CROP PROTECTION PROGRAMME

Promotion of control measures for cassava brown streak disease
R8227 [ZA0538]

FINAL TECHNICAL REPORT

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Natural Resources Institute

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PROJECT SUMMARY

TITLE OF PROJECT:	Promotion of control measures for cassava brown streak diseases
R NUMBER:	R8227
PROJECT LEADERS:	Dr Rory Hillocks, Natural Resources Institute
RNRKS PROGRAMME:	Crop Protection Programme
PROGRAMME MANAGER:	Dr. F. Kimmins
SUB-CONTRACTORS:	Ministry of Agriculture & Food Security Naliendele Agricultural Research Institute [NARI] and Sugarcane Research Institute [SRI], Kibaha Tanzania. SARRNET, Malawi INIA, Maputo, Mozambique
COMMODITY BASE:	Cassava
BENEFICIARIES:	Smallholder cassava farmers
TARGET INSTITUTIONS:	Naliendele Agricultural Research Institute, Mtwara, Tanzania Sugarcane Research Institute, Kibaha,
GEOGRAPHIC FOCUS	Tanzania, Mozambique and Malawi
START DATE: **FINISH DATE:**	01 January 2003 31 March 2005
TOTAL COST:	£211,047

Executive Summary

This project follows-on from two previous DFID-CPP projects, R6765 and R7563. The first project established the incidence and distribution of CBSD and confirmed that it was still limited to altitudes below 1000m, and showed that some local varieties were resistant to the associated symptom of root necrosis. CBSD was identified in Mozambique for the first time. CBSD was shown to be a major threat to food security in coastal eastern and southern Africa, affecting a population of around 20 million people. In the second project the control measures were developed and a programme of on-farm research initiated in 8 villages in Tanzania. Virus-free stock was selected of several CBSD-tolerant local varieties and the extent of CBSD in Malawi was established. Field studies on transmission and spread of CBSD suggested that periods of rapid spread coincided with periods of high whitefly populations.

The main focus of the present project was promotion of control measures developed under R7563. Initial on-farm research into roguing and selection of planting material was abandoned because of farmers' hostility to roguing and annual shortage of planting material. The project then focused exclusively on dissemination of CBSD-tolerant varieties accompanied by an information campaign to raise farmers' awareness of CBSD symptoms and availability of tolerant varieties.

In the Southern Zone of Tanzania, on-farm validation of the tolerant varieties was completed in six target villages and the emphasis with the farmers groups shifted to community multiplication. In the community multiplication phase of the project, secondary schools have also been used, and the plots form the focus for inclusion of cassava production and utilisation in the school curriculum. Teachers from six schools received training at Naliendele. In addition, the CBSD-tolerant varieties have been distributed to a further two villages in Rwangwa district at the request of the District Extension Officer. In all these villages the varieties have been multiplied and distributed.

In the Eastern Zone, the project has linked with the EZCORE [Eastern Zone Client Orientated Research and Extension]. The project is funded by Irish aid and implemented by Muheza District Extension Office. They agreed to multiply the CBSD-tolerant varieties in their 30 contact villages. The project provides them with the initial planting material. In addition, we are conducting on-farm evaluation of the varieties in three villages closer to Kibaha.

In Mozambique, the project provided technical support to Save the Children in support of their project, funded by US AID, to multiply and distribute CBSD-tolerant varieties. The project has also provided technical and financial support to the Mozambican National Root Crops Programme at INIA, to assist with their work to identify resistance to CBSD in local varieties and improved lines.

In Malawi, the project has collaborated with SARRNET and the National Programme to make an initial collection of local cassava germplasm for resistance to CMDs and CBSD at Karonga sub-station. A number of promising local and improved lines have been identified with tolerance to CBSD root necrosis. One of these looks as if it may have some resistance also to CMD. These lines were planted in on-farm trials in November 2004.

On-farm evaluation of the CBSD-tolerant varieties in Tanzania, has shown that there is high approval among farmers for some of them. Cv. Kiroba for instance, has proved very popular with farmers who market their cassava because of its early

maturity and sweetness. An improved variety, Nal 34 has yielded well and also has good culinary characters. Nal 34 has been approved by the variety release committee as a CBSD-tolerant variety. These varieties will provide a temporary solution to CBSD until the IITA programme comes up with more resistant material. Their main draw-back is susceptibility to CMDs.

The variety distribution programme has been supported by a communication strategy that has involved an information leaflet, information posters and radio broadcasts. Extension officers in the Southern Zone of Tanzania have received training in all aspects of cassava production, crop protection and post-harvest utilisation.

After several years of trying to transmit CBSV with whiteflies, successful transmission with *Bemisia tabaci* was achieved in growth rooms at NRI and the transmission was confirmed by PCR diagnostics. This work has been submitted for peer-reviewed publication. The implication of this finding is that host-plant resistance to whitefly may be considered as a possible method of control for both CMDs and CBSD.

In December 2004, symptoms resembling those of CBSD were seen in Uganda. Leaf samples were sent to NRI and the presence of CBSV was confirmed. It appears that greatly elevated whitefly populations now occurring in Uganda have led to this outbreak of CBSD. This is the first time that substantial numbers of CBSD-infected plants have been reported in the Lake Victoria basin and at altitudes above 1000 m.

Following the section on background to the present project, achievements are summarised under each output. Detailed presentation of results and discussion can then be found in the Appendices. Each Output is presented as a separate appendix.

Background

Cassava brown streak disease was first identified in northern Tanzania in 1936. Under the East African Agriculture and Forestry Research Organisation [EAAFRO] much work was done in breeding for resistance to both CBSD and CMD. When EAAFRO moved from Tanzania to Kenya in the 1950s the work on CBSD was discontinued. When IITA took over the mandate for cassava improvement in Africa in the 1970s, their emphasis was on CMD which was important in West Africa. CBSD was more or less forgotten until the early 1990s when NRI [Mike Thresh] recognised its potential importance in coastal east Africa and approached DFID-CPP for research funds.

Project R6765 established the distribution of CBSD in the coastal areas of eastern, developed methodologies for disease assessment and identified tolerance to CBSD in local cultivars. CBSD was found at high incidences on the coast at altitudes below 500m and the disease was reported by the project in Mozambique for the first time, where incidences of 100% occurred in some fields in Zambezia Province. Because of the associated symptom of root necrosis, the disease impacts directly on yield and is a major threat to food security in areas worst affected by the disease. A rural population of some 20 million people are affected by CBSD in the affected area that extends form Kenya to the Zambezi river in Mozambique.

R7563 identified a type of resistance to CBSD in local cassava varieties. These varieties are susceptible to infection by the virus but are much less prone to root necrosis. Root necrosis is the damaging symptom of CBSD which often has little effect on the above-ground parts of the plant. These ‘CBSD-tolerant’ local varieties were chosen on the basis of survey data from Project R6765. The material was

collected at ARI Naliendele [NARI] in southern Tanzania where it was subjected to intensive selection for two seasons to eliminate both CMD and CBSD. This then constituted our 'virus free stock' which then had to be multiplied and distributed to villages for on-farm evaluation and tertiary multiplication. This strategy was adopted at two centres in Tanzania, in the Southern Zone [NARI] and in the Eastern Zone [Sugarcane Research Institute (SRI)].

R7563 also worked in Mozambique and Malawi. In Mozambique we provided technical assistance to Save the Children [STC]. US AID awarded $US 5 million over 5 years to STC in Nampula to multiply and distribute CBSD-resistant varieties that we had identified. In Malawi we conducted a nation-wide survey for cassava virus disease, showing that CBSD was a major problem in the lower altitude areas close to Lake Malawi. These are the areas where households are most dependent on cassava for food security. On the basis of this survey work began to identify local cultivars with resistance to CBSD, as we had successfully done in Tanzania and Mozambique.

In addition to the work on identification and deployment of host-plant resistance to CBSD, the CPP projects have supported basic research on vector transmission of CBSV. Progress was slow although all the indications were that whitefly was the vector because of the close association between fluctuations in whitefly populations and the amount of virus spread. This research carried over into the present project.

By the time the present project began we had succeeded in drawing attention to the risk to food security posed by CBSD. Based on NRI's findings, IITA recognised the importance of CBSD and has now made resistance to CBSD a priority for improved varieties intended for the East African coast. At the end of 2004 there were a number of research and development [variety multiplication and distribution] projects, in addition to the DFID-CPP project. There are now projects on CBSD supported by IITA, US AID and Rockefeller Foundation in Tanzania, Mozambique and Kenya, all of which were doing work based on the earlier findings of the CPP projects.

