CROP PROTECTION PROGRAMME

Extending the control of cassava mosaic disease and cassava whiteflies in East Africa

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Executive Summary

The project has addressed the need to disseminate knowledge on how to control cassava mosaic disease (CMD) in NW Tanzania, in part as a testing and learning exercise as well a means of alleviating the current hardship caused by the CMD pandemic there. The project has continued its previous approach of working closely with other actors in development, particularly NGOs, the project providing staff time, training materials and starter amounts of planting material of CMD-resistant varieties so as to enable their extension staff to assist farmers. This has allowed an expansion of geographical coverage to include parts of Kigoma region as well as Kagera. In addition to leaflets describing control measures, small numbers of an in-depth guide for extension officers have been produced and distributed. The main control measure remains the use of CMD-resistant varieties. The project has also worked directly with farmer field schools, providing additional training and final graduation. An impact assessment has been done in the communities, in which these schools occur, assessing impact on both members and non-members. Members had better knowledge of CMD than non-members and more frequently put appropriate control practices into practices, but there were still considerable shortages of planting material of resistant varieties. Some non-members also felt excluded from membership of the group; that this occurred seemed an issue that needs addressing.

The project also addressed the problem of the whitefly vector of CMD, *Bemisia tabaci*, being a few orders of magnitude more abundant during and after the spread of the CMD pandemic. Whiteflies have become a direct pest, the adults and nymphs draining plants of sap and causing the development of sooty molds on leaves smothered by the sugary excreta. The project has addressed this problem by testing more comprehensively whitefly resistance already identified in African germplasm, using multilocational and replicated field trials. These have confirmed the resistance. The project has also imported cassava germplasm from the Americas which has been selected for resistance to another whitefly species; results testing for resistance to *B. tabaci* in Uganda look promising.

The project also initiated the identification of an epidemic of *Cassava brown streak virus* in Uganda, a potential outcome which was a basis for the focus on developing whitefly-resistant cassava. It has also disseminated project outcomes through 13 scientific papers plus presentations at scientific meetings.

Background

A pandemic of cassava mosaic disease (CMD) caused by whitefly-borne geminiviruses swept through Uganda in the 1990s, invaded other East and Central African countries including Kenya, the Lake Zone of Tanzania, Rwanda, Burundi and D.R. Congo and now threatens West Africa. Its dynamics were researched by R7505 and earlier projects and a full background is provided in their Final Technical Reports. The pandemic is associated with the presence of a natural recombinant between *African cassava mosaic virus* (ACMV) and *East African cassava mosaic virus* (EACMV): this has been named EACMV-UG. This recombinant may be more readily transmitted by whiteflies and, although isolates with a spectrum of severities has developed, is generally more severe (Plate 1) than ACMV, especially when the two co-infect.

Plate 1. A susceptible landrace (Ebwana Teraka) of cassava showing the severe symptoms developed when infected with EACMV-Ug. In the background is a CMD-resistant variety.

CMD-resistant cassava varieties (Plate 1), mostly with parentage derived from crosses made by the International Institute of Tropical Agriculture (IITA), have been developed and released in Uganda by the Ugandan Cassava Programme. Several of these together with other resistant clones have also been released in Tanzania. Strategies involving cultural and phytosanitary controls and based on knowledge of the epidemiology of cassava mosaic geminiviruses (CMGs) and CMD-resistant varieties have also been developed as part of a collaboration amongst the Ugandan National Cassava Programme (UHCP) based at Namulonge Research Institute (NAARI), the Tanzanian Root Crops Programme (TRCP), particularly staff based at ARI-Maruku and the UK-based Natural Resources Institute (NRI). The benefits of modern CMD-resistant varieties and cultural and phytosanitary controls have been described in a brochure in Luo, English and Swahili developed by R8303 and based largely on knowledge developed by R7505. Associated with the much later arrival of the pandemic in Tanzania, dissemination of resistant varieties and farmer training began more recently there and the need remained urgent there. Various actors are/have been involved in this; the now-completed Kagera Agricultural and Environmental Management Project (KAEMP), the USAID-funded regional CMD mitigation project lead by IITA and the Norwegian People's Aid (NPA). The Lake Zone Agricultural Research and Development Institute (LZARDI) has multiplied millions of cuttings of CMD resistant varieties throughout the Lake (Victoria) Zone through the support of OFDA-IITA CMD mitigation project. Significant support has also been received in Ngara and Mukeba districts from NPA. Links with NPA, KAEMP, the FAO FSS [Farmer Field School] programme in Kagera and government extension has allowed ARI Maruku to provide 'training of trainers' (TOTs) on CMD control to Ministry and NGO extensionists.

Plate 2. Large whitefly populations colonizing the young leaves of a cassava plant growing in the field in Uganda

An integral part of the CMD pandemic has been a 10 – 100-fold increase in populations of cassava whiteflies, *Bemisia tabaci,* which has been a key factor in the continued rapid spread of CMD and consequent expansion of the pandemic (Colvin *et al*., 2004). New CMGs seem to be generated relatively quickly by different virus species naturally recombining when co-infecting in a plant and there is concern that these large populations of a virus vector may facilitate the survival and spread of yet more natural recombinants, some of which may be even more damaging than EACMV-UG. There are also unrelated non-geminate viruses which are spread by whiteflies and can infect cassava including, in Africa, *Cassava brown streak virus* (CBSV). This pathogen which can cause very severe necrosis to cassava storage roots to the extent they may be uneatable, currently has a geographically restricted range and the large populations of whiteflies associated with the pandemic may provide a means by which this could be extended. In addition to transmitting plant pathogenic viruses, these large *B. tabaci* populations have also become a problem in their own right and a threat to the CMV-resistant varieties. *B. tabaci* populations in Uganda have been shown to cause yield losses of up to 50% by direct feeding damage (Legg *et al*., 2004; Omongo *et al*., 2004) reported in the FTR for R8303. This has led to demands by farmers for appropriate control methods and also to concerns that the plant symptoms associated with these large whitefly populations may be caused by yet another disease about to devastate their crops. Indeed, farmers have adopted the term 'black mosaic' to describe the sooty mould which often covers the leaves of affected plants, unaware that this is caused by fungi growing on the 'drizzle' of honeydew from the whitefly adults and nymphs.

Plate 3. Black sooty mould covering the lower leaves of a cassava plant supporting large whitefly populations.

R8303 identified whitefly resistance in landraces and clones in national advanced and uniform yield trials (AYT & UYT) in Uganda (Omongo *et al*., 2004). MM96/4271 and MM96/0686 supported few whiteflies and whitefly nymphs in UYT and were also chosen by farmers and scientists using other criteria. These clones needed be tested in on-farm multi-locational trials as a last step prior to release. Cassava clones found by CIAT to be highly resistant to the whitefly *Aleurotrachelus socialis* in S America have also been found at NRI to be partially resistant to African *B. tabaci*. Since cassava originated in the Americas, it seems likely that these could provide a different source of resistance to the Ugandan sources. Colleagues at IITA-ESARC are also working on the role of predators and parasitoids in the control of whiteflies including means of enhancing it, with the aim of adopting cultural methods to enhance their effect.

J. Colvin, C.A. Omongo, M.N. Maruthi, G.W. Otim-Nape & J.M. Thresh (2004) Dual begomovirus infections and high *Bemisia tabaci* populations: two factors that drive the spread of a cassava mosaic disease pandemic. *Plant Pathology*, in press

J.P. Legg, P. Sseruwagi & J. Brown. 2004. *Bemisia* whiteflies cause physical damage and yield losses to cassava in Africa. *6th Intrtl. Sci. Meeting Cassava Biotechnology Network (Abstr.)* p65.

C.A. Omongo, J. Colvin, W. Sserubombwe, T. Alicai, Y. Baguma, A. Bua, J.P. Legg & R.W. Gibson 2004. Host plant resistance to African *Bemisia tabaci* in local landraces and improved cassava mosaic disease resistant genotypes in Uganda**.** *6th Intntl. Sci. Meeting Cassava Biotechnology Network (Abstr.),* p84.

T Alicai, A Bua, GW Otim-Nape, YK Baguma, GN Ssemakula, W Sserubobwe, CA Omongo, D Akullo, S Tumwesigye & M Apok. 2003. Research and development strategies for controlling cassava mosaic disease and enhancing the competitiveness of cassava in Uganda. *Symp. Intntl. Soc. Tropical Root Crops (Abstr.)*

CA Omongo, J Colvin, T Alicai, W Sserubombwe, JP Legg & GW Otim-Nape. 2003. Host selection by *Bemisia tabaci* of CMD-symptomatic and non-symptomatic cassava plants. *Symp. Intntl. Soc. Tropical Root Crops (Abstr.)*

Purpose

The project had two main purposes:

1. To continue the dissemination of knowledge on how to control the CMD pandemic including the use of CMD-resistant cassava varieties in north-west Tanzania.
2. To validate whitefly-resistant cassava clones already identified amongst African germplasm and to continue the search for sources of resistance to whiteflies in exotic germplasm.

Research Activities

There were two main activity streams, the geographical distribution of which were driven by the fact that the CMD pandemic affected Uganda some 10 – 15 yrs ago whilst it has only recently affected Tanzania and only in the Lake Zone. Consequently, there is a continued need to disseminate knowledge and assistance to farmers on how to control the devastating effects of the pandemic in the affected areas of Tanzania. In Uganda, most farmers were therefore well aware of the cause of the pandemic and the dissemination of control measures including the distribution of CMD-resistant varieties was already in the hands of the Cassava Programme. Controlling the CMD there has however led to an appreciation that raised levels of whiteflies persist and may even be rising even higher. They were affecting cassava yields and the sooty molds on the cassava foliage was itself causing concern amongst farmers. There were also longterm concerns amongst scientists that the raised levels of whiteflies threatened further evolution and spread of whitefly-borne viruses, leading the Ugandan National Cassava Programme placing a high priority on the initiation of research seeking to control them. During the course of the project, these fears were justified by the occurrence of CBSV in Uganda.

Activity 1. Dissemination of training and training materials on the control of CMD

Provide technical know-how to NGOs and government institutions funded by NPA and other donors on which cassava varieties resistant to CMD are appropriate for the locality to multiply and how best to do this to achieve large quantities of disease-free planting material for distribution and providing training in how to control CMD to TOTs.

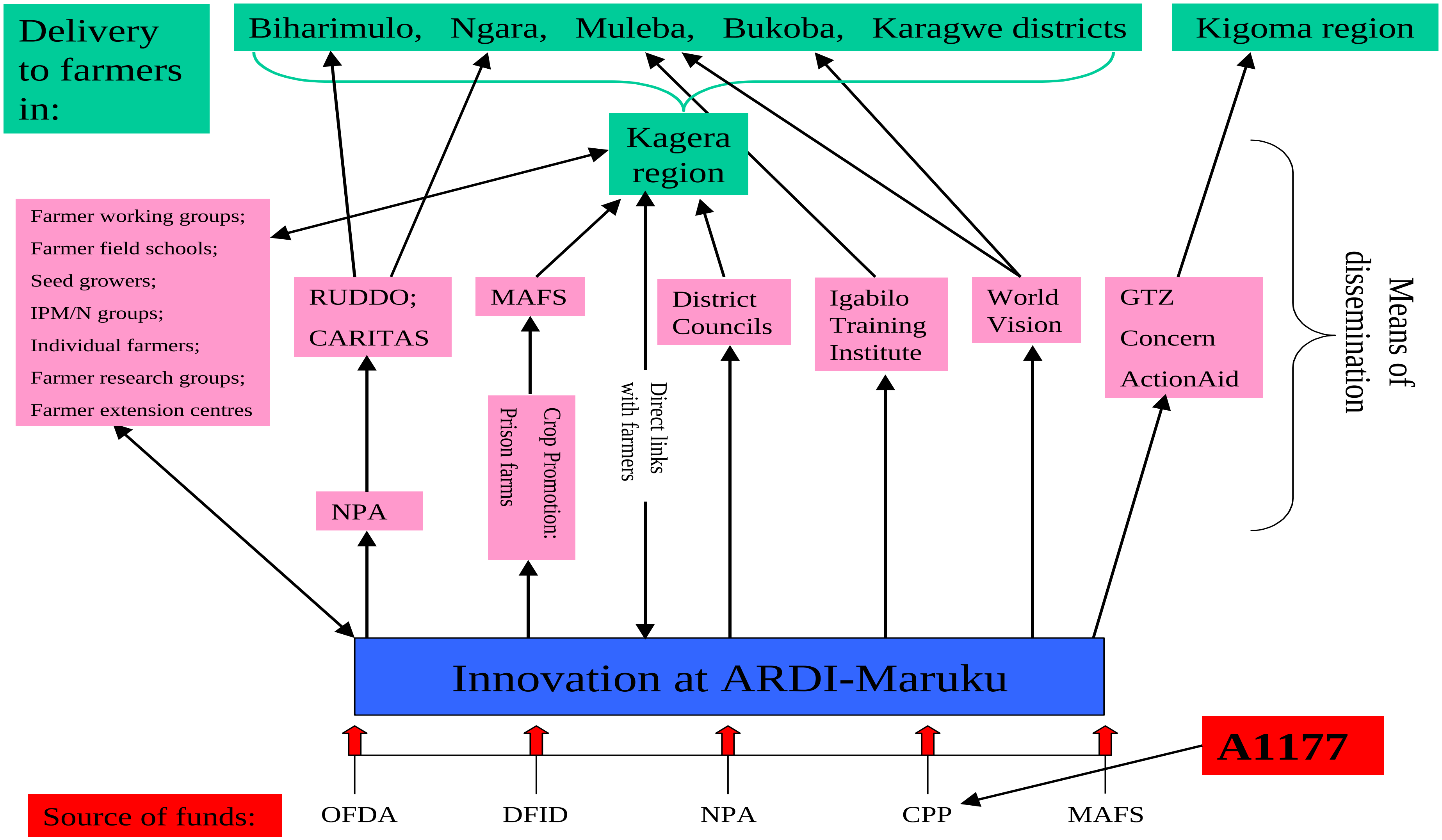
Maruku Agricultural Research Institute is the main centre for agricultural knowledge generation in Kagera region, in the northwestern Tanzania. CPP is one of several funding agencies supporting the Root and Tuber Programme at ARI Maruku to work on the mitigation of CMD pandemic, each supporting different research and technology transfer activities in the region. The information generated is also communicated to farmers through a variety of channels, many with their own funding. In this manner, the impact of previous project achievements was extended in a very cost-effective manner. This strategy of working closely with other regional actors in development had been found to be particularly effective during the previous phase of the project particularly in the Kagera Region of Tanzania and builds on the previously approach developed in Uganda, though with even greater reliance on the inputs of regional partners. This approach was expanded still further in this extension by project partners at ARDI-Maruku in Tanzania. The range of NGOs involved and the areas involved are shown in Figure 1: in particular there has been an expansion into Kigoma Region.

The support given by NRI/CCP project enabled Maruku Research Institute to strengthen its linkage with other agricultural stakeholders inside and outside the region. Several training and multiplication activities were conducted to extension officers and link farmers working with different NGOs and government institutions in the region. Institutions included Action Aid in Kigoma and Kibondo districts, GTZ in Kigoma and Kasulu districts and NPA in Ngara district and extension personnel working with the ministry of internal affairs (prisons) and training included the principles of cassava production, disease management and cassava planting materials multiplication techniques. Links between researchers and district agricultural offices were strengthened, aiming to stabilise cassava production by boosting the use of phytosanitation and CMD-resistant varieties. Researchers from Maruku continued to support Farmer Field School (FFS) groups established in Bukoba and Muleba districts, aiming to scale up dissemination of already developed technologies to other farmers in the locality. As an incentive to increase cassava production and stimulant for adoption of improved cassava varieties especially those resistant to CMD, training was also done on cassava post harvest technologies with FFS groups in the project working areas in both districts. A few non group members were also involve in this training as a strategy to facilitate knowledge transfer from group to non-group members in the community.

Brochures already prepared by R8303 were distributed and a more comprehensive extension guide developed. FFS members also graduated and received certificates for qualifying as FFS training on cassava production.

As a final project activity, an the impact study was conducted in all working areas during the last three weeks of December 2005 to investigate the impact of the project on the knowledge on disease (CMD), its management, impact on the livelihood of people living in the project area and to identify the gap existing between group member and non group members within the same area. A pre-prepared and pre-tested questionnaire and checklist were used for farmers' interview and discussion with group and non-group members respectively. All group members attended the discussion but only ten members were interviewed. At least ten non-group members were randomly selected from all villages where group were located and they also attended group discussion in a separate group.

Fig. 1. ARDI-Maruku strategy for developing and disseminating knowledge and resistant varieties to address need for control of CMD in north-west Tanzania



Activity 2. Deployment of whitefly resistance

2.1 Establish an additional on-farm trial of pre-release cassava clones (which will include whitefly-resistant clones) in Wakiso district (high whitefly prevalence area) in Uganda and monitor numbers of whitefly adults and nymphs at this and two other on-farm multi-locational sites monthly. Involve local farmers closely in clonal assessments.

2.2 Analyse data obtained in 2.1 for whitefly-resistant clones examining G x E interactions between sites.

Three genotypes- MM96/0686, Nase 12 -161(8) and MM96/4271, previously identified as poorly colonized by whitefly from the varietal development scheme run by the Ugandan Cassava Programme, were identified for validation for resistance to whiteflies. The genotypes were planted in May 2005 in three trial sites, namely Mukono Agricultural Research and Development Centre (ARDC), Namulonge Agricultural and Animal Production Research Institute (NAARI) and Serere Agricultural and Animal Production Research Institute (SAARI). NAARI and Mukono ARDC, both located in central Uganda, were considered, from their track records to be "hot spots" for whiteflies whilst whiteflies are usually less common at SAARI. Two whitefly susceptible cultivars (Nase 12 and TME 204) and a resistant one (Nase 9) were included in the trial. The experimental set up was a randomized complete block design (RCBD) with three replications. Each plot was 7 x 6m, giving 56 plants per plot.

Whitefly adults were counted on the top 5 leaves on 20 plants randomly selected per plot and nymph population was obtained from the 14th leaf of all the 20 plants where adults were counted. Scores of levels of feeding damage (scale 1-6; 1= no damage, 6= very severe damage leaf fall) and sooty moulds (scale 1-5; 1= no soot on canopy; 5= > 75% canopy covered in soot) on the leaves were also taken. Data were taken monthly starting two month after planting (MAP) for four consecutive months. Repeated measures analyses of whitefly populations were done using GENSTAT (5th Edition). The trial at NAARI was discontinued after destruction by heavy hailstorm 3 MAP and cultivar Nase 12 and TME 204 at SAARI were discovered with cassava brown streak symptoms during the first record taking and were therefore rogued out.

2.3.1 Whitefly-resistant cassava genotypes that originated from CIAT will be sent by NRI to NAARI. These genotypes will be planted in plots in an area isolated from CMD-infected cassava. Half the number of plants will be sprayed regularly to prevent CMD infection and the other half will be used to monitor the populations of B. tabaci present. Nase 9, a relatively B. tabaci-resistant genotype, will be used as the local check.

2.3.2 The preference of B. tabaci for the whitefly-resistant neo-tropical genotypes will be assessed and compared to local genotypes in the screenhouse using virus free whiteflies.

A CIAT clone, Ecu 72, that had been found by CIAT to be resistant to *A. socialis* whiteflies and against a colony of African cassava whitefly, *Bemisia tabaci* in very restricted laboratory tests at NRI were sent to Uganda for further evaluation by NRI along with a Colombian check variety. Eighty tubes of tissue culture plantlets (40 for each clone) were received in June 2005 from NRI. The materials were first kept in the tissue culture laboratory at NAARI for 14 days to acclimatize and later transferred to a humidity chamber to harden before use. Although the plantlets were stressed, 24 of them (12 per clone) established well and could be used. 18 of these were planted directly in the screenhouse to establish hard wood for future use and 9 were potted for oviposition studies (Plate 4).

Plate 4a. Ecu 72 and “Colombian” planted in screenhouse at NAARI

Plate 4b. Ecu 72 and “Colombian” planted in buckets at NAARI

Newly emerged adult females were singly clip-caged on the leaf of Ecu 72 and Colombian and allowed to oviposit (Plate 5). The caged female was shifted from one leaflet to another after every 48 h until death or escape occurred. A replacement was made in the event of death or escape but starting on a new leaflet. The number of eggs laid were counted and recorded each time the cage was shifted.

Fig.5. Mr. Odongo James, a technician at NAARI explains to Dr. John Colvin (NRI) the process of using clip cages in whitefly developmental studies.

2.4 Prepare a brochure describing whitefly adults and nymphs and the damage they cause to cassava including sooty mould. The brochure to include colour photos and to be available in English, Luganda and Swahili.

Outputs

1. Dissemination of training and training materials on the control of CMD
Ministry and NGO extensionists in the Lake Zone of Tanzania trained in the multiplication and dissemination of planting material of CMD-resistant cassava varieties and TOT extensionists trained in the use of these varieties and other control measures to counter the CMD pandemic there.

Linkages with other agricultural stakeholders inside and outside the region were strengthened (Fig. 1). Training in CMD control and multiplication of CMD-resistant varieties were conducted with extension officers and link farmers working with different NGOs and government institutions in the region. These included Action Aid in Kigoma and Kibondo districts, GTZ in Kigoma and Kasulu districts and NPA in Ngara district and extension personnel working with the ministry of internal affairs (prisons). More that 300,000 cassava cutting were distributed to Kigoma, Kibondo and Kasulu district, each district received 100,000 cuttings of different varieties as part of a collaboration with GTZ. CPP support also facilitated the broad activities of the Root and Tuber Programme scientists at ARI Maruku by achieving reliable transport, the vehicle bought by OFDA project being maintained partly by funds from CCP project.

Researchers from Maruku continued to support FFS groups established in Bukoba and Muleba districts. This was initiated during the past phases of the project, and therefore the goal of the project during this phase was to scale up dissemination of already developed technologies to other farmers in the locality. Also to distribute planting materials to other far areas especially those working in the recently CMD affected and highly threatened areas. Training in postharvest technologies was also included as a necessary component of boosting cassava production.

Table 1. The numbers and gender of trainees attended the training at five training sites.

Site	Men	Women	*Total*
Kyaka	14	12	26
Ngenge	19	8	27
Kyema and Kanazi	9	15	24
Kanyigo	1	18	19
Mushozi	4	12	16
Total	47	65	112

More than 3,000 leaflets on cassava mosaic disease identification and management techniques had already been produced and a more limited number of extension guides for TOTs giving a deeper explanation of how control strategies work covering all aspects on cassava production, cassava FFS approach and CMD management has been produced for distribution to different agricultural stakeholders in the region in the current phase (see frontispiece on following page). This guide also covers the control of sweet potato viruses: this was appropriate given their common vector, the frequent association of the two crops and that several of the control practices are also common. The electronic copies of both the leaflet and the guide are kept at ARI Maruku for further improvement and production of more hard copies were needed by potential stakeholders who may request at any moment.

Figure 2. Frontispiece of the TOT guide

KILIMO CHA ZAO LA MHOGO NA VIAZI

UWEZESHAJI WAKULIMA, UDHIBITI WADUDU NA MAGONJWA NA UKUSANYAJI NA MATUMIZI YA TAKWIMU

MAFUNZO KWA WATAFITI, WAGHANI NA WAKULIMA

Kimeandaliwa na:
G. M. Rwegasira na E. F. Marandu

Kitengo cha mazao ya mizizi
ARDI Maruku
P.O Box 127 Bukoba
Tanzania

Kwa Msaada wa IITA/CPP/NRI

At the end of the 3 year FFS course, group members graduated and received the certificates for qualifying as FFS training on cassava production.

Table 2. FFS graduation participants

Site	Group members		Others		Total
	Men	Women	Men	Women	
Kyema	2	9	4	16	29
Kanyigo	0	27	6	4	37
Ngenge	12	8	25	32	77
Mushozi	14	5	5	4	28
Kyaka	2	4	17	10	33
Total	30	53	57	66	206

It is anticipated that FFS group members will be able to train other farmers using different informal meetings conducted in the area and neighboring villages. Farmers once they graduate they are responsible to disseminate the knowledge they got from training to other farmers in the village and neighboring villages.

Project impact assessment survey

FFS group members generally appeared to have a much higher awareness of CMD, its causes and how to control it (Table 3). Perhaps most noticeable was their better knowledge of its causes, consequent selection of disease-free planting material and their knowledge and use of CMD-resistant varieties

Table 3. Percentage of group and non-group member's responses on the CMD and management practices during impact survey in Bukoba and Muleba district.

Item assessed	% group members (N=130)		% non-group members (N=130)	
	Yes	No	Yes	No
Know CMD symptoms	100	0	87.7	12.3
Know CMD causes	59.4	40.6	18.2	81.8
Mentioned stunted growth as CMD symptoms	60.3	39.7	34.8	65.2
Mentioned curling of leaves as CMD symptoms	81.3	18.8	59.1	40.9
Mentioned roguing as action for to reduce CMD incidence	98.4	1.6	92.4	7.6
Mentioned selection as action to reduce CMD incidence in the field	64.1	35.9	33.3	66.7
Mentioned use of resistant varieties as action to control CMD	48.4	51.6	12.1	87.9
The use roguing to control CMD in their fields	100	0	93.8	6.3
Use selection to control CMD in their fields	57.8	42.2	25.0	75.0
Use resistant varieties to control CMD in their fields	23.4	76.6	3.1	96.9

Despite belonging to a group associated with ARI-Maruku, most FFS group members said planting materials for resistant materials is still a problem to them (Figure 3). Only small amounts of these new varieties are available in multiplication plots, implying there is still a need to accelerate multiplication of CMD-resistant varieties.

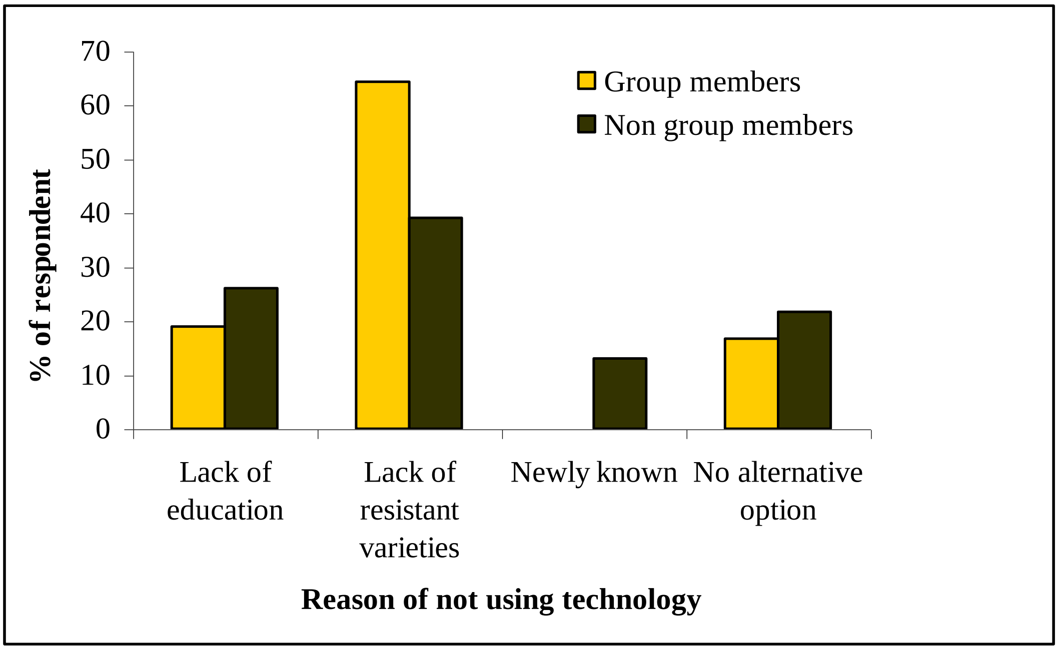


Figure 3. Reasons given by respondents and percentage of respondent (%) on why farmers do not use the mentioned disease control options.

In principle, technologies developed by researchers in Tanzania are distributed to farmers through extension systems. However, the FFS groups had been set up partly as a learning process for researchers. Not surprisingly therefore, many group members highlighted this source of information. Otherwise, they and other farmers learnt mainly from other farmers who were neighbours or friends (Fig. 4).

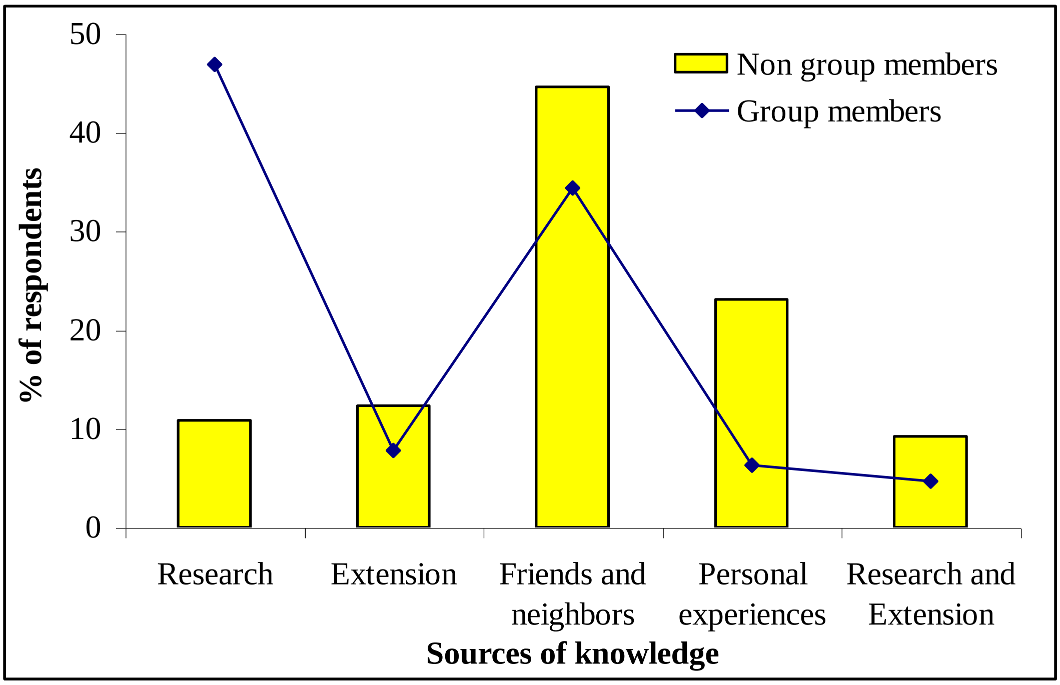


Figure 4. The institutions mentioned by farmers as their major sources of agricultural technologies in Bukoba and Muleba districts.

Both local and resistant cassava varieties were mentioned during interviews as being grown (Table 4): associated with the lack of planting materials of resistant varieties in many areas, farmers were generally still growing local varieties. In areas like Ngenge and Kyema, farmers are multiplying CMD-resistant cassava varieties in a plot managed by the group. At Kanazi and Kyaka, the materials raised in the group nursery had been sold and the money divided among group members; further materials will be will be planted in individual farmers' fields. Even group members mentioned few improved varieties and some of these had been rejected because they are susceptible to CMD and take very long time to mature.

Table 4. Cassava varieties mentioned by farmers during impact assessment survey in Bukoba and Muleba districts.

Improved/Introduced varieties	Local varieties
SS4, TMS 4(2) 1425 (Nigeria) , Kiloba, MM series (not identified by names, except at Ngenge where MM 96/4446, MM 96/3075B, MM 96/4619, MM 96/4684 were identified), Msitu Zanzibar. I 91/0063, I 91/0067. KAEMP (New variety distributed by KAEMP project) were mentioned in some areas.	Rushula, Katakya, Mukarukwatage, Miezi sita, Kinyangingo, Bukalasa, Kaitampunu nyeupe, Konyo, Lwilabanafu, Kasindi, Njubu, Kashukari, Mpologoma, Muyanja, Mpira, Mani ga abalimi, Kimotoka, Kyangua, Mukazialanda, Nusu rupia, Klimpilini, Kachali, Ka-Buganda, Limila abanafu, Mkunda, Amini, Mtanzania, Rushuri, Matoke, Kakofu, Familia, Kinyaibabi, Siila, Goonya, Sungusungu, Mkaikuru, Biliomunyungu, Kyaibale, Kalokola, Mulinda, Machunda, Sengerema/Mabale/Lusharira/Kaitampunu, Nfundo ngufi, Mgongo, Manvuli, Marekani, Kisefuria, Pikipiki, Nailoni, Kinyonyi, Mwasa, Musa, Kikobe, Gajaigajai, Mukanyinya, Mulumangoma, Rwilabanafu, Bukoba tenaga, Mulegu, Biliomunyungu, Sengerema, Kinogofu, Kashanje, Shelekela, Tema ekibira and others.

Farmers mentioned several technologies to manage cassava diseases especially CMD. These included use of resistant varieties, selection of disease-free stems at harvesting or planting time, uprooting (roguing) of infected plants, use of ashes and soaking of cutting in the human urine for few days before planting the cuttings in the field. Farmers did not confirm the use of urine and ashes was effective in controlling virus diseases. Some farmers mentioned the use of resistant varieties as the major control options for cassava diseases but they said that the planting materials is not available to them since these new cassava varieties were given to group members by researchers, KAEMP and other NGOs. In addition they said that new varieties lacks some good qualities many farmers do prefer such as early maturing, tastes, dry matter e.t.c..

Both group members and non-group members commented positively on the use of groups as technology transfer approach. However, a few non-group members said that group members do not want to allow others to join them and difficult condition given to them by those who are already in the group. They suggested that all village members should be given a free chance to join the group or during group formation village leaders should be involved directly and should be given the mandate to decide some of issues concerning the group activities.

Output 2. Deployment of whitefly resistance
Output 2.1 *Data on whitefly prevalence as well as socioeconomic data on pre-release cassava clones with the aim of including it (for the first time in Africa) as supporting documentation for the release of cassava varieties.*
Output 2.2 *Knowledge of how Genotype x Environment (G x E) interactions affect whitefly resistance in cassava in Uganda.*

Considering the trial at Mukono ARDC alone where all the cultivars were present, compared with Nase 12, MM96/0686 showed reasonable level of resistance to whitefly followed by Nase 12 -161(8) and MM96/4271 showed moderate resistance (Table 5). TME 204 and Nase 12 showed consistent susceptibility to whitefly as indicated by the high mean numbers of adult and nymph populations on them; Nase 9 appeared consistently to support the fewest whitefly adults and nymphs.

Whiteflies were generally more abundant at Mukono ARDC than at SAARI (Table 6). Mean numbers of adult and nymph were far higher and lower than the grand mean for Mukono and SAARI, respectively. The apparent difference in the relative abundance of whiteflies in the two locations was clearly reflected by the level of colonization of the cultivars (Table 7). For instance, mean numbers of adults differed significantly amongst cultivars only in Mukono but there seemed no shift in the relative resistance of the different genotypes despite this..

Table 5: Mean populations of whitefly on cassava at Mukono ARDC

Cultivar	**Adult no./5 top leaves**	**Nymph no./leaf**
Nase 9	16.8	13.7
MM96/0686	29.6	25.4
Nase 12 -161(8)	40.5	23.1
MM96/4271	49.0	29.7
TME 204	76.9	58.7
Nase 12	90.6	62.4
Grand mean	**50.6**	**35.5**
F value:	**4.32**	**4.0**
DF:	**5**	**5**
P< 0.05		

Table 6: Mean population of whitefly at Mukono ARDC and SAARI

Site	**Adult no./5 top leaves**	**Nymph no./ leaf**
Mukono ARDC	34.0	23.0
SAARI	25.4	12.5
Grand mean	**29.7**	**17.8**
F value	**3.19**	**10.2**
DF:	**1**	**1**
***P*< 0.05**		

Table 7: Mean populations of whitefly on cassava at Mukono ARDC and SAARI

Cultivar	Adult no./5 top leaves		Nymph no./leaf	
	Mukono	**SAARI**	**Mukono**	**SAARI**
Nase 9	16.8	21.8	13.7	8.2
MM96/0686	29.6	22.9	25.4	14.6
Nase 12 -161(8)	40.5	25.3	23.1	12.8
MM96/4271	49.0	31.4	29.7	14.5
Grand mean	**34.0**	**25.4**	**23.0**	**12.5**
F value	**3.56**	**0.43**	**1.25**	**1.21**
DF:	**3**	**3**	**3**	**3**
P< 0.05				

Output 2.3. *An assessment in Africa of the whitefly resistance and agronomic attributes of the neo-tropical germplasm identified by CIAT in S. America as having resistance to* A. socialis *and at NRI as having resistance to African* B. tabaci

The number of days taken by the females on the leaves varied amongst test plants of a given clone and also between the clones (Tables 8a & b). For instance adults 2 and 3 for plants 1 and 2 on Ecu 72 (see Table 8a) remained present up-to 29 and 27 days, respectively while in plant 3 adult 1 and 2 died within two days of caging. A similar pattern is observed on the check cultivar Colombian (Table 8b). While the results presented on table 8a & b are preliminary, they none-the-less reveal that the mean number of eggs laid by *B. tabaci* on Colombian was twice that on Ecu 72. This finding is highly encouraging for future planned research.

Table 8a. *B. tabaci* oviposition on clone Ecu 72 in NAARI screenhouse

	Adult 1	Adult 2	Adult 3	Adult 4	Adult 5	**Mean**
Plant 1						
No. days taken	6	11	29	-	-	
No. eggs laid	7	41	54	-	-	
Av eggs/day	**1.16**	**3.72**	**1.86**	**-**	**-**	**2.25**
Plant 2						
No. days taken	18	27	-	-	-	
No. eggs laid	62	89	-	-	-	
Av eggs/day	**3.44**	**3.29**	**-**	**-**	**-**	**3.37**
Plant 3						
No. days taken	2	2	6	6	14	
No. eggs laid	0	1	36	13	27	
Av eggs/day	**0**	**0.5**	**6**	**2.16**	**1.93**	**2.65**
Overall						**2.76**

Table 8b. *B. tabaci* oviposition on clone Colombian in NAARI screenhouse,

	Adult 1	Adult 2	Adult 3	Adult 4	Adult 5	**Mean**
Plant 1						
No. days taken	8	2	20	-	-	
No. eggs laid	30	0	170	-	-	
Av eggs/day	**3.75**	**0**	**8.5**	**-**	**-**	**6.13**
Plant 2						
No. days taken	9	2	3	13	-	
No. eggs laid	42	0	20	72	-	
Av eggs/day	**4.67**	**0**	**6.67**	**5.54**	**-**	**5.63**
Plant 3						
No. days taken	7	25	-	-	-	
No. eggs laid	15	215	-	-	-	
Av eggs/day	**2.14**	**8.6**	**-**	**-**	**-**	**5.37**
Overall av.						**5.71**

As support to further research on the exploitation of whitefly resistance in other Colombian germplasm. virus-free meristematic tissue cultures of the following whitefly-resistant [in the Americas] cassava genotypes were obtained from CIAT [Centro International de Agricultura Tropicale]: Ecu 72, Ecu 64, Per 273, CG 489-31, CG 489-34 and a susceptible 'Colombian' variety. These have been re-established as plants in the UK and retested for freedom from cassava viruses. Phytosanitary certificates and import permits were obtained from the UK Department for Environment, Food and Rural Affairs [DEFRA] and the genotypes were sent and established successfully in Uganda.

In addition, a technician at NRI [Mrs Chanban Black] has been trained in the use of PCR to detect cassava-infecting viruses. This enables her to provide a sustainable routine service satisfying the requirements of DEFRA officials enabling cassava and other crops in tissue culture to be exported by NRI with the appropriate phytosanitary documentation.

2.4. *A brochure describing the symptoms of whitefly damage including sooty mould and the use of resistance.*
A first draft of the brochure has been prepared but I (R Gibson) understand there was a desire for better colour photographs. Printing is therefore expected to be completed in March.

Additional output. Cassava plants in the whitefly (Activity 2.3) trials in Uganda were discovered with virus symptoms resembling those of CBSV during routine visits. Samples of these plants were transferred to NRI and the presence of CBSV was confirmed by Dr Maruthi [R8404]. This is the first time that the virus has been identified extensively in mid-altitude Uganda and highlights initial concerns [see Background] that the presence of large populations of *B. tabaci* is likely to lead to novel viral diseases becoming prevalent. Further activities on this including a survey were transferred to R8404.

Contribution of Outputs to developmental impact

Project impact and future opportunities

Cassava is the second most important staple food throughout Africa but is particularly important in conditions of widespread drought when it, unlike the main staple maize, can often continue to yield. Such conditions are expected to increase in Africa as a consequence of global warming. Cassava is also a particularly important food for poor people as it can grow with no or few inputs apart from labour on marginal soils to which poor farmers are often restricted and is often also the cheapest source of carbohydrate for urban poor. Cassava can also be readily dried as chips and ground into flour which is used in porridge and other local dishes. Both the chips and the flour can be stored long-term, again explaining cassava's importance as a source of food security but also providing the potential to use the crop as an industrial feedstuff. In this way, cassava is amongst only a few crops widely grown in Africa which have the potential to be the basis for development of industries both for food and various chemicals. It is thus a very important crop both for Africa's survival and also its development. By targeting cassava, the project therefore directly targets hunger and poverty alleviation, major targets of the Millenium Development Goals.

The CMD pandemic is the main current threat to the crop; it has already spread to affect production in most countries in East and Central Africa and is likely to affect all sub-Saharan Africa. Nigeria, by far the largest producer of cassava in Africa, neighbours a country (Cameroon) which is already affected. The pandemic has had devastating impact on cassava production in all affected countries including Uganda and Tanzania. Its adverse effects have mainly been on the poorer sectors of communities. We currently have no means of preventing the further expansion of the epidemic – only means of minimising its effects. These effects could potentially be much worse when it reaches West Africa because of the greater importance of the crop there. The project has, with others, played a key role in advertising these risks

The project has contributed both directly and indirectly to alleviating the effects of the CMD pandemic on farmers and their families in NW Tanzania. It has contributed directly by providing training and training materials in how to control CMD plus limited supplies of planting material of resistant varieties to farmers and their families. The indirect impact achieved by supporting the activities of government and non-government agencies (Fig. 1) working in the region has, however, been much greater. Training and initial stocks of planting material have again been provided to their extension staff, enabling them to use their own funds to leverage much greater impacts. A very limited survey has established positive impacts of project activities. Some weaknesses as well as benefits of working through farmer groups have been identified.

The project has also confirmed the presence of whitefly resistance both in African and in S American cassava germplasm. How useful the latter will be is still unclear but it represents a potentially different source of resistance to that already present in African landraces. Further potential sources of whitefly resistance have already been provided to NAARI scientists by NRI collaborators from CIAT for future testing. Although whiteflies reach populations which are themselves damaging to cassava, the most worrying threat is the all too real [as demonstrated by CBSV epidemic] threat of novel whitefly-borne viruses becoming prevalent as a result of the hightened numbers of vectors.

Both the project activities in Tanzania and Uganda should, however, above all be seen as much as research into how the effects of the CMD pandemic can best be controlled in the wider theatre and it is therefore necessary for these results to be disseminated more widely. The project expects to achieve this partly by a quite exceptional publication record [see below]. This also helps leverage impact by drawing in additional international funds to support research on the pandemic and by developing alternatively strategies such as novel methods of controlling the whitefly vectors, for example, the potential of biological agents. The project also directly feeds project outcomes into the world-wide DFID-funded Tropical Whitefly IPM Project, R8041 and this will also ensure project outputs help alleviate poverty in the long term.

Disseminations

Training materials

KILIMO CHA ZAO LA MHOGO NA VIAZI [Tanzanian training guide for TOTs]

Scientific Papers

1. Colvin,J., Omongo, C.A., Govindappa, M.R., Stevenson, P.C., Maruthi, M.N., Gibson, G., Seal, S.E. & Muniyappa, V. (2006) Mechanisms driving the spread of some vector-borne plant-virus disease epidemics: effects of host-plant viral infection effects on arthropod-vector population growth, development and behaviour: management and epidemiological implications. Advances in Virus Research, in press.
2. Legg, J. P., Owor, B., Sseruwagi, P. and Ndunguru, J. (2006). Cassava mosaic virus disease in East and Central Africa: Epidemiology and management of a regional pandemic. Advances in Virus Research (in press).
3. Legg, J. P. (2005). Whiteflies as vectors of plant viruses in cassava and sweetpotato in Africa: Introduction. In “Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action” (P. K. Anderson, and F. Morales, Eds.), pp. 15-23. Centro Internacional de Agricultura Tropical, Cali, Colombia.
4. Legg, J. and James, B. (2005). Whiteflies as vectors of plant viruses in cassava and sweetpotato in Africa: Conclusions and recommendations. In “Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action” (P. K. Anderson, and F. Morales, Eds.), pp. 98-111. Centro Internacional de Agricultura Tropical, Cali, Colombia.
5. Legg, J., Whyte, J., Kapinga, R. and Teri, J. (2005). Special topics on pest and disease management: Management of the cassava mosaic disease pandemic in East Africa. In “Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action” (P. K. Anderson, and F. Morales, Eds.), pp. 332-338. Centro Internacional de Agricultura Tropical, Cali, Colombia.
6. Markham, P., Briddon, R., Roussot, C., Farquhar, J., Okao-Okuja, G and Legg, J. (2005). Whiteflies as vectors of plant viruses in cassava and sweetpotato in Africa: The diversity of cassava mosaic begomoviruses in Africa. In “Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action” (P. K. Anderson, and F. Morales, Eds.), pp. 77-82. Centro Internacional de Agricultura Tropical, Cali, Colombia.
7. Ndunguru, J., Legg, J. P., Aveling, T. A. S., Thompson, G., and Fauquet, C. M. 2005. Molecular biodiversity of cassava begomoviruses in Tanzania: evolution of cassava geminiviruses in Africa and evidence for East Africa being a center of diversity of cassava geminiviruses. Virology, 2:21.
8. Ndunguru, J., Legg, J., Fofana, B., Aveling, T., Thompson, G., and Fauquet, C.
9. (2006). Identification of a defective molecule derived from DNA-A of the bipartite begomovirus of East African cassava mosaic virus. Plant Pathology 55, 2-10.
10. Ndunguru, J., Sseruwagi, P., Jeremiah, S., and Kapinga, R. (2005). Whiteflies as vectors of plant viruses in cassava and sweetpotato in Africa: Tanzania. In “Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action”

(P. K. Anderson, and F. Morales, eds.), pp. 61-67. Centro Internacional de Agricultura Tropical, Cali, Colombia.

11. Otim, M. Legg, J., Polaszek, A. and Gerling, D. (2006). Population dynamics of Bemisia tabaci (Homoptera: Aleyrodidae) parasitoids on cassava mosaic disease-resistant and susceptible varieties in Uganda. Biocontrol Science and Technology 16, 205-214.
12. Sserubombwe, W., Thresh, M., Legg, J. and Otim-Nape, W. (2005). Special topics on pest and disease management: Progress of cassava mosaic disease in Ugandan cassava varieties and in varietal mixtures. In "Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action" (P. K. Anderson, and F. Morales, Eds.), pp. 324-331. Centro Internacional de Agricultura Tropical, Cali, Colombia.
13. Sseruwagi, P., Legg, J. P., and Otim-Nape, G. W. (2005). Whiteflies as vectors of plant viruses in cassava and sweetpotato in Africa: Uganda. In "Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action" (P. K. Anderson, and F. Morales, Eds.), pp. 46-53. Centro Internacional de Agricultura Tropical, Cali, Colombia.

Presentations at international conferences

1. Gibson, RW, Manu-Aduening, JA, Lamboll, RI, Lyimo, NG & Acola, G. 2005. Some farming practices may delay the development of virus-resistant landraces. Presentation at the IX International Plant Virus Epidemiology Symposium, April 4 – 7, 2005. Lima, Peru
2. CA Omongo, J Colvin, JP Legg & T Alicai. 2005. The effect of cassava mosaic disease on the settling behaviour and oviposition of the cassava whitefly, *Bemisia tabaci*. Presentation at the IX International Plant Virus Epidemiology Symposium, April 4 – 7, 2005.
3. JP Legg, P Sseruwagi, J Ndunguru & JK Brown. 2005. A continent-wide perspective on the epidemiology of cassava mosaic geminiviruses in Africa. Presentation at the IX International Plant Virus Epidemiology Symposium, April 4 – 7, 2005. Lima, Peru
4. Asiimwe, P., Ecaat, J. S., Otim, M., Gerling, D., Guershon, M., Kyamanywa, S. and Legg, J. P. (2005). Mortality factors affecting populations of *Bemisia tabaci* on cassava in Uganda. 7th African Crop Science Society Conference, 5-9 December, 2005, Entebbe, Uganda.
5. Mallowa, S., Isutsa, D., Kamau, A. and Legg, J. (2005). Effectiveness of phytosanitation in cassava mosaic disease management in a "post-epidemic" area of western Kenya. 7th African Crop Science Society Conference, 5-9 December, 2005, Entebbe, Uganda.
6. Ndunguru, J, Legg, J. P. and Fauquet, C. M. (2005). Molecular epidemiology of cassava mosaic geminiviruses in Tanzania. IXth International Plant Virus Epidemiology Symposium. Lima, Peru, April 4-7, 2005.
7. Njenga, P. W., Njeru, R. W., Mukunya, D., Legg, J. P., Muinga, R. and Ateka, E. M. (2005). Farmers' knowledge on virus diseases of cassava. 7th African Crop Science Society Conference, 5-9 December, 2005, Entebbe, Uganda.
8. Otim, M., Kyalo, G., Kyamanywa, S., Asiimwe, P., Legg, J., Guershon, M. and Gerling, D. (2005). The searching and oviposition behaviour of parasitoids of *Bemisia tabaci* on cassava. 7th African Crop Science Society Conference, 5-9 December, 2005, Entebbe, Uganda.
9. Sseruwagi, P., Brown, J. K., Maruthi, M. N., Colvin, J., Rey, M. E. C. and Legg, J. P. (2005). Diversity of Bemisia tabaci Gennadius (Homoptera: Aleyrodidae) and significance to the epidemiology of whitefly-transmitted viruses in Uganda. IXth International Plant Virus Epidemiology Symposium. Lima, Peru, April 4-7, 2005.

Internal Reports:

1. Quarterly report as required by CPP
2. See appendix 1

Follow-up indicated/planned:

Many of the outcomes of this project are directly fed into DFID-funded Tropical Whitefly IPM Project, R8041, ensuring project outputs help alleviate poverty in the long term as well as immediately. The relatively small amount of money set aside in this project to further develop whitefly-resistant cassava seems inadequate for a topic of this potential and further funds should be sought to support this. The identification of an epidemic of CBSV in mid-altitude Uganda is also an outcome not covered in this way and further funds similarly need to be identified to better resource research into this problem.

Competency in Statistics of Dr CA Omongo, principal investigator for the research work on whitefly resistance in Uganda (the work in Tanzania primarily involved developing, validating and promoting training messages).

From:	caomongo@naro-ug.org
Date sent:	Wed, 27 Apr 2005 10:16:26 +0300 (EAT)
Subject:	**Competency in Statistics in Agriculture**
To:	"Dr. Colvin John" <johncolvin@btopenworld.com>

Dear Richard,

Please find listed below courses attended and other exposures that have helped build my statistical knowledge so that I now employ it with relative ease to handle my research activities in Agriculture:

1) Makerere University (Uganda) where I did my Bachelor (October 1989-June 1993) and Master (October 1993-November 1996) of Science degrees in Agriculture offer introductory statistics and Biometrics at undergraduate level and advanced Biometrics in Agriculture at graduate level. Both courses are compulsory and I benefited a lot from them.

2) In 1994 I attended a one month statistics in agriculture workshop at the University of Zimbabwe organised and facilitated by Sr. J. Canhao, Department of Crop Science, University of Zimbabwe and A. Hasted, Q.I. Statistics Readings, U.K. This workshop was funded by Rockefeller Foundation Forum. The statistical package GENSTAT was core in this training.

3) To date I am confident of my knowledge of Genstat and it is the package I have been using routinely and also used it immensely in my PhD work at NRI, University of Greenwich, (2000-2003). I added more knowledge on this package through interactions with Drs. David Jeffries and Flavia Joliffe both of whom were at NRI, albeit at different times, when I was for my PhD studies.

4) Challenges in statistics are dynamic and whenever need arises there are two statisticians who have always helped NARO scientists: Dr. Nabasirye at the Faculty of Agriculture, Makerere University and Dr. Rwagama for IITA-Uganda. I have been in touch with both and certainly will continue as and when required.

As I said earlier the challenges are dynamic and I keep my mind open for any opportunity of new knowledge in statistics in agriculture.

Best Regards,

Chris

Appendix 1: Working with farmers in the management of cassava mosaic disease in the western Tanzania

Ndyetabula Innocent
Maruku Agricultural Research Institute
P.O.Box 127, Bukoba Tanzania

1. Introduction

Maruku research institute is the only center for agricultural knowledge generation in Kagera region, in the northwestern Tanzania. The information generated is always communicated to farmers through different channels. These include researchers themselves establishing demonstration plots in farmers' fields or at Farmers Extension Centers (FEC). Establishing field trials at different stages of research development, through district extension office, establishing linkage with different government organizations and non government organization supporting agriculture by providing them either direct or indirect the technologies developed like crop varieties, training materials and by training the staffs attached with these projects. (Figure 2). CPP is the one of funding agencies supporting Maruku Research Institute through the linkage established by IITA for a number of years now. The support given facilitated different research and technology transfer activities in the region. One of the programme benefited from CPP support is the root and tuber programme at ARI Maruku working on the mitigation of CMD pandemic in the CMD pandemic affected areas.

For more than five years now, root and tuber programme at Maruku have been working on introduction of new cassava varieties resistant to CMD through an open quarantine facility, evaluation of the introduced varieties under different agro-ecologies. Multiplication of the promising varieties, identification of local landraces resistant to CMD having other good qualities preferred by consumers. Distribution of planting materials, testing of potential cultural practices (Phytosanitation) in the management of CMD and popularization of identified technologies to accelerate its adoption. In addition, the spread of the disease and changes in whitefly vector populations and characterization of its biotypes were monitored in collaboration with IITA office in Kampala, Ukiriguru Research Institute in Mwanza and University of Arizona in United State. The efforts led to understanding of the major control strategies that can be used mitigate CMD in Tanzania, formulating and implementation of different approaches to disseminate the technologies identified and conducting training to different stakeholders on the disease aspects, management strategies and approaches to be used to ensure that the developed technologies reach the end users (farmers). The efforts were funded by the group of donors in which CPP is one of funding agency, and this report therefore presents some of the results obtained through CPP funding during the period of one year between November 2004 to December 2005.

2. Activities done

2.1 Networking and linkage with other stakeholders

The support given by NRI/CCP project enabled Maruku Research Institute to strengthen its linkage with other agricultural stakeholders inside and outside the region. Several training and multiplication activities were conducted to extension officers and link farmers working with different NGOs and government institutions in the region. The potential stakeholders involved are Action Aid in Kigoma and Kibondo districts, GTZ in Kigoma and Kasulu districts and NPA in Ngara district and extension personnel working with the ministry of internal affairs (prisons) on the principles of cassava production, disease management and cassava planting materials multiplication techniques. More that 300,000 cassava cutting were distributed to Kigoma, Kibondo and Kasulu district each district received 100,000 cuttings of different varieties in the collaboration with GTZ. The support facilitated the root and tuber scientists at ARI Maruku to be able to implement different activities supported by IITA/OFDA, and other sponsors by having reliable transport since the vehicle bought by OFDA project was maintained using part of funds from CCP project. During the same period, researchers at Maruku were able to monitor research trials effectively and timely.

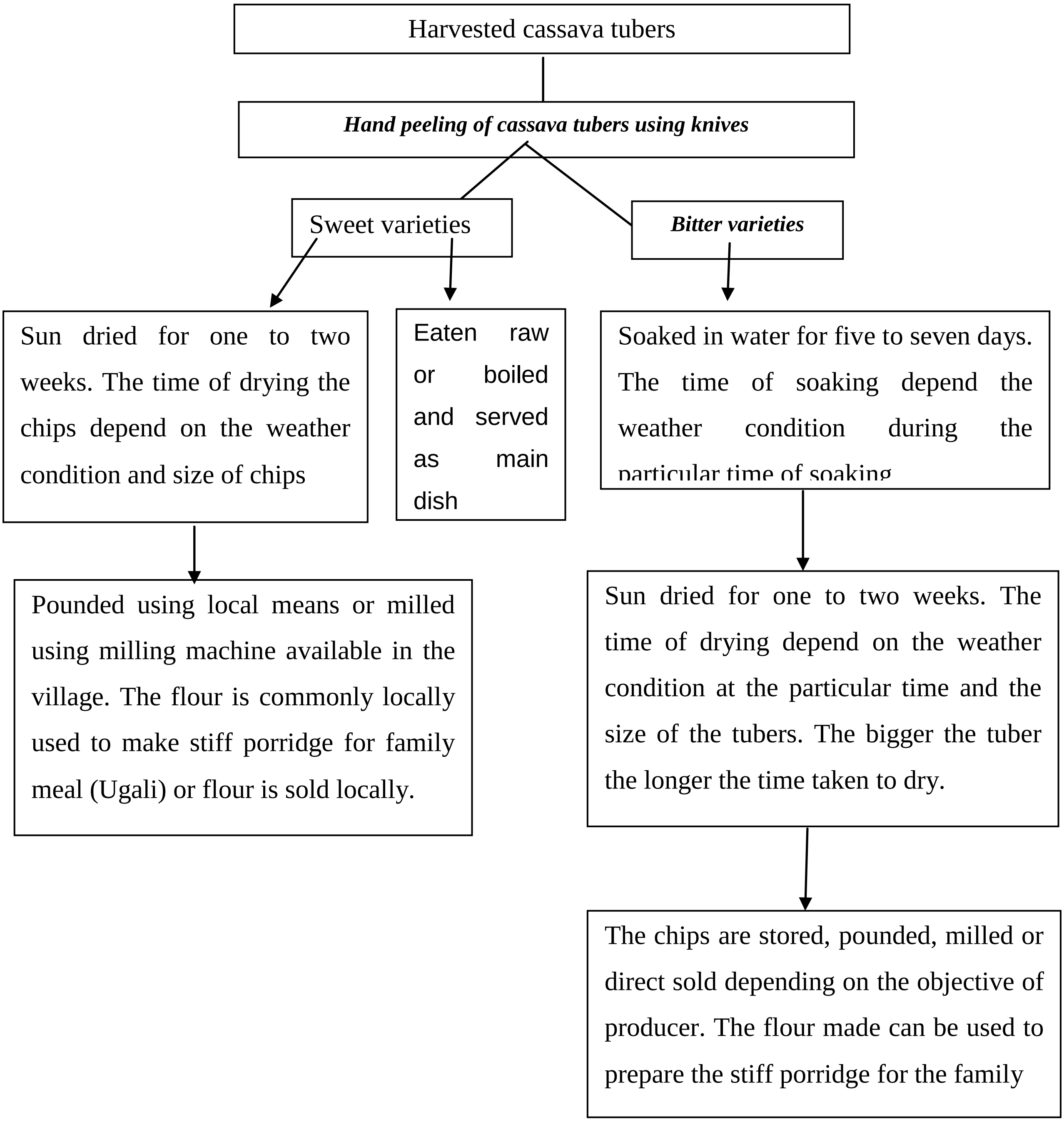
Researchers from Maruku continued to support FFS groups established in Bukoba and Muleba districts. This was initiated during the past phases of the project, and therefore the goal of the project during this phase was to scale up dissemination of already developed technologies to other farmers in the locality. Also to distribute planting materials to other far areas especially those working in the recently CMD affected and highly threatened areas. The link between researchers and district agricultural offices were strengthened and made possible to stabilize cassava production by either practicing phytosanitation and use of resistant varieties in areas where cassava is an important food crop.

2.2 Farmers training on cassava post harvest opportunities, marketing and farm records

Cassava tubers once is harvested is either processed for bitter varieties or eaten raw or boiled and eaten as main meal at home for the case of sweet varieties. Harvesting always is done using peace meal harvesting techniques because of poor storage facilities at farm level. Local processing is done techniques commonly used are either direct sun drying after peeling and washing for making chips called makopa or water soaking or heaping for the couple of days, followed by sun drying. After all these important processes, the dried cassava is either manually pounded and sieved or milled in areas where milling machine is available ready for making stiff porridge (Ugali) for the family. Few farmers they produce for selling either the tuber or already processed products. The products are sold either to local retailers or to business people from the neighboring country (Uganda) commonly coming in the area to collect already processed cassava products to be transported to their country (Figure 1).

Sweet varieties are most preferred by farmers in Bukoba district and in some areas in Muleba. In some parts of Muleba such as Ngenge and Kimwani areas, farmers grow both sweet and bitter varieties. So cassava processing is more common in Muleba than Bukoba district. As an incentive to increase cassava production and stimulant for adoption of improved cassava varieties especially those resistant to CMD, root and tuber programme at ARI Maruku decided to conduct the training on cassava post harvest technologies through FFS groups in the project working areas in both districts. FFS group member and few non group members were involve in this training. Farmers from outside the group were involved in this training as one of the

Figure: Flow chart of cassava processing commonly used in Bukoba and Muleba district.



strategy to facilitate the knowledge from the group to non-group members in the community.

The following aspects were covered during cassava post harvest training:

- Different cassava local storage methods
- Cassava processing techniques using hand operated and motorized machine
- Processing and different products development using cassava flour as raw materials
- Farm record keeping and price determination
- Cassava marketing and marketing opportunities

The training intended to expose farmers especially FFS members to different opportunities that can be used to commercialize cassava as a commodity rather than regarding cassava only as source of food and rarely used as source of income. It was anticipated that if farmers can produce cassava for selling purposes to earn some income from it, this will be an incentive for the local community to invest in cassava production, then high adoption of improved varieties. The total of 112 farmers attended the training at different locations as indicated in the table below. (Table 1). Most of farmers were involved in FFS training prior to this training. Few of the attended trainees were invited from groups present in the same village or neighboring villages. This intended to rise awareness among farmers on the present of new technologies for processing of cassava at farm level.

Table 1. The number of trainees attended the training at five training sites indicating their gender.

Site	Men	Women	*Total*
Kyaka	14	12	26
Ngenge	19	8	27
Kyema and Kanazi	9	15	24
Kanyigo	1	18	19
Mushozi	4	12	16
Total	47	65	112

2.3 Training materials production and distribution

Maruku Research Institute produces research reports at different time during implementation of research activities. The scientific results are presented in the form of publications, field notes and project reports (quarterly, annual or final reports). The final outputs of research activities are distributed to extension officers and farmers in the more simplified forms of reports or extension and training materials. This enable our stakeholder to understand apply the information generated by the institute as it is communicated to hem is the simple language.

The information generated from this project and other sister projects working together in the mitigation of CMD pandemic in Kagera region. The information were written in the form of leaflets and extension guide to be used by farmers and extension officers working direct with farmers in different areas where CMD is the major problem. More than 3,000 leaflets on cassava mosaic disease identification and management techniques and 10 extension guides covering all aspects on cassava production, cassava FFS approach and CMD management were produced for distribution to different agricultural stakeholders in the region. The electronic copies were kept at ARI Maruku for further improvement and production of more hard copies were needed by potential stakeholders who may request at any moment.

2.4 Graduation of FFS members in both Muleba and Bukoba district

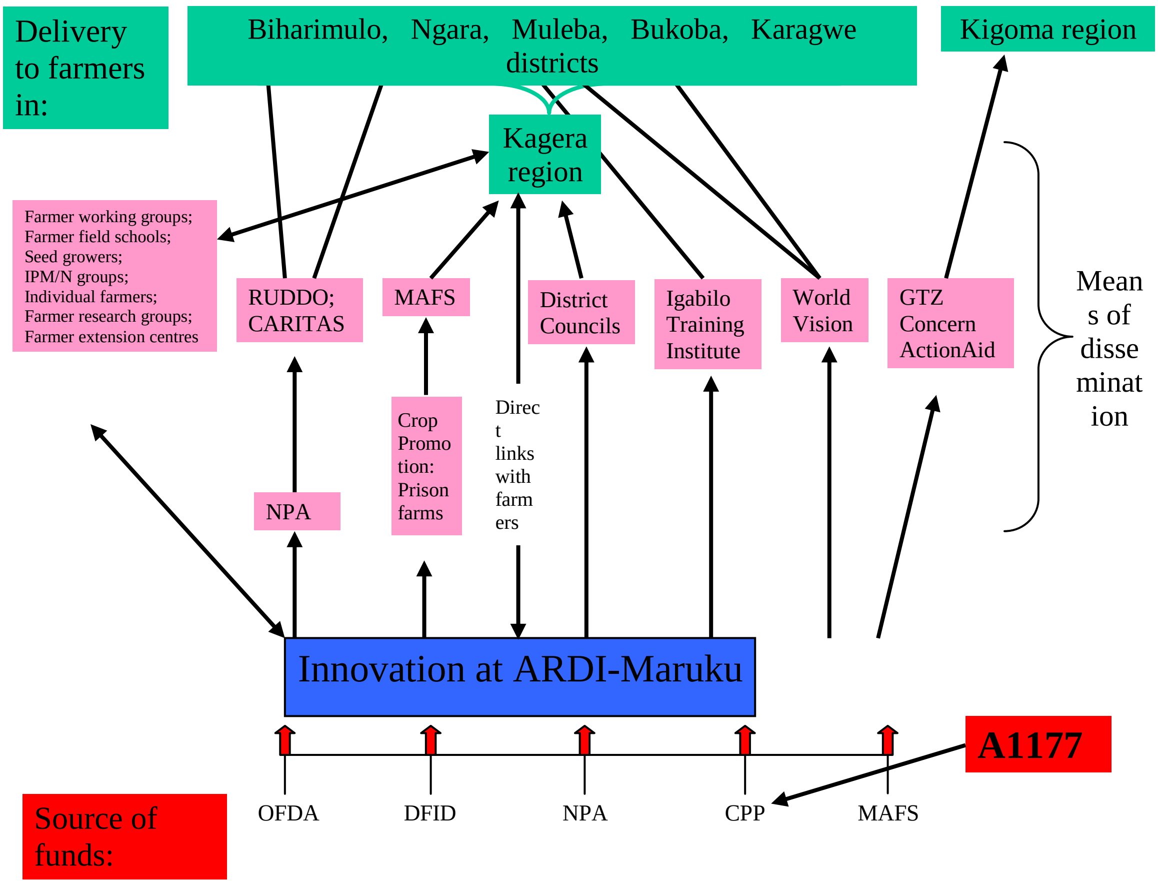
At the end of FFS course that undertaken for about three years, FFS group members graduated and received the certificates for qualifying as FFS training on cassava production.

Table 2. FFS graduation participants

Site	Group members		Others		Total
	Men	Women	Men	Women	
Kyema	2	9	4	16	29
Kanyigo	0	27	6	4	37
Ngenge	12	8	25	32	77
Mushozi	14	5	5	4	28
Kyaka	2	4	17	10	33
Total	30	53	57	66	206

It is anticipated that FFS group members will be able to train other farmers using different informal meetings conducted in the area and neighboring villages. Farmers once they graduate they are responsible to disseminate the knowledge they got from training to other farmers in the village and neighboring villages. However, farmers complained on the lack of training facilities that can be used for training (*See section on impact assessment*). All group members were given training materials in form of notes, leaflets and manuals prepared by researchers who were involved in different training sessions to help them to conduct training to other farmers.

Figure 2: The mode of technology development and dissemination different stakeholders in the northwestern Tanzania in the mitigation of cassava mosaic disease



3. Project impact assessment survey

During the last three weeks of December 2005, the impact study was conducted in all working areas to investigate the impact of the project on the knowledge on disease (CMD), its management, impact on the livelihood of people living in the project area and to identify the gap existing between group member and non group members within the same area. The pre-prepared and pre tested questionnaire and checklist were used for farmers' interview and discussion with group and non-group members respectively. All group members attended the discussion but only ten members interviewed and at least ten non-group members were randomly selected from all sub villages were group members are coming from interviewed during the first day and attended the discussion in the second day. Each category conducted the discussion in separate group.

3.1 Knowledge on disease and disease management practices

All FFS group members interviewed identified the CMD by confidently describing its symptoms, its cause, mode of spread and possible management practices. Roguing of infected plant, use of resistant varieties was mentioned by group members as their important management methods commonly used in their field. About….% of group members mentioned that the disease is caused by viruses and is transmitted by whitefly vector. On the other hand, non group members has the limited knowledge on the cause of the disease despite the fact that many of them were able to mention confidently the name of the disease in Swahili language as *Batobato*) or in local language (*Luhaya*) as *Makoko or Kananga* in some areas. When asked to explain the effect of the disease to plant, they said no tuber is harvested from the diseased plant and stunted growth. In most cases non-group members failed to understand the cause of the disease and how it is transmitted from one plant to another. Most of farmers who are non-group members said that insects, drought, and change in weather condition causes the disease. On transmission agent, they said that the disease is transmitted by wind. On management techniques used to control used to reduce disease incidence and severity they said that they used to uproot the diseased during early stages of plant growth since they do not get any tubers in case the diseased plant left to grow in the field. When asked why still in their field there are many plants showing CMD symptoms, they responded that for some varieties small tuber can be harvested even if the plant is infected later in the growing season. That is why diseased plants is still seen is some field in many areas in Bukoba. In case there are no disease free plants in the fields, farmers tend to select only vigorous growing plant for establishing new fields.

Many farmers who are not member of FFS groups suggested that the government should be involved in multiplication of resistant varieties. The reasons given is that involving only groups in multiplication results into low rate of material spread from the group to other non group members because group members tend to make profit from the materials given by selling the cuttings at 15/= to 20/= per cutting. Under normal circumstances, normal farmers can not afford to buy planting materials such price.

Table 3. Percentage of group and non-group member's responses on the CMD and management practices during impact survey in Bukoba and Muleba district.

Item assessed	% group members (N=130)		% non-group members (N=130)	
	Yes	No	Yes	No
Know CMD symptoms	100	0	87.7	12.3
Know CMD causes	59.4	40.6	18.2	81.8
Mentioned stunted growth as CMD symptoms	60.3	39.7	34.8	65.2
Mentioned curling of leaves as CMD symptoms	81.3	18.8	59.1	40.9
Mentioned roguing as action for to reduce CMD incidence	98.4	1.6	92.4	7.6
Mentioned selection as action to reduce CMD incidence in the field	64.1	35.9	33.3	66.7
Mentioned use of resistant varieties as action to control CMD	48.4	51.6	12.1	87.9
The use roguing to control CMD in their fields	100	0	93.8	6.3
Use selection to control CMD in their fields	57.8	42.2	25.0	75.0
Use resistant varieties to control CMD in their fields	23.4	76.6	3.1	96.9

The study indicated that many farmers either group members or non-group members are knowledgeable on the symptoms of the disease. All group members interviewed identified the disease and mentioned it by name and more that eighty percent of non group members were aware (Table 3). The situation was opposite when farmers were required to mention the caused of the disease and its transmission. Majority they responded that the disease is due to drought, nutrient deficiency or insect infestation. Both categories of farmers identified the possible control measure that can be used to manage the disease. The mentioned technologies include Use of resistant varieties, selection of disease free stems and roguing of the CMD infected plants in the field. The number of farmers who mentioned these technologies differed among farmer's categories (Table 3). Despite the fact that many farmers identified the right technologies commonly recommended for the management of disease in the fields, many of them found not using these technologies in the their filed. The reasons given are presented in figure 2 below. Most of FFS group members said planting materials for resistant materials is still a problem to them (Figure 2). Very little amount of these new varieties is still under multiplication plots and is still in small quantities. This implies that they're still a need of more efforts to accelerate multiplication of CMD resistant varieties in order to meet the demand.

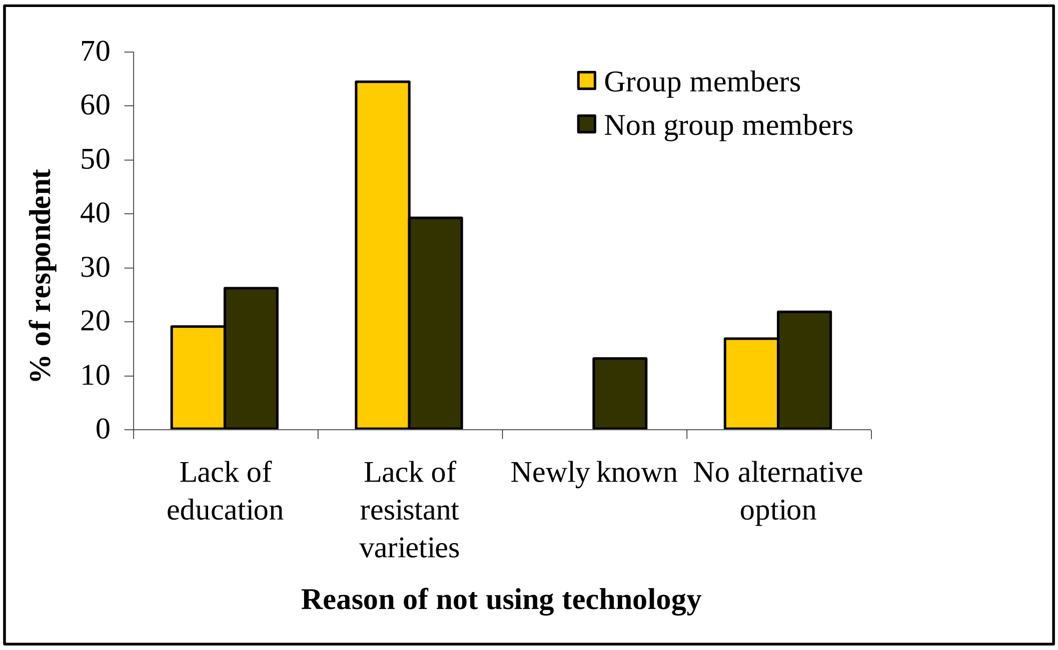


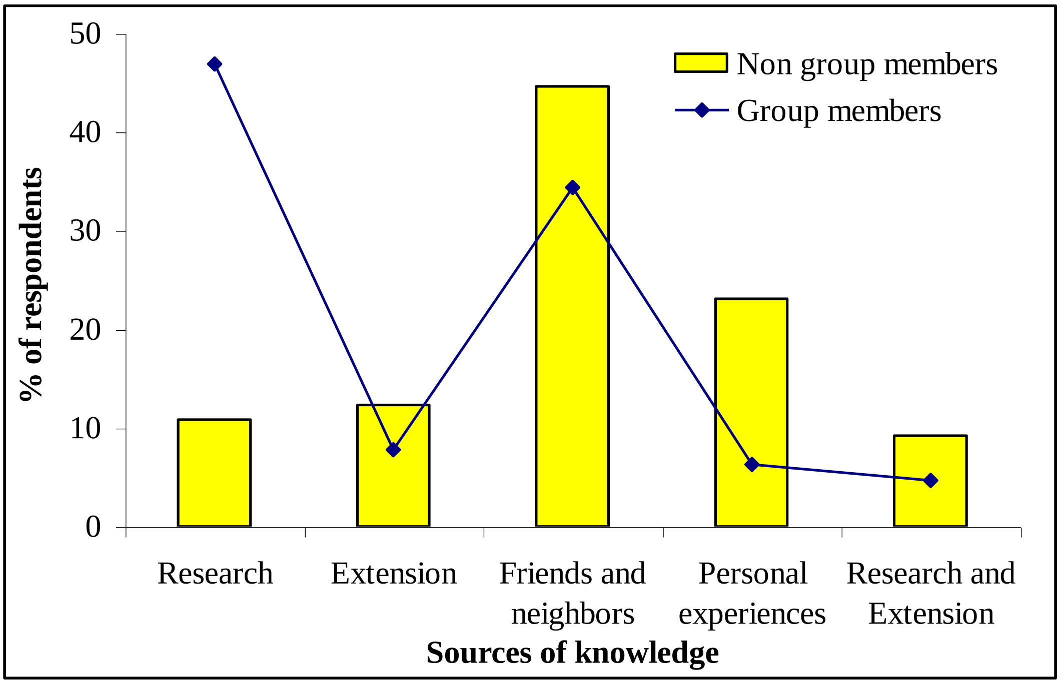
Figure 2. Reasons given by respondents and percentage of respondent (%) on why farmers do not use the mentioned disease control options.

3.2 Sources of information or technologies on the control of CMD to farmers

In principal technologies developed by researchers in Tanzania are used to pass through extension system to distribute he technologies to farmers. In some situation researchers themselves are involved to disseminate technologies to farmers through on farm demonstration plots, on farm evaluation trial, conduction adaptive research in order to recommend appropriate technologies. One of the key question during the impact study was to ask on the sources of agricultural technologies available to farmers in the area of the study. It was noted that still many farmers they get technologies through farmer to farmers exchange system unless they are directly involved in any contact with research. But still those who have contact with research, still they are sharing knowledge with relatives and friends. Figure 3 indicated the highest percentage or group members getting technologies from research and non group members said that in most cases they get technologies from their neighbors and friends.

Maruku Research Institute, district extension offices and NGOs working in the area was mentioned as their main source of information on crop production. The important NGOs mentioned include KAEMP, FAO, World vision programme and Partage Tanzania. Few group members complained that some fellow non-group members in the village they do not trust them when they tell them the technical issues they got from FFS training. They want to be trained by either extension officers or researchers and not fellow farmer. Also they reported on the lack of training materials like leaflets, brochures, posters covering different aspects on crop production such as good cultural practices, level of fertilizers to applied, land selection and preparation e.t.c.

Figure 3. The institutes mentioned by farmers as their major sources of agricultural



technologies in Bukoba and Muleba districts

3.3 Cassava planting materials (varieties) grown

Both local and resistant cassava varieties were mentioned during the interview to be grown in all areas. Generally it was observed that still farmers they are growing their own cassava varieties. This was mainly connected to the lack of planting materials of resistant varieties in many areas. In some areas like, Ngenge and Kyema farmers said that they are still multiplying the CMD resistant cassava varieties in the plot managed by the whole group. At Kanazi and Kyaka, the materials raised in the group nursery were sold and the money obtained from cutting sales was divided among group members. During the coming season, the materials that will be harvested will be planted in individual fields. At all sites farmers mentioned a range of cassava varieties grown. The name of varieties differed among locations. It was observed many farmers name their varieties depending on the level of resistance to diseases, yielding ability of the variety, its origin, the name of the person who brought the variety for the first time in the area, morphological characteristics of the variety or growth habit, flowering habit, maturity time e.t.c. In most cases only local varieties were mentioned and group members mentioned few improved varieties. They said that some of the varieties were rejected because they are susceptible to CMD and take very long time to mature. The commonly mentioned varieties are listed in the table below.

Many varieties were nicknamed as KAEMP since were distributed by KAEMP project. In Bukoba and Muleba district very few varieties were mentioned to be bitter. Farmers they grow sweet cassava. Some of local varieties mentioned have got good level of resistance to mosaic. Many areas where this study was conducted they mentioned both CMD susceptible and resistant cassava varieties, in areas with high CMD incidence the high incidence were noted in the few fields assessed.

Table 4. Cassava varieties mentioned by farmers during impact assessment survey in Bukoba and Muleba districts.

Improved/Introduced varieties	Local varieties
SS4, TMS 4(2) 1425 (Nigeria) , Kiloba, MM series (not identified by names, except at Ngenge where MM 96/4446, MM 96/3075B, MM 96/4619, MM 96/4684 were identified), Msitu Zanzibar. I 91/0063, I 91/0067. KAEMP (New variety distributed by KAEMP project) were mentioned in some areas.	Rushula, Katakya, Mukarukwatage, Miezi sita, Kinyangingo, Bukalasa, Kaitampunu nyeupe, Konyo, Lwilabanafu, Kasindi, Njubu, Kashukari, Mpologoma, Muyanja, Mpira, Mani ga abalimi, Kimotoka, Kyangua, Mukazialanda, Nusu rupia, Klimpilini, Kachali, Ka-Buganda, Limila abanafu, Mkunda, Amini, Mtanzania, Rushuri, Matoke, Kakofu, Familia, Kinyaibabi, Siila, Goonya, Sungusungu, Mkaikuru, Biliomunyungu, Kyaibale, Kalokola, Mulinda, Machunda, Sengerema/Mabale/Lusharira/Kaitampunu, Nfundo ngufi, Mgongo, Manvuli, Marekani, Kisefuria, Pikipiki, Nailoni, Kinyonyi, Mwasa, Musa, Kikobe, Gajaigajai, Mukanyinya, Mulumangoma, Rwilabanafu, Bukoba tenaga, Mulegu, Biliomunyungu, Sengerema, Kinogofu, Kashanje, Shelekela, Tema ekibira and others.

3.4 Qualities for selection of planting materials

Several identified several criteria used for selection of the varieties they want to grow at planting time. They said that materials can be selected prior planting and conserved under the shade or selection can be done at harvesting time. The mentioned criteria are yielding ability of the variety, taste of tubers, duration in the soil (they prefer varieties that stay in the soil for the long time), time of maturity (both early and late maturing varieties are preferred), resistant to pest and diseases, drought resistant, easy to intercrop with other crops and the variety producing good quality stems (i.e. big stem with many nodes).

3.5 Technologies used to manage cassava diseases.

Farmers interviewed mentioned different technologies used in the management of cassava diseases especially CMD. The technologies mentioned include use of resistant varieties, selection of disease free stem at harvesting or planting time, uprooting (roguing) of infected plants, use of ashes and soaking of cutting in the human urine for few days before planting the cuttings in the field. Farmers did not prove the local practices such as use of urine, and ashes if it is effective in controlling virus diseases. Some farmers mentioned the use of resistant varieties as the major control options for cassava diseases but they said that the planting materials is not available to them since very few farmers in the village have got these new cassava varieties given to group members by researchers, KAEMP and other NGOs. In addition they said that new varieties lacks some good qualities many farmers do prefer such as early maturing, tastes, dry matter e.t.c. Few group members reported to have already new varieties being promoted by research, extension sector and some NGOs such as KAEMP, Partage, world vision Tanzania.

3.6 Use of group approach as the means of technology transfer.

Both group members and non-group members commented positively to the use of groups as technology transfer approach. Few non-group members said that most of farmers once they join the group they do not want to give room for other to join them. The want to benefit from the group by getting grants, free loans and frequent trips made to other groups. They said that many people they would like to join groups but they fail because of difficult condition given to them by those who are already in the group. They suggested that all village members should be given a free chance to join the group or during group formation village leaders should be involved directly and should be given the mandate to decide some of issues concerning the group activities.

4. Project impact and future opportunities

Knowledge: The project increased knowledge to participated farmers on the different aspect on crop production especially sweet potato through training, farming system analysis and provision of training materials. The training materials will be used as reference tools for extension officers and farmers who can read the leaf lets developed. Farmers within the FFS groups understand the usefulness of using of the developed technologies and where they can get the technology. In addition the community they have the choice to go, either to grow improved varieties or continue growing their local landraces for sustainable cassava production.

The project enhanced the knowledge on variety selection, seed multiplication and the approaches to be used to disseminate the materials to farmers in the sustainable way. The quality of planting materials were insisted whenever the training were conducted. During training the society participate in planning their own activities funded by different NGOs. This resulted into smooth implementation of the planned activities of the projects collaborated with Maruku research.

The weakness identified is that only group members have benefited the knowledge from the established groups. Farmers outside the group they are still using their experience to solve their problems and entirely growing local varieties that are highly succumbed by CMD in all places in of intervention.

Financial: Resistant varieties are becoming commodity in some areas by selling cassava cuttings to NGOs and government institutions responsible in the distribution of planting materials. Few people already sold cuttings and earn some money from it. This could lead to increased income and livelihood of the participating community.

Genetic diversity: The project increased genetic diversification of cassava by increasing new varieties grown by farmers in the community. This will reduce disease incidence in the fields and increase availability of planting materials during the periods when the materials are highly needed by farmers for establishment of the fields. This reduced the workload to farmers for collecting the planting materials for planting.

Food availability: Availability of food has increased for group members in areas such as Ngenge where people depend on cassava as their major staple food crop and either plant resistant varieties or practice phytosanitation. The only farmers involved with the project found to have enough food and other they are facing food shortage due to the fact that in many places the prolonged drought affected maize fields.

Collective efforts (collaboration): The community witnessed the higher level of collaboration of different stakeholders either funding activities or at implementation of CMD pandemic mitigation activities in the field (Figure 2). More that ten stakeholders participated at different levels with different roles actively participated in the process.

The existing gaps and future opportunities.

No involvement of the whole community in the process in case only few farmers are involved in the group. Maruku research station need to enhance the farmers based system of technology transfer in which grass root communities should be encouraged.

The groups formed should be institutionalized and registered so that they can get access to the institution giving loans to farmers in the area. Farmer to farmers seed distribution should be institutionalized, strengthened and promoted to ensure sustainable seed production. The farmers based system will enable the community to participate and take important role in seed production and conservation of vegetative propagated crops.

Annex 1: Key questions used to investigate farmers' knowledge on CMD and control strategies during the project impact survey

Go to farmer's cassava plot for this part

1. Has the amount of cassava that your household produces increased or decreased or remained the same during the past 5 years?	
2. If there were any changes, what were / are the reasons for these changes?	

3. What varieties of cassava did you grow earlier, do you currently grow, and will you / are you planning to grow in the future and why?

Variety names	Reason for growing / planning to grow this variety and reasons for stopping to grow it
5.Before 2005	
Current season	

6. What type of cassava varieties with what characteristics would you like to grow in the future? (list characteristics)	
7. *(Show a farmer a plant with CMD symptoms in the field or a leaf):* Do you know what happened to this plant? What do you call this?	
8. Do you know what causes these symptoms? *(Try to find out what the farmers' understanding of the problem is)*	
9.Will there be any difference between the plants showing these symptoms, and those plants that don't show them?	
10. If yes, what will be the difference?	
12. Do you know of any methods to reduce the incidence or severity of the disease? If yes, what?	
13. Where did you get this knowledge / information from?	
14. Which of these methods do you use in your own field?	
15. For those methods not used, why not?	

16. Any other comments or observations on cassava: