture visit to one of the trial sites, the supply of glyphosate has increased tremendously. More than 3500 litres of glyphosate have been purchased between November 2004 to February 2005 in areas where the project has been operating compared to less than 500 litres in 2003.

Lead farmers and extension workers were trained at the Kilimanjaro Agricultural Training Center. 30 rice cultivation manuals on rice production were provided to participants and seven videocassettes on improved rice cultivation methods were given to agricultural extension staff from participating villages. These have been useful tools for creating awareness to participating and non-participating farmers on current methodologies of rice production.

Project results and lessons learnt with demonstration farmers have been incorporated into two learning tools. These are a leaflet and a poster that provide knowledge on how to manage wild rice species effectively (See Annex 1 & 2). 3000 leaflets have been produced and 2400 have already been distributed to farmers and district extension staff in target and none targets villages. 1500 posters have been produced out of which 1000 have been distributed. The rest of the leaflets and posters will be

distributed during this years' National Agricultural Show to be held in Morogoro in August 2005

5. Contribution of Outputs to Project Goal

The project has demonstrated with farmers that wild rice control will enhance sustainability of the floodplain rice production systems. Application of glyphosate to wild rice regrowth 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. Results from the project provide district council extension managers with an opportunity to consider how to incorporate wild rice management issues into future extension programmes.

5.1 How will outputs be made available to intended users?

Most lowland rice farmers currently use little or no fertiliser or manure and the majority use the photosensitive late maturing (160-170 days) tall cultivar Super India. This responds poorly under intensive and high input management. When the rains end early there is risk of terminal drought with long duration cultivars. A new lowland rice cultivar TXD 306 (SARO 5), developed in Tanzania, is rapidly becoming popular in Kilombero as it is aromatic (a trait demanded by the market in Tanzania) and high yielding. This non-photoperiod sensitive cultivar with maturity of 130 days is however, a semi-dwarf that is less competitive with wild rice than the traditional types currently grown. TDX 360 therefore needs relatively good weed management and good water conditions. Farmers have therefore proposed concentrating on production of TXD 306 on fertile areas of the flood plain where water is deepest, by taking advantage of wild rice suppression by using glyphosate. CPP has now agreed to support the promotion of wild rice management practices in Tanzania for a further 10 months during 2005/06. During the 2004 season farmers groups will be facilitated to utilise the fertilizer-responsive, high yielding rice variety under conditions of good soil fertility to increase the efficiency and utilization of glyphosate.

At Ruvu and Dakawa rice farms there is insufficient irrigation water available to maintain flooded conditions across either scheme (total 3000 ha). As the water level falls after transplanting *O. punctata* germinates. To overcome dense populations of wild rice farmers have recently tried switching from direct seeding to transplanting but find the puddling operation very expensive. An alternative for these sites is to plough/harrow in January (ahead of rain) as at present, wait for wild rice and other weeds to grow after early showers, and then spray-off with glyphosate. Rice can then be transplanted when either rainwater accumulates or irrigation is available. One application of glyphosate costs TSh. 15,000 per acre compared to Tsh. 25,000 for hiring a rotavator to puddle the soil. The project extension will allow this alternative method of transplanting to be evaluated.

These additional activities will be undertaken through farmer groups in collaboration with district extension. The District Agricultural Extension (DAE) service is the primary vehicle for promotion of agricultural technologies in the target areas proposed for the project.

DAE staff are located in the district council offices and form part of the district teams in Tanzania. DAE assist with the promotion of technologies to a wide group of farmers through a range of village, district activities and the National Agricultural Shows (Nane Nane Show). By working with and training district agricultural teams the project has and will continue to collaborate with the institution that has the mandate to take forward promotion of agricultural technology in the future. Districts are to take on greater responsibility for targeting extension activities under the national Agricultural Sector Development Programme, due to begin in September 2005. During the 2005 project extension the research team will work with district teams in target area to develop strategies for future promotion of wild rice management to be put forward for inclusion in district council annual budgets. During the project extension a training of trainers manual on improved management methods, including the use of high yielding varieties, fertilizers, crop establishment methods and the use of glyphosate will be produced for training of extension officers. Further copies of these information resources will be printed and made available to the extension service and the Kilimanjaro Agricultural Training Centre (KATC) in Moshi, a principle institution for training DAE and farmers in rice cultivation.

5.2 Other Dissemination of Results:

NATURAL RESOURCES INTERNATIONAL (2004) Integrated management of wild rice *O. longistaminata* and *O. punctata* in Tanzania. 3000 copies. Natural Resources International Limited (NRIL), Chatham Maritime, Kent, UK. [Leaflet] [Field] [Swahili]
2400 have already been distributed to farmers and district extension staff in target and none target villages

NATURAL RESOURCES INTERNATIONAL (2004) The management of wild rice in rice fields. 1500 copies. Natural Resources International Limited (NRIL), Chatham Maritime, Kent, UK. [Poster] [Field] [Swahili] 1000 have been distributed. The rest of the leaflets and posters will be distributed during this years' National Agricultural Show to be held in Morogoro in August 2005

MBAPILA, J.C., RICHES, C. and PYUZA, A. G. (2003). Irrigated Rice Production Techniques for Farmers' Leaders. Kilimanjaro Agricultural Training Centre, Moshi, Tanzania 22nd September –3rd October 2003 [Training course for 22 farmers and 7 extension staff from Kyela, Dakawa, Ruvu and Kilombero districts] [Swahili]

MBAPILA, J.C., PYUZA, A. G. and D. Uhwelo (2003). Rice Production Techniques. 20 minutes. 7 copies to Agricultural extension Officers. Kilimanjaro Agricultural Training Centre Extension Unit. [Videocassette] [Swahili)

MBAPILA, J.C., RICHES, C., HELLA, J.P. and MTWAENZI, H.M. (2003). MBAPILA, J.C., RICHES, C., HELLA, J.P. and MTWAENZI, H.M. (2003). Rice Production and the use of Logical Framework as a tool in Projects: A Sensitisation Workshop on Rice Production to District Stakeholders. September 2003 (One-day workshop for each districts of Mvomero, Kilombero and Kyela for 64 stakeholders [Swahili]

6. Acknowledgement:
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7. References:

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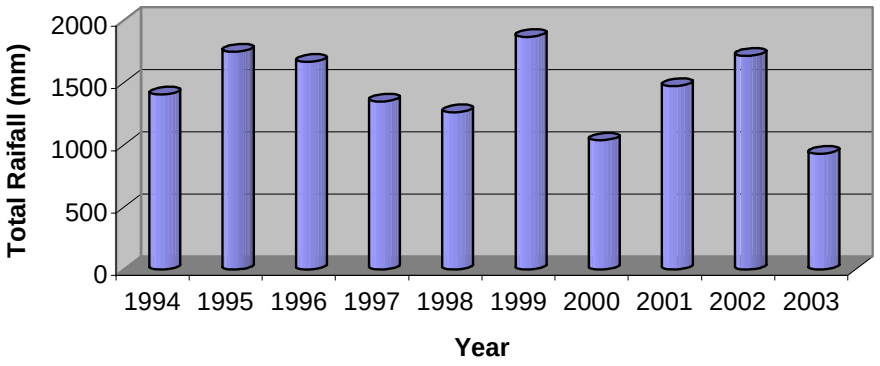
Matthews, G.A., Mumford, J.D. and Price, C.E. (1994). Survey to assess methods for improving herbicide use in developing countries. Report of project X0255, Silwood Pest Management, imperial College, Berkshire, 88 p.

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.

Appendix 1: Ten years (1994-2003) total rainfall recorded at KATRIN, Ifakara, Kilombero District



Appendix 2: Field days, Workshops and training in herbicide application in photographs

Field day participants, Kyela

Field day participants, Kyela

Workshop participants, Dakawa- Dihombo

Workshop participants, Kilombero

Workshop participants, Kyela

Training farmers in the field on herbicide calibration and application

Appendix 3: Activities performed by course participants during training at KATC Moshi

Opening sessions

Problem identifications

Seed selection

Theory class

Bund making

Leveling using water and simple farm tools

Seed sowing in wet nursery beds

Preparation of seedlings before transplanting

Line transplanting

Weeding by hand push weeder

Participatory Learning and Action sessions (PLA)

Direct observation during field visit

Group Discussions

Participant are conferred with Certificate of attendance by guest of honour

Closing remarks by Guest of honour

Appendix 4: Wild rice *O. punctata* and *O. longistaminata* at flowering stage

Wild rice *O. punctata*

Wild rice *O. longisataminata*