THE PROJECTS COLLABORATIVE NETWORK:

TANZANIA

Main sub-contractor:

Ministry of Agriculture & Food Security: Southern Zone – Naliendele Agricultural Research Institute [NARI], Eastern Zone – Sugarcane Research Institute [SRI], Kibaha.

Collaborative partner:

Eastern Zone Client-Orientated Rural Extension Project [EZCORE], funded by Irish Aid.

Technical support to:

IITA/Rockefeller Foundation Project on cassava improvement for resistance to CBSD, based at ARI Mikocheni, Dar es Salaam.

MOZAMBIQUE

Main sub-contractor:

National Agricultural Research Institute [INIA], Maputo and Namplua

Collaborative partner:

Save the Children, Nampula

MALAWI

Main sub-contractor:

Southern Africa Root crops Research Network [SARRNET], Lilongwe in collaboration with Ministry of Agriculture & Irrigation.

KENYA

Technical support to:

University of Nairobi

UGANDA

Technical support to:

Root Crops Programme, NARO, Namulonge agricultural Research Institute.

Project Purpose

CBSD has been established as the main biological constraint to cassava in the coastal regions of eastern and southern Africa. CBSD adversely affects food security and utilisation of cassava to produce value-added products. The purpose of the project was to improve food security by promoting control measures for CBSD. This was achieved by producing virus free planting material and setting-up community multiplication sites for secondary multiplication of CBSD-tolerant varieties. This was supported by an information campaign on the biology and control of the disease. Studies on vector transmission of CBSD further added to our knowledge of disease epidemiology.

Research Activities

The project built on knowledge gained in previous projects to promote control measures for CBSD and to develop an information communication strategy. Local cassava varieties that had been identified as tolerant to CBSD were first evaluated by farmers groups in the 9 target villages in Southern and eastern Tanzania. Each of ten farmers in the group planted a plot containing the varieties and the six villages each represented a replication for the purposes of analysis.

Having established the suitability of the CBSD-tolerant varieties, the farmers groups planted multiplication plots to provide planting material for the community. Six secondary schools also became community multiplication centres and cassava production and processing was included in the curriculum. Teachers from the participating schools joined extension officers in a training course.

In Mozambique INIA conducted disease screening trial and ' mother and baby trials' to introduce CBSD-tolerant varieties to farmers. Also, a survey was carried out by INIA to cover Cabo Delgado and some districts of Nampula that had not been previously surveyed.

In Malawi, we undertook with SARRNET and the National Root Crops Programme, a collection of local cassava germplasm which was then screened in the field at Baka Experimental Station for its reaction to CBSD and CMD.

Vector transmission studies conducted in Tanzania had remained inconclusive. A number of experiments were conducted therefore, in the controlled growth facilities at NRI. Whitefly placed in clip cages were allowed to feed on CBSD-infected plants and were then transferred to virus-free cassava plants.

Outputs

OUTPUT 1. CBSD-tolerant varieties multiplied and distributed.

From the outset the project has worked mainly with locally adapted cultivars. These have either been local 'landraces' with some tolerance to CBSD, that were identified in previous projects, or selections from the in-country cassava breeding programmes. The use of local varieties or landraces already being grown, has allowed the project to distribute then without the need for official variety approval. In the case of one of the 'improved' selections from the Naliendele programme, NAL 34, this has now been approved by the variety release committee.

The work is at a different stage in each country where the project has operated: Tanzania, Mozambique and Malawi. In Tanzania five promising CBSD-tolerant varieties have been identified, evaluated in participatory on-farm trials and multiplied for wider distribution. In Mozambique, local varieties that were identified as CBSD-tolerant by earlier CPP projects were immediately taken up by a number of other project for multiplication and distribution. The CPP project provided technical inputs to one of these project funded by US AID and implemented by Save the Children. Over a 5 year period 50,000 people received cuttings of the CBSD-tolerant variety, Nikwaha. The CPP project also supported the INIA programme to undertake participatory screening and evaluation of prospective CBSD-tolerant lines. In Malawi, where the CPP is the sole donor for CBSD-related research, the process is at an earlier stage. Accessions with some tolerance to CBSD were identified, on-station in 2002/2003 and 2003/2004 and in November 2004, those that looked promising were evaluated on-farm.

Cassava planting material is bulky to handle and the multiplication factor is low compared to seed. A research project has only limited capacity for multiplication and distribution. In Tanzania, we have undertaken primary multiplication of the CBSD-tolerant varieties on station at ARI Naliendele [NARI] in the Southern Zone [SZ] and at the sugarcane Research Institute [SRI] in the Eastern Zone [EZ]. Two other sub-stations have been used in the SZ. This has provided enough planting material for 13 villages, nine of which were also used for participatory variety evaluation. In the EZ the project established a collaboration with an extension project funded by Irish aid [EZCORE] in which they used cassava cuttings from SRI to set-up community multiplication sites in their 30 contact villages.

CBSD-tolerant varieties identified

Tanzania

Nachinyaya	UK G 93/041
Kiroba	TMS 8475
Kigoma Red	TMS 82/0061
Namikonga	Naliendele 34
Kitumbua	
Kalulu	
Kikombe	

Mozambique

[Only preliminary evaluations have been carried out]

Nikwaha
Mulaleia
Nachinyaya
Chigoma Mafia
Mwento Waloya

Binte Massuea
MZ 89001
MZ89186

Malawi
[based on survey]

Gomani	CH95/196
20:20	CH95/102
Korobeka	BA95/070
Nyankwazi	MK 96/054

Table 1.1a. Yield performance of 4 CBSD-tolerant cultivars in on-farm trials conducted in five villages in southern Tanzania [2001/2002].

	Villages and yield [kg/plant]					
Cultivars	Ziwani	Mtniko	Mtua	Chisegu	Tulieni	MEAN
Nal 34	0.80	0.47	4.00	0.71	1.81	1.56
Kitumbua	0.68	0.40	2.37	0.61	1.16	1.04
Kigoma	0.70	0.27	1.83	0.60	1.15	0.91
Namikonga	0.41	0.22	2.34	0.57	1.05	0.92
MEAN	0.65	0.34	2.64	0.62	1.29	
LSD*[p =0.05, 12 df]						±0.53

*Analysed as randomised block with 5 reps

Table 1.1b. Yield performance of 4 CBSD-tolerant varieties in on-farm trials conducted in five villages in southern Tanzania [2002/2003].

	Villages and yield [kg/plant]						
Varieties	Ziwani	Mtniko	Mtua	Chisegu	Tulieni	Madaba	MEAN
Nal 34	1.76	0.98	1.06	0.99	1.62	1.14	1.26
Kitumbua	1.06	1.14	1.28	1.09	1.81	1.38	1.29
Kigoma	0.81	0.97	0.89	0.91	0.89	1.06	0.92
Namikonga	0.25	0.52	0.77	0.48	0.67	0.71	0.57
MEAN	0.97	0.90	1.00	0.87	1.25	1.07	
LSD[p = 0.05, 15 df]							±0.29

On-farm evaluation of four CBSD-tolerant varieties was completed at the end of 2003 with Naliendele 34 and Kitumbua outyielding the older improved variety Kigoma Red [Table 1.1]. It was unfortunate that during 2002 and 2003 whitefly populations were

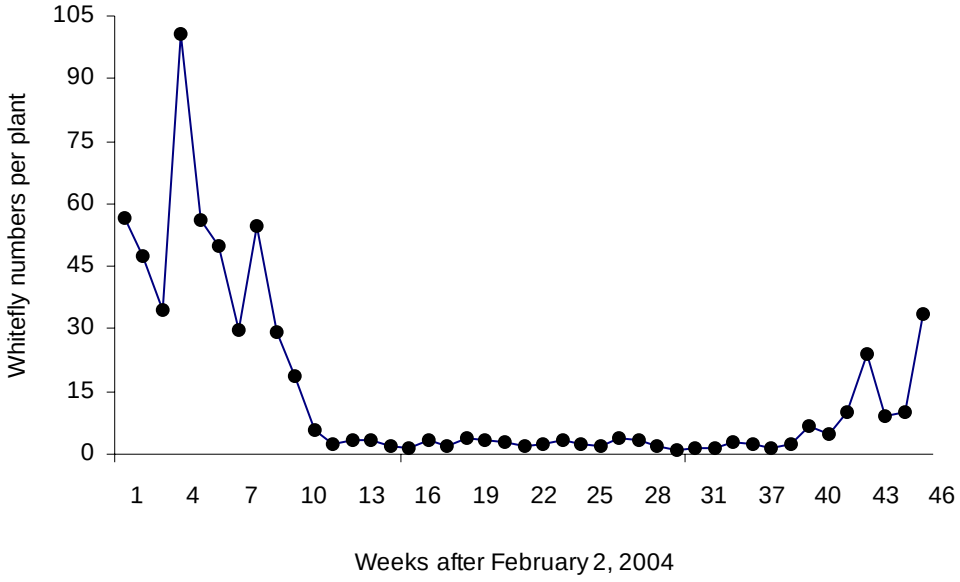

Fig.1.1. Weekly changes in total whitefly populations at NARI [2004]

very low and little disease transmission took place, so it does not mean much that our varieties remained free of CBSD and CMD at all sites.

The same lack of inoculum pressure hampered screening efforts also at NARI and it was only in 2004 when whitefly populations were high [Fig.1.1] that we were able to obtain data on the response of different varieties to virus diseases. Table 1.2 shows the results of a trial to compare some recently collected local varieties with Naliendele 34 and Kigoma Red. The local variety Chindumoto seems to have tolerance to root necrosis and also yielded well, as did the improved line KBH 96/094 [ANOVA not provided by collaborators by report submission date].

Table 1.2. Response of some local and improved cassava varieties to CBSD root necrosis at NARI Mtwara [2004]

Varieties	Necrosis Score 1-5	Yield* kg/plant
Nal 34	1.00 [1.0]	0.91
Sheria	2.75 [3.0]	0.34
Kigoma	1.25 [2.0]	0.65
KBH 96/094	1.00 [1.0]	0.80
Kibandameno	1.25 [2.0]	0.65
Chindumoto	1.00 [1.0]	0.89
Mreteta	2.00 [3.0]	0.47

At Kibaha, Nal 34, Namikonga and Kikombe remained free of root necrosis. Kikombe also seems to have some resistance to CMD [Table 1.3]. Namikonga yielded poorly due its being a late-bulking variety.

Results from the trial at Chanika village look rather different to the trial at Kibaha. Nal 34 was badly affected by CBSD root necrosis [Table 1.4]. Namikonga produced a good yield. Unless the varieties have been mixed up, this is the first time Nal 34 has shown severe root necrosis. This is an important result and Nal 34 should be further tested at Chanika to see if this result is repeated.

Table 1.3. Yield and disease response of CBSD-tolerant varieties at SRI Kibaha [2004]

Varieties	Emergence %	Disease incidence CMD %	CBSD %	Necrosis score 1 – 5	Yield t/ha
Kiroba	88	23	26	1.08	4.34
Nal 34	88	79	6	1.00	6.70
Kitumbua	88	9	17	1.10	5.39
Kigoma	93	31	49	1.13	3.30
Namikonga	98	29	0	1.00	1.83
Kibaha	95	57	0	1.03	6.13
Kikombe	98	3	0	1.00	5.49
LSD		22	*	0.14	2.57

*No LSD due to %0 zero values

Table 1. 4. Yield and disease response of CBSD-tolerant cultivars at Chanika village [2004]

Variety	Emeregence %	Disease incidence CMD %	CBSD %	Necrosis score 1-5	Yield t/ha
Kiroba	96	60	52	1.11	15.98
Nal 34	64	85	87	3.07	6.67
Kitumbua	56	80	62	1.84	15.08
Kigoma	43	55	60	1.69	11.00
Namikonga	95	22	5	1.04	13.12
Kibaha	69	65	58	1.72	10.98
Cheupe	59	72	48	2.33	8.06
LSD		26	30	0.58	8.50

OUTPUT 2. CBSD-tolerant varieties evaluated in Mozambique.

This component of the project was implemented by the Mozambican National Root Crops Programme at the National agricultural Research Institute [INIA]. They undertook a number of on-station and on-farm screening for reaction to CBSD.

Table 2.1. Disease incidence and root necrosis from trial data collected at Mogincual, Mozambique [2002/2003].

Clone N-	Disease incidence (%)			CBSD	Clone selected
	CBB	CBSD	CM	Root necrosis severity Score 1 - 5	
1. PAN 0176	63	6	63	5.0	
2. PAN 0171	100	0	25	4.0	
3. PAN 0136	100	81	19	5.0	
4. PAN 01127	100	13	0	5.0	
5. PAN 0114	100	0	0	5.0	
6. PAN 0144	50	0	0	5.0	
7. PAN 0140	100	6	0	3.6	
8. PAN 0181	63	44	0	3.8	
9. PAN 0148	0	19	0	1.0	x
10. PAN 01119	100	0	0	5.0	
11. PAN 013017	94	0	25	1.0	x
12. PAN 01124	100	13	0	1.0	x
13. PAN 0156	50	31	0	1.0	
14. PAN 012	50	0	19	1.0	x
15. PAN 0178	94	0	75	1.0	x
16. PAN 01122	100	0	31	5.0	
17. PAN 0133	13	0	13	5.0	
18. PAN 0191	0	0	19	1.0	x
19. PAN 0132	100	44	25	3.5	
20. PAN 0110	31	0	0	1.0	x
21. Likonde	100	0	0	1.0	x
22. TMS30395	25	6	0	4.0	
23. Nikwaha	88	0	88	1.0	x
24. TMS3001	0	0	0	3.0	
25. Murwemulhe	100	100	50	2.0	

CBB= Cassava Bacterial Blight; CBSD=Cassava Brown Streak Virus; CM= Cassava Mosaic

Table 2.2. Tolerant cassava clones to CBSD displayed during the field days in Mozambique

Descriptor		MZ89186	MZ89192	MZ89001	MACIA 1	NIKWAHA	TMS30001	MACIA 2	Kigoma Máfia	Likonde	Nachinyaya
Root	Epiderm texture	Lisa	lisa	Lisa	lisa	Ruguso	Ruguso	Liso	rugosa	rugosa	lisa
	Periderm C	white	white	white	white	brown	brown	white	dark brown	dark brown	white
	Cortex C	white	white	white	white	white	white	white	rosada	white	white
	Polp Color	white	white	white	white	white	white	white	crème	white	white
	Forma	cilindric	conic-cilindric	cilindric	conic-cilindric	conic-cilindric	cilindric	cilindric	conic-cilindric	conic-cilindric	irregular
	Taste	beeter	beeter	beeter	beeter	sweet	beeter	beeter	sweet	beeter	sweet
	Length	long	long	long	long	long	long	long	long	long	intermêdio
	Average Yield	18	22	17	14	17	16	12	22	in study	12
Stem	C	grey	grey	grey	grey	orange	grey	Marr-light	dourado	grey	grey
	Hight 1ª B(cm)	15	20	27	100	100	30	150	90	100	50
	c terminal stem	green	green	green	green	green	green	purpure	green-purpure	green-purpure	green-purpure
	internodo	short	short	medium	medium	medium	medium	medium	medium	medium	medium
Leaf	Expanded leaf C	green dark	green dark	green light	green light	green	green	green	green	green	green
	Inexpanded leaf C	green dark	green purpure	green dark	green purpure	green dark	green dark	green purpure	purpure	purpure	green dark
	Pubescence	absent	absent	absent	absent	present	absent	absent	absent	absent	present
	Nº lobuls	7	7	9	7	5	7	7	5	7	7
	Forma dos lobulos	lanceolat	eliptico lanceolat	eliptico lanceolat	obova-lance	lanceolat	lanceolat	lanceolat	lanceolat	lanceolat	lanceolat
	Cor da nervuras	green	green and red	green	green	red	green avermelha	red	red	purpure clara	green-red
	Peciol C	green yellow	red green	green yellow	green yellow	red	green yellow	red	red	green purpure	purpure
Pest	CGM	4	4	4	3	1	4	3	3	2	2
	CM	3	3	3	4	2	3	3	4	2	2
Disease	CM	2	1	1	2	2	1	2	2	2	2
	CBSD* roots	1	1	1	1	2	1	1	1	1	2
	CBSD* leaf	2	1	2	2	2	2	2	1	2	2

* Results from trials and surveys

Entries in the screening trial [Table 2.1] were selected for further evaluation on-farm, if the root necrosis score was low unless the score for CMD was high. Seven of the PAN lines and the local varieties Likonde and Nikwaha were selected, several of which showed good resistance to both virus diseases. A full description of the CBSD-tolerant cassava lines and varieties available to farmers is given in Table 2.2.

OUTPUT 3. Germplasm between Tanzania and Mozambique exchanged.

Achievements

The planned activities to transfer virus-indexed material between Tanzania and Mozambique were not carried out, as a number of CBSD-tolerant local varieties were identified in all the countries where CBSD occurs and there was no demand for exchange of germplasm. Instead, IITA requested NRI to provide them with tissue-cultured plantlets of two Tanzanian varieties. In connection with their work on genetic modification of cassava for virus resistance based on virus coat protein, IITA required virus-free material of a known CBSD-susceptible cultivar from Tanzania. We were able to supply them with 20 plantlets of cv. Albert that were virus indexed [both CMDs and CBSD] and a further 20 plantlets of cv. Kigoma red which is fully susceptible to infection by CBSV, but has some tolerance to root necrosis. The material was virus-indexed before being sent to IITA and confirmed free of CMGs and CBSD. The request for this material came to NRI from Caroline Herron, an IITA molecular biologist based at ARI Mikocheni in Dar es Salaam, with whom the CPP project has close contact. The plantlets were sent to Dr Ivan Ingelbrecht at IITA in February and March 2005. These will be multiplied and used in transformation experiments to confer resistance to CBSD. Cv Albert was once popular in Mtwara [s. Tanzania] until it was largely abandoned due to its high susceptibility to CBSD root necrosis. If a modified Albert could be obtained that was CBSD-resistant, it would be readily adopted.

OUTPUT 4. Technology on CBSD transferred

Achievements

MOZAMBIQUE
Save the Children
At the beginning of the project we continued to provide STC with technical advice for their cassava multiplication and distribution programme. We also made a film with them about the impact of CBSD on food security in Nampula. which was produced by Television Trust for the Environment and screened on BBC World Service. We also conducted a survey with STC to assess the different ways that CBSD impacted on food security and poverty.

The survey results emphasise reports by NRI, Save the Children, World Vision and other organisations, that there is an acute food shortage in some of the coastal districts of northern Mozambique that rely heavily on cassava for their food security. The food shortage is due to the prevalence of CBSD. Although I have worked on CBSD in Tanzania for many years, I was surprised by the seriousness of the problem in the three districts of Mozambique that we visited. The survey has revealed two important aspects of the impact of CBSD that were not fully appreciated before. Firstly, that the main harvest period is on average one - two months earlier than was the case before 1994. Some households harvest as much 3 - 4 months earlier than the optimum date of September/October. In these districts the practice of leaving cassava in the field for two or even three season has been lost due to the increased severity of root rot the longer the crop remains in the field. This has a major impact on food security in the lean months of February/March, before the short season crops are harvested. Secondly, and related to the first point, planting material has become very scarce in some villages, as cassava is increasingly harvested early, requiring longer storage before planting. Longer storage leads to loss of viability that might be

exacerbated by mealy bug infestation of the cuttings. It was interesting that the belief that mealy bug was the cause of root rot was common in all nine villages. There does not seem to be any scientific basis for this and CBSD was first reported long before CMB arrived in Africa.

Given that cassava is the staple food in the survey area, it is a worrying situation when some people in several of the villages we visited said that they had not planted cassava this year. This is due it seems, to a combination of having lost their planting material and lack of incentive to find more, on the basis that the crop would inevitably be affected by CBSD.

1. In the districts of Nacala Velha, Memba and Mossuril, the amount of cassava being harvested has gone down dramatically since 1994.

2. The decrease in cassava production is due directly and indirectly, to CBSD-induced root necrosis.

3. CBSD has decreased cassava production in three ways:

a) Through direct loss of root due to rotting, that increases the longer the crop is left in the field.
b) Through early harvesting before roots reach their optimum size.
c) Through loss of planting material.

4. There is an additional impact on food security as farmers no longer leave cassava in the field into the second season.

5. Planting material is lost due to early harvesting and the consequent need to store cuttings for 4 - 5 months before the rains arrive.

MOZAMBIQUE
INIA
When no further inputs were required to the STC programme, the project began to support the INIA CBSD programme. The initial identification and surveys of CBSD in Mozambique were conducted by NRI in earlier CPP-funded projects. The methodology was transferred to the National Programme which undertook further surveys during 2003 in Nampula and Zambezia Provinces and conducted the first survey of Cabo Delgado Province that borders southern Tanzania.

Surveys were conducted in northern Mozambique to give a fuller picture of disease distribution and incidence. The northern Province of Cabo Delgado [CD] was not included in previous surveys organised by NRI. CBSD was widespread also in CD but incidences were not as high as those reported from Zambezia and Nampula. CBSD was however, found in all districts in the three northern coastal Provinces of Mozambique [Fig. 4.1].

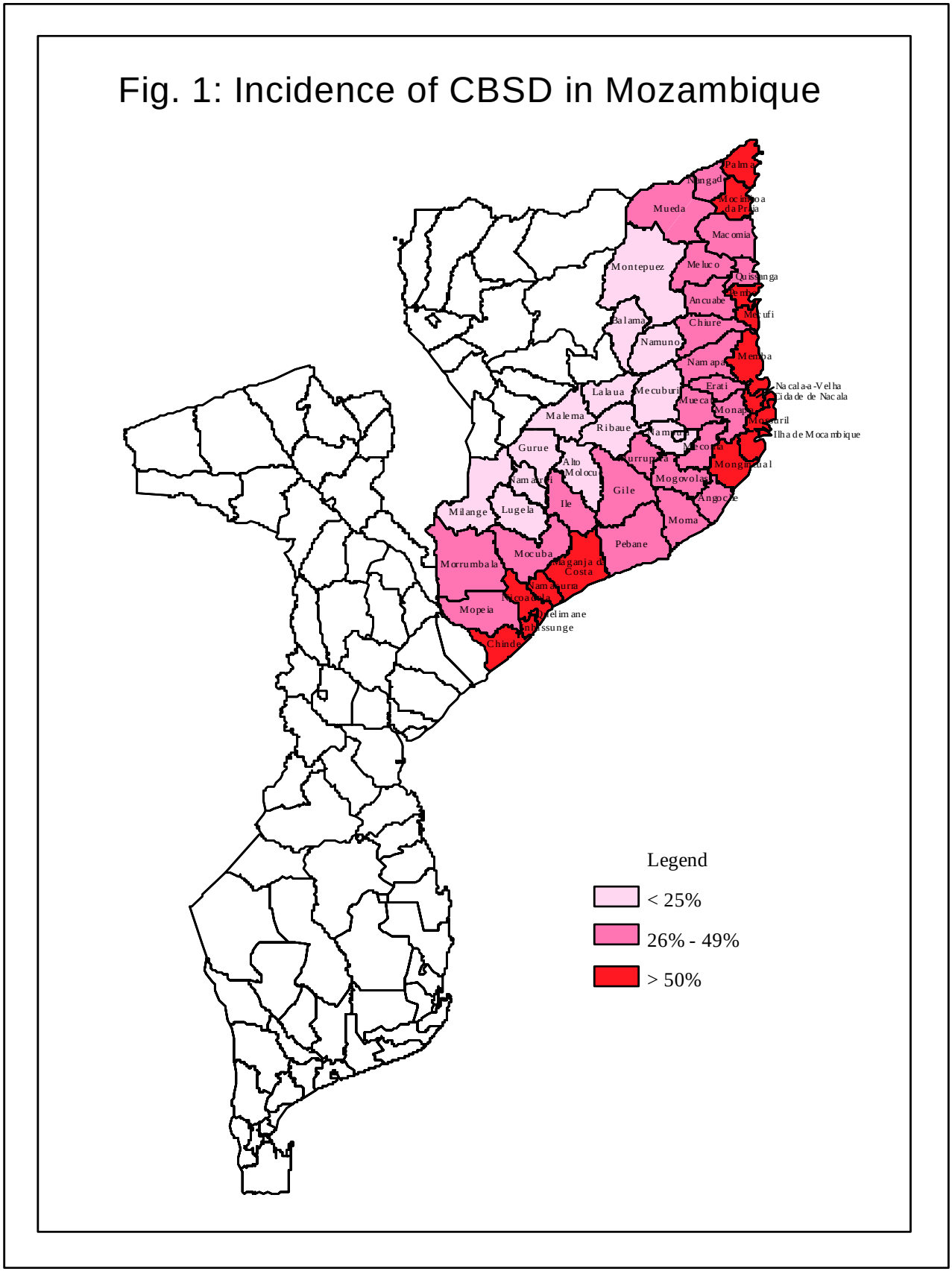

Fig. 4.1. Incidence of CBSD leaf symptoms by District in the three northern coastal Provinces of Mozambique [Cabo Delgado, Nampula and Zambesia]

MALAWI
SARRNET & Ministry of Agriculture
In Malawi the project has worked with the National root Crops Programme with SARRNET acting as the sub-contractor. The previous CPP project completed the first nation-wide survey for both the main cassava virus diseases in Malawi. CBSD was found to be present at high incidences on the coastal strip of Lake Malawi which is the main cassava area of the country. In the present project we collected over 50 local varieties and screened them for their reaction to CMDs and CBSD at Baka sub-station near Karonga, which is a 'hot-spot' for CBSD. Most of the varieties developed foliar symptoms of CMDs and CBSD in either or both 2003 and 2004. However, some of the varieties appeared to be tolerant of CBSD root necrosis. Only one variety might also have some resistance to CMDs [see below]. During the extension

Most promising entries over two seasons of screening in Malawi
[Entries resistant to both CBSD and CMD and entries resistant only to CBSD]

1. Resistant to CBSD and CMD over both seasons:

Banga

2. Resistant to both diseases in 2003 but not planted in 2004

Mulanje

3. Resistant to CBSD in both seasons

Balaka
Chitembwere Kapantha
Chitembwere
Masoyabazungu

4. Resistant to CBSD in 2004 but not planted in 2003

Tukuyu
Nyautonga
Nyaninki
Masoghanawahindi

Improved varieties included as resistant checks

Mkondezi
Sauti

International checks

TMS 42025 [highly susceptible to CBSD]
TMS 30001 [less susceptible to CBSD]

KENYA
University of Nairobi
The Project Leader was involved in submission from Rose Njeru at University of Nairobi of a proposal to Rockefeller Foundation [Forum on Agricultural Resource husbandry].The project title is: 'An integrated management of cassava mosaic and

cassava brown streak disease in coastal Kenya'. Delays in approval meant that this project did not begin until the CPP project was almost. Within the period project extension, one visit will be made to Kenya to provide supervision to one of the MSc students attached to the project.

TANZANIA
Rockefeller Foundation CBSD Breeding Project
Technology transfer – additional funds were provided by CPP for technology transfer and capacity building activities. Dr Maruthi from NRI spent two weeks at MARI training local staff in PCR diagnostics for CBSD and CMD, including the Uganda variant. MARI now has the capability to use PCR methods to detect CBSV and CMVs in material that may not be showing symptoms. A laboratory manual of PCR protocols for diagnosis of CMDs and CBSD was produced. This capacity will be particularly useful to the recently appointed Biotechnologist, Caroline Heron.

Networking - The CPP project has worked closely with the IITA/Rockefeller Project. The CPP Project Team Leader made several visits to Mikocheni Agricultural Research Institute [National Centre for Biotechnology] to discuss CBSD issues with Dr Kanju andCaroline Heron, when she was appointed in July 2004. In addition, a joint visit to Mozambique was made in October 2004 with Ms Mtunda funded by the CPP project to join Dr Kanju in visiting CBSD programmes run by INIA and by Save the Children in Mozambique [see visit report]. The visit served two purposes:1. Project management to obtain an update on INIA activities funded from the CPP project, 2. To foster regional collaboration in CBSD research.

UGANDA
NARO-Namulonge Research Institute
In November 2004, John Colvin [NRI] with Chris Omongo [NARO] found large numbers of cassava plants at Mukono ARDC showing symptoms resembling those of CBSD. Leaf samples were sent to NRI and PCR diagnostic tests confirmed the presence of CBSV. It seems that CBSD has spread in Uganda as a result of the very high whitefly populations occurring there. The source of the infection may never be known although CBSD was accidentally introduced into Uganda in the 1930s. At the time it was thought that the disease had been successfully eradicated and it has not been reported in Uganda over the last 70 years. This is the first record of the spread of CBSD in the Lake Victoria Basin and at altitudes above 1000 m. Continued spread of CBSD in Uganda would be potentially threatening to food security, especially coming so soon after the CMD epidemic.

OUTPUT 5. Knowledge on CBSD and its control transferred

Achievements

SCHOOLS PROGRAMME - Six secondary schools were selected for the project by District Education Officers to participate in the community multiplication scheme. One teacher from each school joined the training sessions at the Naliendele MATI designed for village extension officers, where they received training in cassava crop production and post harvest utilisation. Messages about crop management and the potential for value added products such as high quality flour were developed into teaching modules for secondary schools.

The teachers and children participated in planting and managing the cassava plot. Most of the schools seemed to have sufficient land to allow the multiplication plot to

be well isolated from other cassava. This was an advantage over the villages where the plots were close to other cassava plots that were often heavily infected with both CMD and CBSD. This led to massive infection of the CBSD-tolerant cvs with virus diseases which was avoided at the schools sites.

EXTENSION SERVICES - One of the M & E activities [see Output 7] was to assess knowledge of CBSD among extension officers. Results showed that knowledge was still poor. In order to deal with this a retraining session was organised with the Ministry of Agriculture Training Institute [MATI] at Naliendele. This first involved project input to a 'training of trainers' workshop to raise the knowledge levels of the instructors in all aspects of cassava cultivation, pest management and post harvest processing.

FM RADIO BROADCASTS - The radio programmes were made by the Lindi studio of Radio Tanzania. Design of the programmes involved Mrs Hamza with Mr Fakihi from the Extension Liaison Office at Naliendele, and broadcast in 2003. The programmes were broadcast on national radio and repeated on Radio Tanzania local to Mtwara/lLindi.

INFORMATION LEAFLET – The Extension Liaison Office at Naliendele with inputs from the Root Crops Section [Mr Raya] designed a leaflet in Kiswahili that described symptoms and control of CBSD. The CPP project provided funds for the colour separation and printing of the leaflet. 4000 copies were made and distributed to District Extension offices and directly to farmers in our contact villages, at workshops and farmers fairs.

INFORMATION POSTER – high quality, laminated posters were produced by the Publications Department at University of Greenwich at Medway, based on designs by Rory Hillocks. Two complementary posters depicted CBSD symptoms on one and CBSD control on the other. CBSD resistant varieties were listed and where they could be obtained. The text was written originally in English and translated into Kiswahili by Marton Muhana [SRI] and Portuguese by Chande Osufu [STC]. An English version was distributed in Malawi, the Kiswahili version in Tanzania and the Portuguese version in Mozambique. Fifty copies were printed in each language and distributed to District and Village Extension Offices to be displayed in a prominent location.

TELEVISION PROGRAMME - Television Trust for the Environment [TVE] have been contracted by the BBC to make programmes for the series 'Earth Watch' on the World Service. TVE contacted me after they approached CPP for some ideas and the CBSD project was suggested. In Mozambique the project works closely with a consortium of NGOs, including Save the Children and World Vision. I then contacted Save the Children, as they are working in an area where CBSD is particularly important. They were keen to be involved in the programme and I put TVE in touch with them to finalise the arrangements. CPP then agreed to provide funds to cover some of my time and T&S as an add-on the existing CBSD project, to enable me to travel to Mozambique to ensure that the role of research was adequately covered. In particular, to cover the collaboration between the CPP-funded research that NRI is doing and Save the Children's food security project.

The programme was filmed over three days around the town of Nacala on the coast of Nampula Province in northern Mozambique. Cassava is the staple in this area and essential for food security. CBSD is present at high incidences and some of the local varieties are highly sensitive to root necrosis. Under such circumstances, CBSD

decreases the cassava available for consumption, contributing to food insecurity and famine. The filming was based on case studies of families whose cassava was badly affected by CBSD, showing the importance of cassava to their livelihoods and the effects of the disease on the crop. Farmers were interviewed in the field with a translator. Interviews were done with Save the Children staff in relation to food security and the work they are doing to combat CBSD, and with myself to cover the broader areas of research on the disease and its control.

Evaluation of the communication strategy:

Under M & E activities [see Output 7] the knowledge of CBSD – its recognition and means of control were evaluated among farmers in our contact villages in southern Tanzania and among extension officers. Farmers were informally surveyed but knowledge of CBSD among extension officers was formally assessed. The communication strategy was not particularly successful in Tanzania and most people interviewed had not seen any of the outputs.

Leaflets – these were the most successful because they were cheap to produce and large numbers could be distributed.

Posters – These were the least successful because of their high quality and cost meant that the numbers were limited. This led extension officers to treat them as precious possessions which they kept at home or in the r office drawer to be used for workshops and to give to selected individuals. We did not find a single District Extension Office that was displaying the poster. A request was made to District Extension officers that the poster be displayed as son as possible. It seems that if posters are to be useful they need to be available in large numbers.

Radio – few farmers and few extension officers had listened to the radio broadcast. Most respondents said that either they did not listen to the farming programme or that their radio was not working at the time of the broadcast because they did not have batteries.

OUTPUT 6. Vector transmission studies

Achievements

Insect transmission - whiteflies were thought to be the insect vector of CBSV right from the earliest descriptions of the disease. When the causal agent was recently placed among the ipomoviruses, this further indicate a whitefly vector. However, experiments in Kenya in the 1970s failed to transmit CBSD with *Bemisia tabaci*. In previous CPP projects we have conducted transmission experiments in cages with both *B. tabaci* and the other whitefly on cassava in Africa, *B. afer*. Most of the experiments did not achieve transmission but on two separate occasions in Tanzania, a single test plant became infected. Successful transmission was not confirmed by PCR.

Experiments continued at NRI in the present project with some success. We have been able to demonstrate conclusively that *B. tabaci* transmits CBSD between cassava plants and transmission was confirmed by PCR. A paper describing this finding has been accepted for publication. However, transmission rates were low and reproducibility was unpredictable. At the present time we are unable to say which environmental factors affect transmission. We were unable to confirm transmission

by *B. afer*. The recent appearance of CBSD in Uganda would seem to be due to the present high populations of whitefly (predominantly *B. tabaci*).

Table 6.1. Summary of different types of transmission experiments carried out both in the controlled glasshouse/insectary and field conditions to identify the vector of CBSV using *B. afer* and *B. tabaci* populations

Sl. No.	Experiment type	Location	Whitefly species or treatment	No. of replications	No. of inoculations	Total No. of whiteflies transferred	Total No. of cassava plants infected/ No. inoculated
1	1st controlled transmission[1]	Insectary, NRI, UK	*B. tabaci* + *B. afer*	3	3	120 (60 each)	3/15
2	2nd controlled transmission[2]	Insectary, NRI, UK	*B. tabaci*	3	2	40	0/12
			B. afer	3	2	40	0/12
			B. tabaci + *B. afer*	3	2	60 (30 each)	0/15
3	3rd controlled transmission[2]	Insectary, NRI, UK	*B. tabaci*	3	2	40	2/10
			B. afer	3	2	40	0/10
			B. tabaci + *B. afer*	3	2	60 (30 each)	0/10
			Control - uninoculated	1	-	-	0/3
4	4th controlled transmission[3]	Insectary, NRI, UK	*B. tabaci*	3	2	40	0/45
			B. afer	3	2	40	0/45
			Control - uninoculated	1	-	-	0/20
5	Cage transmission[4]	Glasshouse, Kibaha, Tanzania	*B. tabaci*	3	1	100	2/9
			B. afer	3	1	100	0/9
			1 control each for *B. tabaci* & *B. afer*	1	1	100	0/6
6	Cage transmission[5]	Insectary, NRI, UK	*B. tabaci*	3	1	1000	0/9
			B. afer	3	1	500	0/9

			1 control each for *B. tabaci* & *B. afer*	1	1	500	0/6
7	Field transmission	Field, Kibaha, Tanzania + Insectary, NRI, UK	*B. tabaci*	1	1	15-20	0/20
			B. afer	1	1	15-20	0/20
			B. tabaci + *B. afer*	1	1	30 (15 each)	0/15
			Beetles	1	1	15	0/12
			Thrips	1	1	5	0/7
			Control - uninoculated	1	-	-	0/12
8	Seed transmission	Glasshouse, NRI, UK	Seeds from diseased plants	5	-	-	0/89
			Seeds from healthy plants	3	-	-	0/32
10	Field trials	(a) Kibaha, Tanzania	-	1	-	-	207/900
		(b) Naliendele, Tanzania	-	1	-	-	151/900

[1]Five plants of cassava var. Albert were each inoculated with CBSV thrice and each time by *c.* 20 adults each of *B. afer* and *B. tabaci*. Experiment was repeated three times following the same protocol.
[2]Three or four plants of cassava var. Albert were each inoculated with CBSV twice and each time by *c.* 20 or 30 adults each of *B. afer* and *B. tabaci* together or separately. Experiment was repeated three times following the same protocol.
[3]Fifteen plants of *N. benthamiana* were each inoculated with CBSV twice and each time by *c.* 20-30 adults each of *B. afer* and *B. tabaci* together or separately. Experiment was repeated three times following the same protocol.
[4]Three healthy, one CBSD-infected cassava plant var. Albert and *c.* 100 *B. afer* or *B. tabaci* adults were placed in separate cages for six months. Three similar cages were set up for each whitefly species and two control cages without diseased plants.
[5]Three *N. benthamiana* plants, one CBSD-infected cassava plant and *c.* 500 *B. afer* or 1000 *B. tabaci* adults were placed in separate cages for six months. Three similar cages were set up for each whitefly species and one control cage without diseased plants.

Seed transmission - None of the 50 plants grown from seed collected in Tanzania from plants showing leaf symptoms of CBSD, showed symptoms of CBSD after six months in the NRI glasshouse. The plants grown alongside that were obtained from diseased cuttings showed typical symptoms. Absence of CBSV was confirmed in 30 randomly selected plants tested by RT-PCR. The new growth obtained after pruning of plants did not show symptoms. CBSD therefore, does not appear to be seed-borne

OUTPUT 7: Monitoring & Evaluation

A study was conducted in the Southern Zone of Tanzania by Mrs Hamza, the social scientist at NARI, in order to asses the knowledge on CBSD and its control in district extension offices and among village extension workers. The results were disappointing with only about one third of interviewed officers able to properly describe the symptoms of CBSD and to distinguish them from CMD [Table 7.1]. We responded to this situation by encouraging closer involvement between research [NARI] and training institutes [MATI] at Mtwara. We provided a' training of trainers' course to MATI staff, who then organised a retraining of village extension officers in aspects of cassava production and utilisation.

Table 7.1. Extension workers knowledge on CBSD and its control

Districts	Recognition of [say they know]		Are able to describe Symptoms of		Know how to control
	CBSD(%)	CMD(%)	CBSD(%)	CMD(%)	CBSD(%)
Mtwara(R)	71	100	14	29	29
Mtwara (U)	100	100	44	33	56
Tandahimba	50	83	6	39	6
Newala	100	100	40	47	27
Masasi	63	88	17	29	25
Tunduru	80	80	23	17	23
Nachingwea	57	71	19	24	24
Rwangwa	60	80	20	20	40
Lindi (R)	67	67	30	19	42
Lindi (U)	67	100	22	33	33
MEAN	**72**	**87**	**24**	**29**	**30**

The most important sources of information for extension officers to update their knowledge were:
Workshops/seminars (18%), books (18%), newspaper (14%), radio 13% and leaflets (8%).

Conclusions - Extension officers do not know the economic importance of CBSD. If you try to follow the chain of information from researcher to end users (farmers), there is a communication breakdown which makes it difficult for farmers to receive messages about agricultural innovation. This is because most of the time research findings bypass MATIs [Ministry of Agriculture Training Institutes] and extension [District Extension Offices]. The best route would be for information to travel from

research institutes through MATIs and from there to extension. Finally it has to go to farmers. Monthly training sessions (MTS) have stopped been funded by the national agricultural extension project (NAEP II) and extension staff do not normally receive research reports. Village Extension Officers were not confident in advising farmers on control of CBSD. There is an urgent need for VEOs to undergo retraining in cassava IPM and this could be combined with training in post-harvest management and utilisation. There should be closer integration of ARIs, MATIs and District Extension Offices.

Action Taken: As a result of this survey project staff organised a 'training of trainers' course to train MATI [Ministry of Agriculture Training Institute] at Naliendele on aspects of cassava production and processing, including recognition and control of CBSD and CMD.

Publications

Peer-reviewed papers

MUGA, T. and THRESH J. M. (2002) Incidence of cassava mosaic and cassava brown streak virus diseases in coastal Kenya. Roots **8**[1] 12 – 14.

HILLOCKS, R. J. & JENNINGS, D. L. (2003) Cassava brown streak disease: a review of present knowledge and research needs. *International Journal of Pest Management* **49**, 225 - 234.

THRESH, J. M and HILLOCKS, R. J. (2003) Cassava mosaic and cassava brown streak diseases in Nampula and Zambezia Provinces of Mozambique. Roots **8**(2), 10 – 15.

MARUTHI, M. N. (2004) Bionomics, morphometrics and molecular characterization of a cassava *Bemisia afer* (Priesner & Hosny) population. *International Journal of Tropical Insect Science* **24**, 323 – 329.

M. N. MARUTHI[1], R. J. HILLOCKS, K. MTUNDA, M. D. RAYA, M. MUHANNA and H. KIOZIA (2004) Transmission of *Cassava brown streak virus* by *Bemisia tabaci* (Gennadius) [In Press October 2004]

Internal reports

HILLOCKS, R. J. (2003) Report of a visit to Malawi to review project activities conducted by SARRNET and the National Root Crops Programme, 14 - 17 July 2003. Project R8227, Natural Resources Institute, Chatham, Kent, 2 pp.

HILLOCKS, R. J. (2003) Report of a visit to Tanzania to review CBSD dissemination activities, 17 - 24 August 2003. Project R8827, Natural Resources Institute, Chatham, Kent, 3 pp.

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HILLOCKS, R. J. (2003) Report of a visit to Mozambique to evaluate the different ways that CBSD impacts on food security in the coastal Districts of Nampula

Province covered by Save the Children, 27 September - 05 October 2003. Project R8827, Natural Resources Institute, Chatham, Kent, 3 pp.

MARUTHI, M. N. (2003) Report of a visit to Tanzania to train the staff of Mikocheni Agricultural Research Institute (MARI), on the use of PCR techniques for the diagnoses of cassava mosaic and cassava brown streak viruses, 15 - 25 November 2003. Project R8827, Natural Resources Institute, Chatham, Kent, 4 pp.

HILLOCKS, R. J. (2004) Report of a project management visit to Tanzania, 13 – 28 March 2004. Natural Resources Institute, Chatham, UK, 8 pp.

Working papers

F.M.T. GONDWE, N.M., MAHUNGU, R.J.HILLOCKS, M.D. RAYA, C.C. MOYO, M.M. SOKO , F.P. CHIPUNGU *and* I.R.M. BENESI (2004) Cassava brown streak disease in Malawi and implications for food security. Working Paper No 1071/1 , Natural Resources Institute, Chatham, UK, 15 pp.

Information leaflets and posters

ARI NALIENDELE (2003) *Kudhibiti Ugonjwa wa Matekenya wa Mihogo*. 4000 copies. Naliendele Zonal Centre for Agricultural Research & Development, Mtwara, Tanzania. [Information Leaflet] [Kiswahili].

NRI (2003) Cassava Brown Streak disease 1. Disease Symptoms 2. Disease Control. 150 copies. Natural Resources Institute [with Ministry of Agriculture in Tanzania, Save the Children in Mozambique and SAARNET in Malawi]. Natural Resources Institute, Chatham, UK.[Posters] [English, Kiswahili and Portuguese]

Other dissemination, training etc.

MARUTHI, M. N. (2003) A laboratory Manual on Molecular Characterisation of Cassava Brown Streak Virus. Natural Resources Institute, Chatham, UK, 19 pp.

This manual formed the basis of training on PCR-based diagnostic methods for detection of CBSV. Training was given to Ministry of Agriculture staff at ARI Mikocheni, 15 – 25 November 2003. [Mikocheni is the Biotechnology Centre for Tanzania].

GOULD, R. (2003) Stopping the rot. Earth Watch. BBC World Service. 5 min. Television Trust for the Environment [Television documentary][English].

HILLOCKS, R. J. (2004) Research Protocols for Cassava Brown Streak Disease. Natural Resources Institute, Chatham, UK. 24 pp.

HAMZA, H. (2004) Cassava virus diseases and post-harvest utilization of cassava. Naliendele Agricultural Research Institute, Mtwara, Tanzania. 15 July 2004.[One-day Training Workshop for Extension Officers and Secondary School Teachers]

Contribution of outputs to developmental impact
Project Goal: Ecology and epidemiology of cassava brown streak disease understood and improved control methods and strategies developed and promoted.

The project has contributed to the above project goal by promoting control measures for CBSD that were developed in predecessor projects. Food security is a pre-requisite for poverty reduction and rural development in Africa. CBSD is the main biotic threat to food security in the coastal regions of eastern Africa. Management of CBSD increases the useable root yield, improving food security and allowing surplus root production to sold directly or made into flour. Because of its direct effect on root quality, CBSD not only decreases food security but is also a constraint to the development of commercial cassava processing. The project has identified and promoted a control measure for CBSD which limits losses to the disease until more resistant varieties become available from the IITA programme. CBSD-tolerant varieties identified by the project have been widely distributed in Tanzania and Mozambique using village-based community multiplication, NGO food security projects and other rural development projects.

We have seen that selection of planting material does not work where, as is often the case, planting material is in short supply. Roguing out of plants showing symptoms can be effective when disease incidence is low, but both CMD and CBSD is often present at high incidences. The use of resistant [tolerant?] varieties is the only remaining method of control. From the outset, the CPP projects have focused on identifying tolerance to CBSD root necrosis in local varieties. Success in finding several such varieties in Tanzania and Mozambique has enabled the project [and other projects that have followed-on from our initial work], to move quickly to multiplication and distribution. This process is most advanced in Tanzania in collaboration with NARS and with the EZCORE project in Tanga. Based on initial advice from the project and some follow-up technical inputs, Save the Children [STC] in Mozambique, have been managing a US AID-funded project to multiply and distribute CBSD-tolerant cvs. The CPP project provided no funding to STC, as they are well-funded by US AID [US$ 5 million over 4 years]. In Mozambique the CPP project has contributed funds to the INIA programme on CBSD management. This has involved disease incidence surveys, variety collection and on-farm screening for reaction to virus diseases. In Malawi where there was no other source of funding on CBSD, the project is working though SARRNET with the Ministry of Agriculture, to identify and evaluate local cvs with resistance to both CMD and CBSD, and having agronomic and quality characters acceptable to farmers.

Cassava is the staple in most of coastal areas from Kenya to the Zambezi river in Mozambique which is the area affected by CBSD, with a population of 20 million people. Our research has shown that CBSD affects food security in a number of ways. Cassava planting material is very bulky to transport and the multiplication factor is low. The project did not have the resources to multiply and distribute the CBSD-tolerant cvs on the scale that has been possible in Mozambique, with the US AID funded disaster relief projects, managed by SARNET and STC. In Tanzania we have been able to expand the distribution process through collaboration with EZCORE. Given the limited resources, the approach we have adopted has been to provide virus-free planting material in relatively small quantities to farmers groups and schools and let them continue the multiplication and distribution. CBSD-tolerant varieties that have other attractive attributes have spread quite quickly amongst farmers and from village to village. This has been seen with cv. Nachinyaya, which was one of the first local varieties that we identified as being tolerant of CBSD root necrosis. Within 5 years Nachinyaya completely replaced cv. Albert, which predominated in Mtwara District up until 1998, but which was highly susceptible to

CBSD root necrosis. The availability of varieties that do not develop root necrosis, increases food security and also allows surplus production to be processed. Production of high quality flour decreases losses to larger grain borer, adds value and opens the way for the development of other value added products made from the flour such as biscuits. As a direct or indirect result of the project's activities, farmers in Tanzania and Mozambique now have access to a number of cultivars with tolerance to CBSD root necrosis. These have the advantage of being already adapted to local agro-ecologies and to local culinary tastes. However, these varieties have two draw-backs: They are susceptible to CMD and they are also susceptible to infection by CBSD although much less prone to the damaging symptom of root necrosis. In the longer-term, IITA cassava improvement programmes will try to develop varieties that are resistant to infection by CBSV. The methods for working with CBSD developed by this project and its predecessors are being used by recent projects implemented by IITA.

Although CBSD has been known since the 1930s, it was only in 2002, in a CPP project based at Bristol University, that the causal agent was described as a virus belonging to the potyviridae. In order to understand the conditions for rapid disease spread, we needed to know how the disease was transmitted. There had been many unsuccessful attempts in the past to identify an insect vector. This project has for the first time demonstrated that the virus can be transmitted by the whitefly [*Bemisia tabaci*], confirming transmission with PCR-based diagnostics.

During the earlier phases of this project, DFID-CPP was the only donor supporting research on CBSD. As a result of the work carried out by these projects, the profile of the disease has been raised and a number of donor and research organisations are now supporting CBSD projects. US AID has supported two disaster relief/food security projects in Mozambique. Rockefeller Foundation and IFAD are supporting projects, managed through IITA, to produce CBSD-resistant cassava varieties for East Africa. IITA has recognised the importance of the disease and made CBSD-resistance a priority for varieties intended for eastern and southern Africa.

The dissemination methods used by the project have helped to raise awareness among extension workers and farmers of CBSD and the control measures available. A radio programme was broadcast nationally and repeated within Mtwara and Lindi. An information poster was distributed to extension offices and contact villages in Tanzania [Kiswahili], Mozambique [Portuguese] and Malawi [English]. The project also contributed to an information leaflet in Kiswahili that was distributed to farmers in Tanzania.

ADOPTION:

There are four dissemination and adoption pathways for project outputs:

1. Through the National Extension Service. The project by providing evidence of poor knowledge of CBSD among village extension workers, stimulated collaboration between Naliendele ARI and Naliendele MATI to develop a training course for extensionists. Although for much of the project links with extension were poor this was much improved by the project end. District Extension Offices have been provided with information literature in the form of a leaflet and a poster on CBSD. In the Eastern Zone, the project has collaborated more directly with the Muheza District Extension Office to multiply and distribute CBSD-tolerant cvs, through the EZCORE project, funded by Irish Aid.

2. Through direct contact between research and farmers. This has been the main way that the project has worked and will be the main uptake pathway. In the southern Zone of Tanzania we have developed farmers groups in 6 villages to which knowledge of symptom recognition and control of cassava virus diseases has been transferred, They have participated in research trials to evaluate the CBSD tolerant cvs and at the end of the project became managers of tertiary multiplication plots. The case is similar in Mozambique where INIA have involved farmers directly in research through 'mother and baby' trials to evaluate CBSD-tolerant cvs. The process is less advanced in Malawi where newly identified CBSD-tolerant cvs went into on-farm trials only in 2004/05.

3. Secondary schools. Six secondary schools participated in a community casaba multiplication scheme which was linked to curriculum development agreed with District Education Offices. This is an excellent adoption pathway as it gets children interested in agriculture and the role of research, while also passing on messages that the children take back to their families.

4. CGIAR. It is the output from this project that has raised the profile of CBSD with IITA. The methods of research on CBSD that were developed by the CPP projects are now being used by a number of projects funded by international donors such as Rockefeller Foundation. The project produced two manuals on methods for research on CBSD, as a guide to researchers on other projects

EXIT STRATEGY:

Now that resistance to CBSD has been made a cassava breeding priority by IITA, continued funding for CBSD research beyond the life of the CPP project is assured. The new SARRNET programme will include CBSD in Malawi and Mozambique. The Rockefeller projects in Tanzania and Mozambique will continue after the end of the CPP project. The government in Tanzania is committed to increasing the acreage under cassava and District Extension Offices are expected to implement this policy. A large number of farmers and all District Extension officers in the Southern Zone of Tanzania have been trained in disease recognition and control. Community-based multiplication has been established in contact villages and schools in the Southern Zone of Tanzania and northern Mozambique [with Save the Children] which requires no further input to be sustainable. Community-based multiplication will be established also in eastern Tanzania under the project extension.

Until 2002, CPP was the only organisation supporting research on CBSD. As a consequence of research conducted by NRI under several CPP-funded projects, the importance of CBSD as a threat to food security has been recognised. Our work in Mozambique where we were the first to report the disease, led to a number of large food security-related projects supported by US AID. These projects have been based on large-scale multiplication and distribution of CBSD-tolerant varieties identified by the CPP project. IITA has now made resistance to CBSD a priority for new cassava varieties intended for the east coast of Africa. This has allowed them to solicit funding from Rockefeller Foundation and other donors to support the breeding programme.

Project Logframe

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Goal			
Livelihoods of poor people improved through sustainably enhanced production and productivity of cassava production systems.			
Purpose			
Ecology and epidemiology of cassava brown streak disease understood and improved control methods and strategies developed and promoted.	By 2005, adoption of virus disease management practices by cassava farmers giving 20% yield increases.	Monitoring against baseline data. Reports of target organisations.	Economic conditions continue to favour cotton production
Outputs			
1. CBSD-tolerant varieties multiplied and distributed.	Numbers of farmers who receive planting material in 2003 and 2004.	Project reports. NGO annual reports.	Absence of adverse weather conditions for cassava production.
2. CBSD-tolerant varieties evaluated in Mozambique.	Varieties collected and entered in on-station trials by November 2003.	Project reports and INIA annual reports.	No unexpected pest or disease epidemics. would adversely
3. Germplasm between Tanzania and Mozambique/Malawi exchanged.	Tissue cultured germplasm produced at NRI and distributed by November 2003.	Project reports.	Countries need the material and agree to exchange
4. Technology for CBSD management transferred from Tanzania.	Technical co-operation with other CBSD projects in the Region.	Annual reports of target organisations.	Continued support from donors for the NGO cassava distribution programmes in Mozambique.
5. Knowledge on CBSD and its control	CBSD diagnosis and	Radio programmes	

disseminated.	control methods disseminated through villages, schools and radio broadcasts.	broadcast.	
6. Knowledge improved of the mode of transmission and spread of CBSD.	Vector transmission experiments conducted at Kibaha and at NRI.	Project reports and scientific papers.	
Output 7. Monitoring and evaluation.	Output 7. Monitoring and evaluation.	Output 7. Monitoring and evaluation.	Output 7. Monitoring and evaluation.
8. FTR	FTR	FTR	
Activities	**Inputs**	**Means of Verification**	**Important Assumptions**
1.1. Multiplication of CBSD resistant varieties in Tanzania. 1.2. Distribution of CBSD-tolerant varieties in Tanzania.	Budget: £211,047	Quarterly and annual project reports.	Transport continues to be available in Tanzania. The project can continue to support contracted field staff at Naliendele.
2.1. Identification and evaluation of CBSD-tolerant varieties in Mozambique.		Quarterly and annual reports.	Continued co-operation from NGOs in Mozambique who provide transport and accommodation to project staff.
3.1. Exchange between Tanzania and Mozambique 3.2. Exchange between Mozambique and Tanzania.		Plantlets received	Absence of adverse weather or pest problems might affect multiplication of planting material.
4.1 Technical advice to NGO cassava distribution programme in Mozambique. 4.2 Technical advice to Rockefeller-funded MSc project on CBSD in Kenya 4.3 Technical advice to Rockefeller-funded CBSD-resistance breeding project based in Tanzania. 4.4 Work with		Visit reports	

SARRNET Malawi.			
5.1. Farmer field schools 5.2. Knowledge transfer in schools 5.3. Training of extension officers 5.4. Radio broadcasts		Project reports and teaching literature.	
6.1. Studies on field spread of CBSD 6.2. Vector transmission studies with potted plants. 7.1. Assess knowledge level of extension workers of CBSD and its control. 7.2. Assess knowledge of cassava virus diseases and selection of planting material among farmers - compare project with non-project villages. 7.3. Assess dissemination of CBSD-tolerant varieties. 8.1 Write and submit FTR		6.1 Project reports and peer-reviewed paper on disease spread. 6.2 Project reports and possibility of peer-reviewed paper if vector unequivocally demonstrated. Socio-economic report. Project reports. FTR	

Biometricians Signature

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

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

Signature:
Name (typed):
Position:
Date: