FINAL TECHNICAL REPORT

MANAGEMENT OF CASSAVA VIRUS DISEASES IN SOUTHERN TANZANIA

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EXECUTIVE SUMMARY

Virus diseases are the main biotic constraint to cassava production in Tanzania. In the Region cassava is affected mainly by two virus diseases, cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). The purpose of this project was to improve food security by minimising losses caused by these virus diseases. The activities consisted of on-station and on-farm field trials, biological and socio-economic surveys, the organisation of farmer research groups in five villages and basic research to identify the means of transmission and spread of CBSV.

A sustainable management strategy for the virus disease complex was developed that has three major components: The use of cultivars resistant to CBSD, the production and distribution of virus-free planting material, selection of virus-free planting material by farmers and roguing. For CBSD, disease incidence and spread was shown to decrease with increasing altitude from sea level and the components of the management system differ according to the zone. Disease resistance is essential for the low altitude zone of rapid disease spread. In the mid altitude zone of moderate disease incidence and spread virus-free planting material should provide adequate control when combined with phytosanitary measures by the farmer. At high altitude (above 400m), careful selection of planting material should be sufficient.

Understanding of the epidemiology was improved and CBSD shown to spread within a field from a line source and the rate of spread seemed to be associated with whitefly populations. However, we were unable to transmit the virus with whitefly in transmission tests. This remains a priority for further research.

Socio-economic surveys showed that farmers in the Southern Zone of Tanzania were highly aware of ‘root rot’ as a problem and it was mentioned as the primary production constraint by more farmers (36%) than any other factor.

The disease surveys were extended to the east African coast from the Kenya border through Tanzania to the Zambesi river in Mozambique. CBSD was recorded for the first time in Mozambique, where it was present at very high incidences. A number of local cultivars have been identified as having some resistance to CBSD, and one of these, Nachinyaya is rapidly replacing the CBSD-susceptible cultivar which previously predominated in Mtwara Region.

A system for the production of virus-free stocks was developed and a stock of three local cutlivars was produced by the end of the project, ready for further multiplication and distribution to farmers.

Farmer-research groups were set-up in five villages and initially they provided information on the potential for adoption of control measures and these groups are the focus of activities to test the disease management strategies in the proposed follow-on project proposal.

BACKGROUND

Vegetatively-propagated crops are prone to virus infection and cassava (*Manihot esculenta* Crantz) is no exception to this generalisation. At least seventeen different viruses of cassava have been described, of which eight are known to occur in Africa (Thresh *et al*., 1994). The main attention in Africa has been on the viruses causing cassava mosaic disease (CMD) and cassava brown streak disease (CBSD) which are the subject of this report. Relatively little attention has been given to the other viruses of cassava or to the diseases they may cause. There is limited information on their distribution and none on their effects on growth or yield. These are serious deficiencies and emphasise the inadequate attention given to the viruses of what is arguably, the most important African food crop.

Surveys conducted in a previous project (R5880CB) showed that CMD and CBSD were both present in Tanzania. CMD was more widely distributed, being present in all areas where the crop is grown. CBSD was restricted mainly to the coast or to areas below an altitude of 1000m (Legg and Raya, 199). However, in southern Tanzania, CBSD was more prevalent than CMD. Subsequent surveys confirmed these findings and in addition showed CBSD to have a direct effect on crop production through the associated symptom of root necrosis (Hillocks and Raya, 199). It was concluded that CBSD was the more important disease in coastal Tanzania but any management strategies would have to take account of the virus disease complex as a whole.

PROJECT PURPOSE

The project purpose was to develop management strategies for cassava virus diseases to minimise cassava losses and increase food security. This was done by a combination of socio-economic and biological surveys to assess the importance of the disease and identify control measures which would be acceptable to farmers. In addition, more strategic issues were addressed in field trials conducted on-station and on-farm. The outstanding basic research issue was to identify the insect responsible for transmission of the CBSV and this was addressed in screenhouse experiments conducted in Tanzania and at NRI.

RESEARCH ACTIVITIES

Research activities have been carried out in collaboration with Naliendele Research Station in the Southern Zone and Kibaha in the Coastal Zone. These activities consisted of socio-economic and biological surveys, field trials at both research stations, on-farm trials and preliminary work with farmer research groups.

Activity 1.1. Develop appropriate screening methods for resistance to CBSD and screen varieties for resistance.

1. In the previous project [5880CB] a method was developed for assessment of crop loss to CBSD. This method was adapted as a screening technique. The important features of the screening method are:

- Both foliar symptoms and root symptoms must be evaluated (see Figs 1 - 3). Above-ground symptoms are unreliable as they may disappear when leaves are lost and new leaf growth may be initially symptomless. Foliar symptoms should be recorded from first sprouting to allow for problems with symptom recognition later in the season.

- A scoring system was developed for above ground symptoms but this is not very easy to use as symptoms vary with cultivar and physiological age of the crop. This is particularly true of stem symptoms. It may not be worthwhile recording the severity of above ground symptoms other than; disease free, mild, moderate and severe (0- 4).

- At harvest all roots should be examined and given a score for root necrosis (Fig.) by cutting the root longitudinally. A mean root necrosis score can then be calculated fro each plant as total necrosis score/number of roots.

- The parameters to be recorded for each harvested plant are; severity of above ground symptoms at two dates, root weight, number of roots, root necrosis score and possibly also marketable yield. Marketable yield is found by discarding any roots with a necrosis score of 3 or above and reweighing.

2. One of the major achievements of the project has been to focus attention of the National Programme on the exploitation of genetic resources that are available within the local cassava cultivars (cvs.). During surveys, local cultivar names were recorded and any which looked to have some resistance to CBSD were collected for evaluation at Naliendele. The aim is to be able to provide farmers with virus-free planting material of cvs that they already know and wish to grow.

The system developed for production of virus-free stocks is as follows:

YEAR 1. Collection of promising cvs. from farmers' fields.

YEAR 2. Entry into observation trial at Naliendele.

YEAR 3. Those cvs that look to be resistant to CBSD and ACMD in the observation trial, go to first stage virus-free multiplication plots at Naliendele. Here, plants are inspected weekly and any plants with virus symptoms are removed.

YEAR 4. Second stage virus-free multiplication at Naliendele (repeat of year 3 and may be omitted for material which is already mostly virus-free).

YEAR 5. Virus-free stocks multiplied at Nachingwea (area of low disease pressure).

YEAR 6. Virus-free planting material distributed to farmers.

Activity 1.2/1.3/1.4 Farmer participatory trials to assess their ability to recognise symptoms and select virus-free planting material

Farmer research groups have been set-up in four villages in Mtwara Region. Each group consists of 30 farmers. The project worked with the socio-economist in the farming systems team at Naliendele who has developed close links with the research groups to obtain information on their ability to recognise virus symptoms and select planting material . It has not been possible to proceed further with the research groups but activities centred around the groups are the main focus of the follow-on proposal. Information on farmer perceptions and practices in relation to cassava cultivation and virus diseases has been obtained for the project by the farming systems team at Naliendele (Project Report No. 2) and by the root crops team at Kibaha [The team leader, Mrs Mtunda, is a socio-economist] (Project Report No.3). In addition, a number of on-farm trials were conducted in which farmers were shown virus disease symptoms on the foliage during the growing season and root necrosis symptoms at harvest in order to improve their understanding of the relationship between the two symptoms.

Activity 2.1 Screenhouse experiments on vector transmission

A screenhouse has been constructed at Kibaha Research Station by IITA/SARRNET which enabled us to conduct insect transmission experiments. The project built small insect-proof cages which were placed within the screenhouse. A plant infected with CBSD was placed in the cage with a test plant grown from seed. Whitefly collected from the field were placed in the cage. In addition the project provided some funds for similar work under more controlled conditions at NRI. Although initially, no successful transmission were achieved, the work on CBSD became part of a PhD programme and it is hoped that further progress towards identification of the vector can be made.

Activity 2.2/2.3 Studies on field transmission and spread of CBSD.

A number of field trials were conducted at Kibaha and Naliendele to determine if there was disease spread taking place. A plot of 30 rows by 30 stands was planted in isolation, using cuttings of a single CBSD-susceptible cultivar taken from symptomless plants. At one end on the plot, two rows were planted with infected cuttings. During the first month after planting any plants that showed symptoms of CBSD or CMD were removed. From the second month onwards new infections were recorded under the assumption that they were derived by transmission from the spreader rows. Under this activity whitefly populations at the research stations have been recorded and a small survey was undertaken to record whitefly populations on cassava in areas of high, moderate and low CBSD incidence.

Acidity 2.4 Field trials on the effect of CBSD on cassava root yield and quality

Yield loss assessment trials have been conducted at Naliendele and Kibaha. Two methods have been used. In the first series of trials, plots were planted with cassava cuttings of several cultivars taken from mother plants that were either showing symptoms of CBSD, or, were symptomless. Disease severity was recorded each month and root necrosis severity and root yield were recorded at harvest. A second trial was conducted in which plots were planted with infected cuttings and then harvested at 6, 8, 10, 12 and 18 months, to determine the period for which different cvs.could remain in the field before root necrosis symptoms developed.

Activity 2.5 Workshop

The workshop was not held as research activities consumed all of the time available and funding had to be organised to bring the participants from Mozambique and Malawi. Plans have been made to hold the workshop at an early stage of the proposed follow-on project, bringing together interested parties from Tanzania, Malawi and Mozambique. World Vision International (WVI) has committed funding for two people to attend from Mozambique.

Activity 3. Surveys of CBSD in coastal Tanzania and Mozambique.

In view of the importance of CBSD in the Southern Zone of Tanzania, additional funds were obtained to conduct a detailed survey along the whole length of the Tanzanian coast and also in Mozambique. The survey in Mozambique was conducted with the assistance of the DFID/World Vision International (WVI) Project in Zambesia Province and WVI/USAID in Nampula Province.

OUTPUTS

All outputs have been successfully achieved.

Output 1. Sustainable management strategy for cassava virus diseases based on disease-free planting material and resistant varieties developed and tested.

1. Screening system for production of virus-free stocks developed.

2. The screening method has been used to screen local cultivars collected during surveys and also some of the improved material in the National/SARRNET programme.

3. Some local cultivars appear to have some resistance or tolerance to CBSD. The first of these to be identified was Nachinyaya (Figs 4 and 5) and further tests have confirmed that it is 'tolerant' to the virus, in that root necrosis develops only very slowly in the cv. (Table 1.). It should be emphasised that Nachinyaya is nevertheless, fully susceptible to infection by CBSV and displays clear foliar symptoms. Nachinyaya has been enthusiastically adopted by farmers in Mtwara District where it is rapidly replacing the CBSD-susceptible cv. Albert, which predominated in the District when the project began.

Fig. 4. Month when first foliar symptoms were recorded in four cultivars

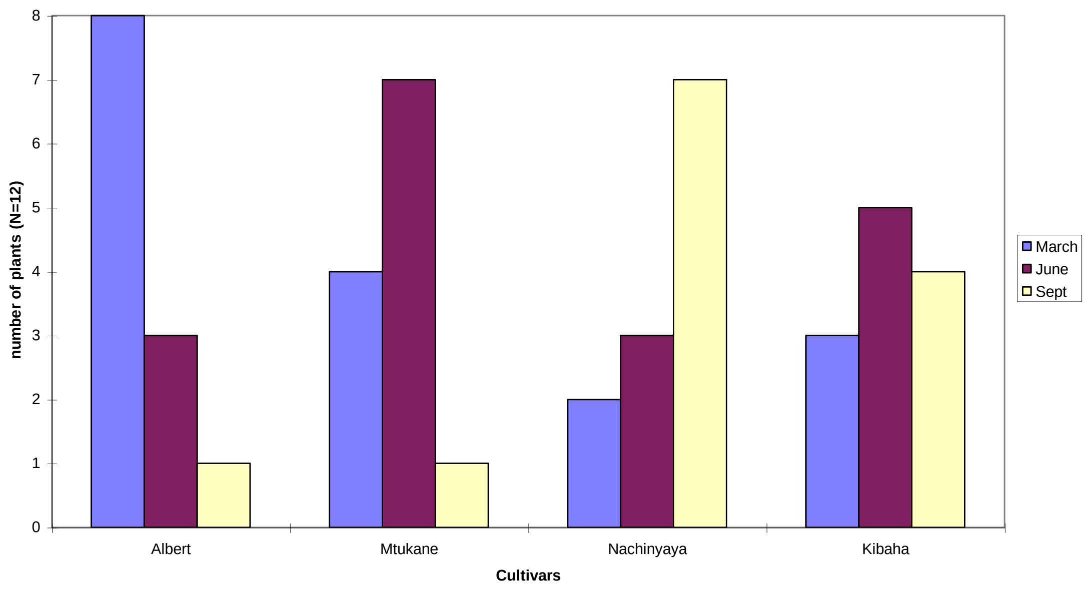


Fig. 5. Frequency distribution of scores for root necrosis severity in four cultivars infected with CBSD[score 1 = no disease.score 3 not recorded].

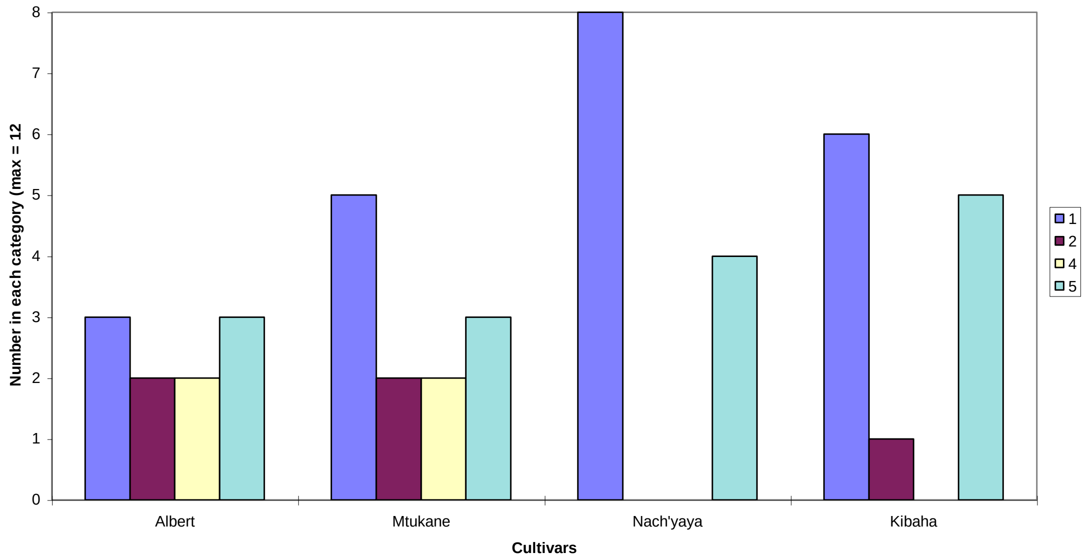


Table 1. Root necrosis severity and root yield in three cultivars at different intervals from planting to harvesting.

Cultivar and months to harvest	Root necrosis score (0- 4)	Root yield (kg)	Marketable yield (kg)
<u>Nachinyaya</u>			
6	0	1.03	1.03
8	0	1.27	1.27
10	0	1.13	1.13
12	1.0	1.00	1.00
18	1.30	2.87	2.74
<u>Albert</u>			
6	1.27	1.03	1.07
8	1.53	1.37	0.90
10	2.20	1.23	0.57
12	4.00	1.17	0.37
18	4.00	1.87	0.50
<u>Mreteta</u>			
6	0.87	1.03	1.10
8	1.73	1.70	1.33
10	2.57	1.40	0.63
12	3.67	1.10	0.43
18	3.33	1.37	1.00
LSD	0.67	0.67	0.58

4. Evidence from data collected at one of the World Vision trial sites in Mozambique suggests that the cultivar ‘Macia’ may be resistant to CBSD, as the entire plot was free of symptoms despite being surrounded by high levels of infection (Table 2.). This cv. might offer the potential for management of CBSD and should be further evaluated as soon as possible.

Table 2. Incidence of ACMD and CBSD recorded in multiplication plots of five cultivars at Mocuba Experimental Station, Zambesia Province, Mozambique.

Cultivar	ACMD (%)	CBSD (%)
TMS 30395	0	100
Muanange	30	100
Fernando Po	97	53
Mucudo-Muevia	47	30
Macia	10	0

5. Virus-free stocks of three cvs. have been produced and are ready for multiplication during the 1999/2000 season, prior to distribution to farmer research groups (follow-on proposal).

6. A number of field trials were conducted in the previous project to quantify the effect of CBSD on yield. Results were complicated by high incidences of CMD in the trials. This work was repeated in the present project and records made of CMD incidence in addition to CBSD incidence. The results support the previous findings that CBSD decreases root yield as well as root quality. Yield correlated more closely with CBSD severity than with CMD severity (Tables 3/4). Yield effects that are statistically significant are difficult to demonstrate because of the large variation normally found in root yield from one plant to the next. However, the data show that yields were significantly higher from plots grown from non-infected cuttings than from infected cuttings in two cultivars, Kigoma and Mreteta (Table 4.)

Table 3. Final score for CBSD/ACMD disease incidence and severity in four cultivars grown from cuttings taken either from plants showing symptoms of CBSD or from symptomless plants (Kibaha).

Cultivar	CBSD		ACMD	
	%	Score	%	Score
Infected mother plants				
Kigoma	84.6	2.83	12.0	1.20
Mreteta	45.0	1.80	55.2	2.10
Albert	95.4	2.75	0	1.00
Kibaha	7.5	1.08	0.7	1.08
Symptomless mother plants				
Kigoma	8.2	1.10	19.3	1.35
Mreteta	28.2	1.50	65.3	1.95
Albert	19.7	1.38	0	1.00
Kibaha	1.80	1.03	4.4	1.08
LSD		0.68		0.29

Table 4. Effect of CBSD on root yield in plants of four cultivars grown either from cuttings taken from symptomless plants or those showing symptoms of CBSD.

Cultivar	No. of roots per plant	% of plants with root necrosis	Root necrosis score (1 - 5)	Root yield (g/plant)
Infected mother plants				
Kigoma	1.0	58.0	2.53	151
Mreteta	1.7	44.6	2.38	266
Albert	2.5	67.1	2.98	505
Kibaha	0.6	32.3	1.58	120
Symptomless mother plants				
Kigoma	2.7	57.8	2.08	484
Mreteta	4.2	36.3	1.60	532
Albert	4.1	21.3	1.48	608
Kibaha	1.5	16.8	1.28	268
LSD	7.5		0.63	265

Output 2. Understanding improved of epidemiology of CBSD in relation to possible vector transmission.

1. Vector transmission studies have been conducted in screenhouses at Kibaha Research Station and at NRI. The prime candidate as a vector is the whitefly (either or both of *Bemisia tabaci* and *B. afer*). No successful transmissions have been achieved in Tanzania. This may however, be due to problems of methodology and the very hot conditions in the screenhouse which were unfavourable to the vector. A single transmission appears to have been made with *B. tabaci* at NRI in the PhD programme but at the time of writing this report, this had yet to be confirmed.

2. Field trials have been conducted to determine if CBSV spreads from plant to plant in the field. Results have varied with location, depending on the numbers of whitefly, the isolation distance of the trial from other sources of CBSD infection and the rigour with which early infections were removed from the trial. Results from the trial conducted at Naliendele show quite clearly that CBSD spread from the row of infected plants at one end of the plot (Fig. 6). The pattern of spread is clear in this case because whitefly populations were relatively small, there was no contamination with CMD and early infections were removed.

3. The absence of contamination with CMD in the trial conducted in 1999 at Naliendele allowed yield comparisons to be made between plants infected at different stages with CBSD and those which remained symptomless at the end of the trial (Tables 5/6). With the exception of the March score, when there were only three infected plants, the percentage of roots with necrosis decreased with increasing interval between planting and first symptoms. However, root necrosis severity on those affected roots was similar for all the infection dates. Loss in root yield was 68% for plants which developed foliar symptoms in April and was still 50% for plants first recorded with symptoms in July, only one month before harvest. Marketable yield was calculated by discarding from the harvest those roots with a root necrosis score of three or above. The additional loss ranged from 7 - 17%.

Table 5. Root necrosis and root yield in relation to date when symptoms of CBSD were first observed in the rate of spread trial at Naliendele (1999).

Date of first symptoms	No of roots per plant	% of roots with CBSD necrosis	Necrosis score (1-5)	Root yield (kg)
March (3)*	13	18	2	2.1
April (65)	7	44	2.3	0.96
May (27)	8	25	2.1	1.24
June (48)	6	28	2.1	1.00
July (6)	9	17	2.2	1.42
Symptomless (30)	11	0	1.0	3.03

* Figures in parentheses are the total number of plants showing first symptoms at each date and from which all other records were derived.

Table 6. Yield from plants which developed CBSD foliar symptoms at different times and yield loss compared to symptomless plants.

Date of first score	Total root yield		Marketable yield	
	Root wt (kg)	% loss*	Market wt (kg)	% additional loss
Symptomless	3.03	-	3.03	-
March	2.10	31	2.10	0
April	0.96	68	0.80	17
May	1.24	59	1.15	7
June	1.10	67	0.93	7
July	1.42	53	1.32	7

4. Whitefly populations have been recorded at Naliendele and Kibaha and show that the period when populations are at their greatest coincides with the main period of virus transmission (Fig.7,8,9). This provides only circumstantial evidence that whitefly is the vector of CBSD and could be explained by the fact that the virus is transmitted more readily between young plants. Also, later in the season, damage by green mite to cassava leaves discourages whtieflies. A small survey conducted in the Southern Zone showed that whitefly populations were greatest in areas of high incidence of CBSD and lower in areas of low disease incidence (Table 7.).

Fig.7. Populations of two whitefly species at Naliendele during the 1998 cassava season

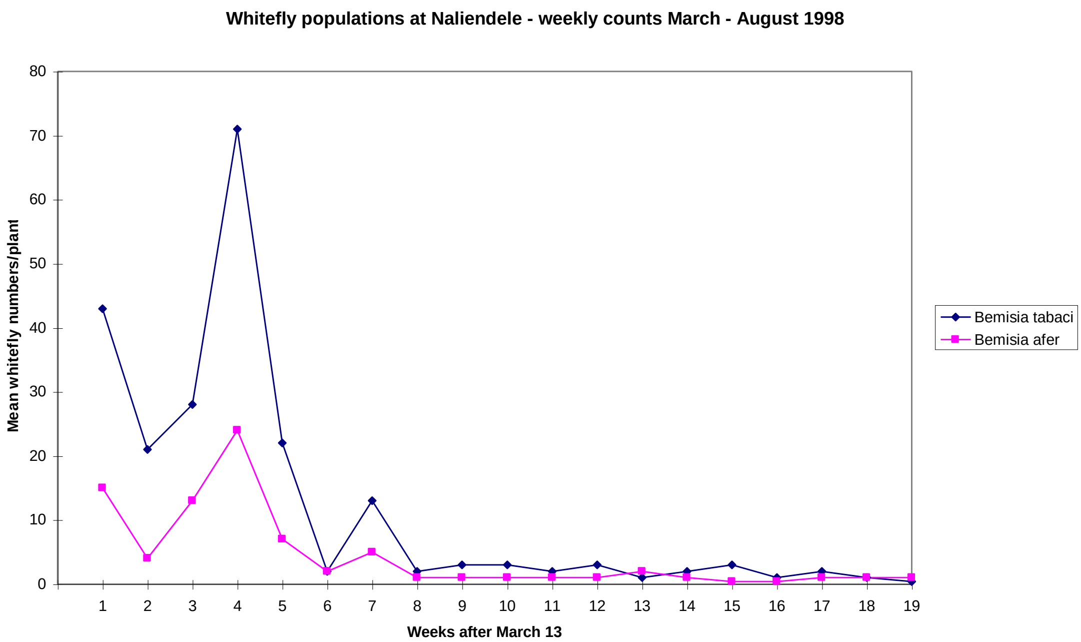


Fig.8. Incidence of CBSD at Naliendele 1998

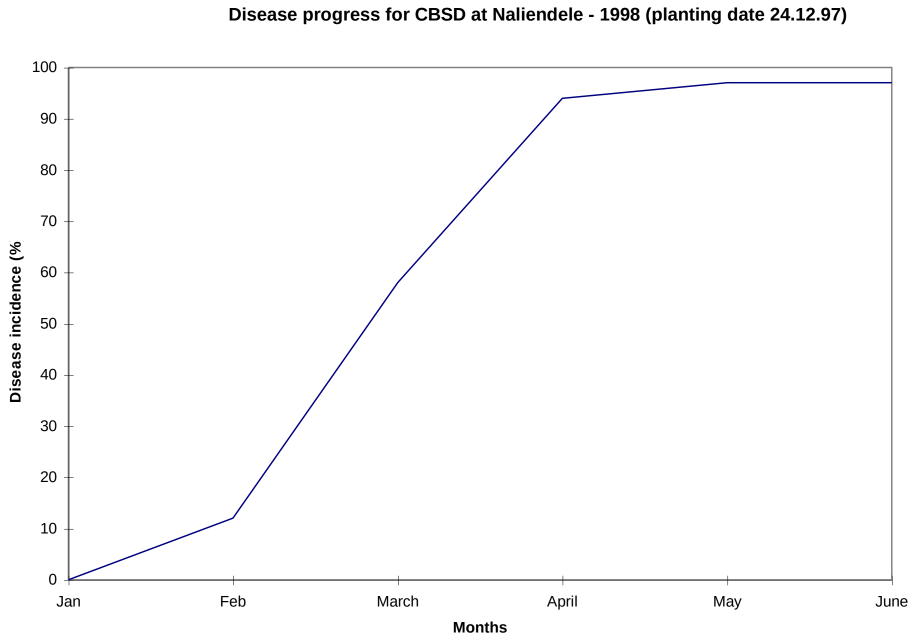


Fig.9a. Relationship between whitefly populations and new incidences of CBSD (Naliendele).

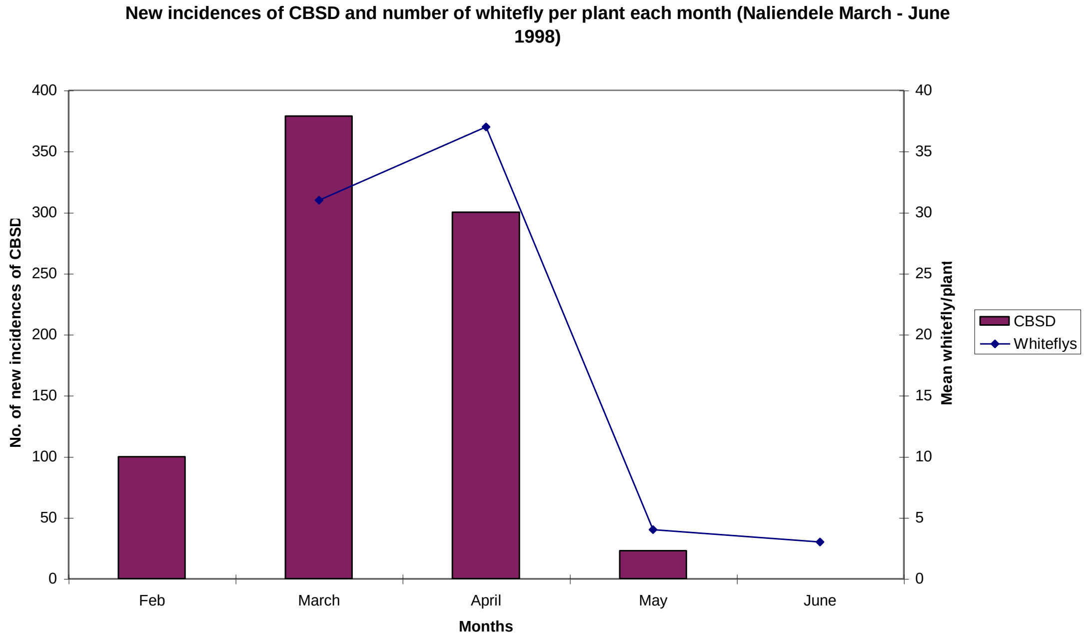


Fig. 9b. Relationship between whitefly population and new incidences of CBSD (Kibaha)

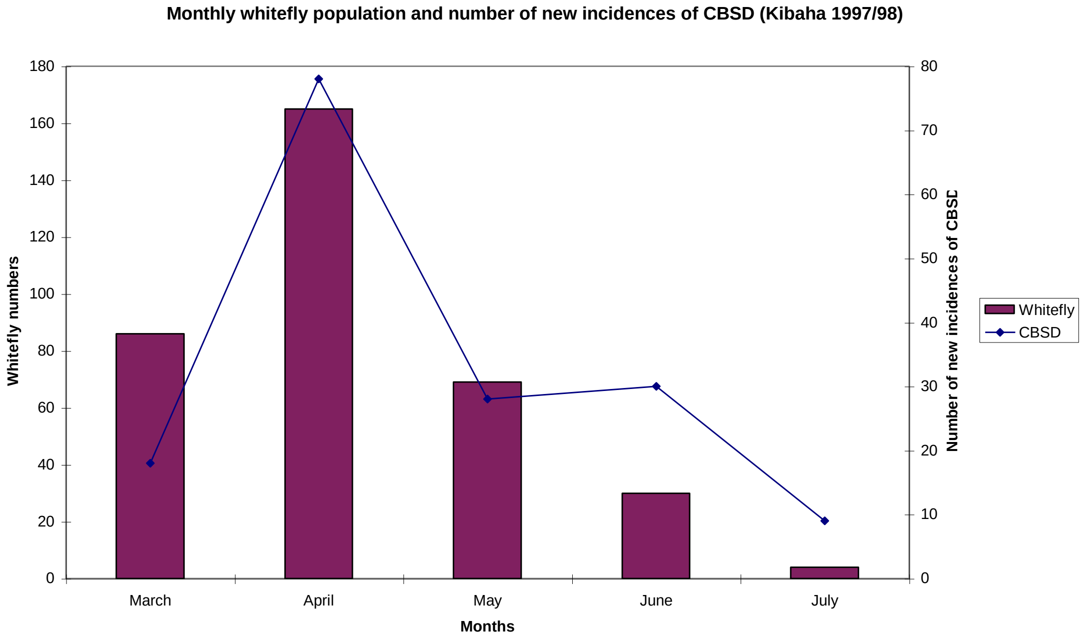


Table 7. Whitefly and virus disease survey in relation to altitude in southern Tanzania (March 1999)

Location	Altitude*	No. of whitefly/plant		Mosaic %	Brown streak %
		B. tabaci	*B. afer*		
Mikandani	LOW	17.9	0.9	0	10
Msijuti		11.7	0.4	3	47
		10.4	0	0	60
		13.5	0.2	0	67
		14.4	0.2	17	0
Mean		13.6	0.34	4.0	36.8
Kitama	MID	4.7	0	3	20
		16.2	0.2	13	3
		9.1	0	3	0
Madaba		2.8	0	10	10
		2.6	0	20	17
Mean		7.1	0.04	9.8	10.0

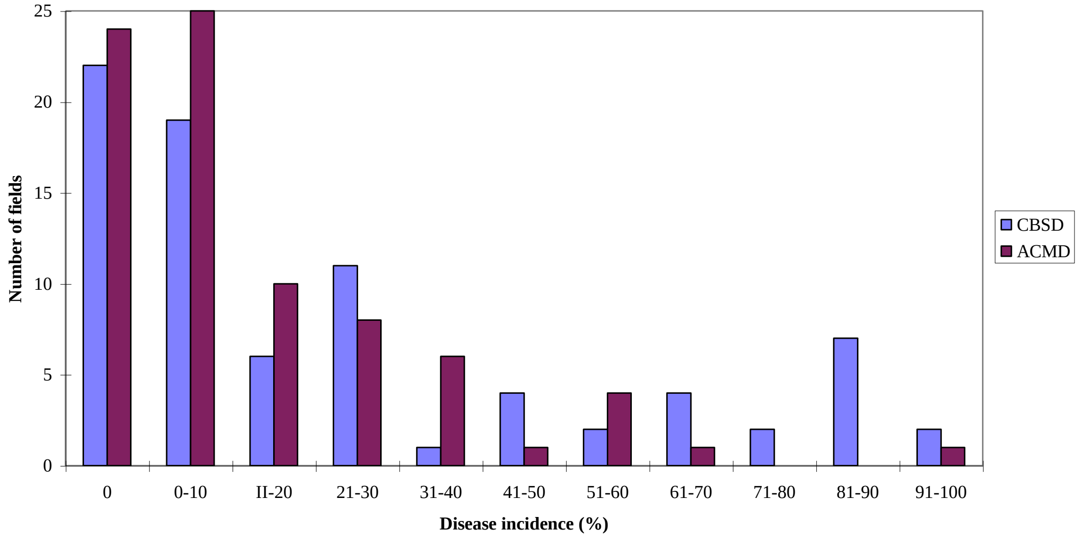
Newala	HIGH	0.5	0.8	3	0
		0	0.1	0	17
		0.2	0	0	0
		0.5	0.4	0	0
		0.6	0.5	0	0
Mean		0.36	0.54	0.6	3.4

* Altitudes: low = 10 - 100 m.a.s.l, mid = 300-400m, high = 700 - 800 m.

Output 3. Knowledge improved of distribution of CBSD in eastern and southern Africa.

1. A previous survey (Legg and Raya, 1994) showed that CBSD was present in most cassava-growing areas of Tanzania below 1000m. A further survey was undertaken in 1998 to provide more detailed information on disease incidence on the coast, from the Kenya border to southern Tanzania. In addition, socio-economic data was collected on farmers' awareness of cassava virus diseases and cuttings taken of any local cvs. which seemed to shows some resistance to CBSD (See Project Report Nos. 2 and 3). The frequency distribution of disease incidence (Fig.10.) shows that both virus diseases were present in most fields but that there were more low incidences of CMD than of CBSD and disease incidences above 60% were more frequent for CBSD than for CMD. Mean disease incidence was 15% for CMD and 29% for CBSD.

Fig 10. Frequency distribution for incidences of CBSD and CMD in fields surveyed in southern Tanzania



2. There is a strong relationship between altitude and CBSD incidence (Fig. 11) with mean disease incidence tending to decrease with altitude and the greatest disease incidence along the coastal plain. The number of sites with high incidences declines with altitude above 200m but high incidences may still be found up to 600m depending on the provenance of the planting material. There does not seem to be anything preventing the expression of CBSD symptoms at higher altitudes but disease spread seems to decrease with altitude. Mean incidence of CBSD was around 50% below 200m, 25% at between 200 and 400m and 10% above 400m (Table 8). No similar trend was apparent for CMD.

Fig.11. Relationship between altitude and CBSD incidence in southern Tanzania

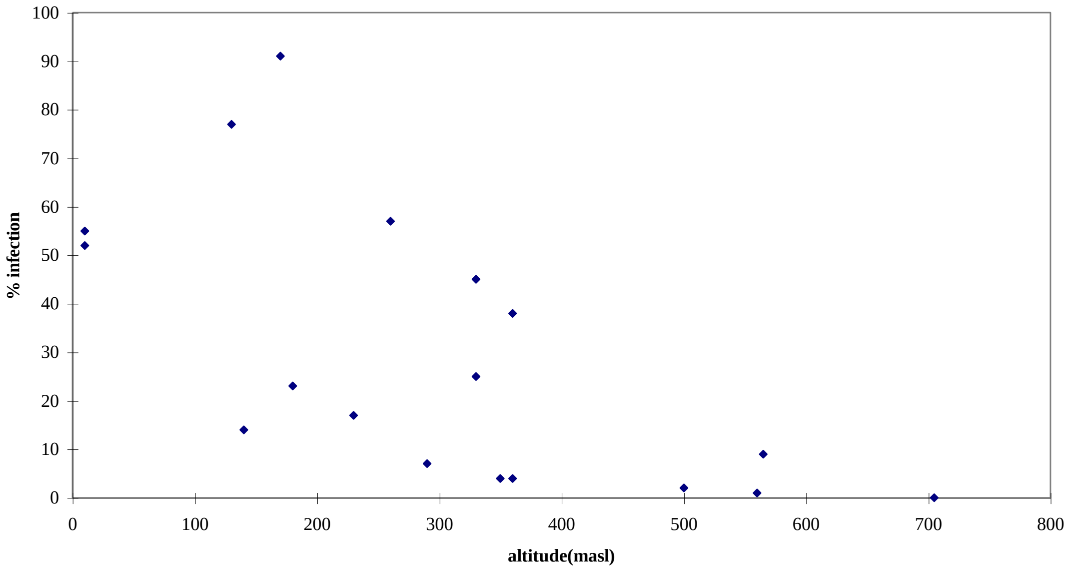


Table 8. Effect of altitude on disease and pest incidence

Altitude (m.a.s.l.)	CMD	CBSD	Whitefly/field. B.t	B.a
HIGH 400 - 700m	17.3	10.3	19.0	2.5
MID 1. 300 - 400m	16.8	23.2	23.0	1.2
MID 2. 200 - 300m	14.3	26.8	92.6	8.5
LOW 0 - 200m	8.8	51.4	119.5	9.9

3. Surveys conducted along the Tanzanian coast from the Kenya border southwards (See Fig. 12.) again showed both virus diseases to be present in many cassava fields but if the coast is divided into three sections, disease incidence varied considerably. North of Dar es Salaam mosaic was more prevalent than brown streak with mean incidences, south of Dar es Salaam up to the Rufiji river disease incidences were lower and CMD and CBSD incidence were similar. In the section between the Rufiji river and Lindi which borders the Southern Zone CBSD incidence was almost three times greater than CMD incidence (Table 9.). Two cultivars which looked as if they may have some resistance to CBSD were Kitumbua and Kiroba.

Table 9. Incidences of CBSD and CMD in cassava fields on the coastal plain of Tanzania

Location	CBSD %	CMD %
Kenya border - Dar es Salaam	32%	46%
Dar es Salaam - Rufiji river	23%	29%
Rufji river - Lindi	41%	13%

4. Socio-economic surveys showed that farmers were highly aware of 'root rot' as a major production constraint and in the southern zone (Table 10) there was a local name for the disease. Further north there was less awareness specifically of CBSD but a similar percentage (36%) of farmers considered diseases to be an important constraint (Table 11). Few farmers were able to associated root necrosis with foliar symptoms.

Table 10. Constraints to cassava production as perceived by farmers in Southern Zone of Tanzania

Problems	No. of Respondents (max = 247)
1. CBSD	89 (36%)
2. Soft rot	56
3. CMD	47
4. Mealy bug	16
5. Insect pests	10
6. Vermin	7
7. Juma*	12
8. Rodents	4
9. Labour shortage	3

* Juma = pupal stage of mealy bug

Table 11. Constraints to cassava production as perceived by farmers in Coastal Zone of Tanzania

Problems	No. of Respondents (max = 50)
1. Theft	19
2. Vermin	38
3. Mealybug	12
4. Shortage of planting materials	30
5. Diseases	18 (36%)
6. Lack of knowledge of disease control	1
7. Lack of capital	1
8. Weed control	3
9. Poor soils	2
10. Too much rains	2
11. Poor variety	3
13. Low yield	1
14. Low man power	1

5. There were no previous records of CBSD in Mozambique but based on the high disease incidence in southern Tanzania which is separated from Mozambique by the Ruvuma river, we believed the disease would be there. Following a request from World Vision International to conduct a survey, additional funds were obtained and a survey conducted in Zambesia and Nampula Provinces (See Fig. 12.) in March and April 1999. Although the National Research Organisation were unaware of the disease, the survey showed that it was present at high incidences in the coastal Districts of both Zambesia (Table 12) and Nampula Provinces. In some fields disease incidence was 100%. CBSD was conspicuous by its absence in Murramballa District but the reason for this is unknown. It is possible that the predominant cultivar 'Mocuba' may be resistant and this should be investigated. Other cultivars found in Murramballa were also free of CBSD although they were infected in other Districts. 'Mocuba' was found only in Murramballa (Table 13). There was no relationship between whitefly populations at the time of the survey and incidence of CBSD (Table 14).

Table 12. Incidence of virus diseases on cassava in six Districts of Zambesia Province in Mozambique

District	Altitude m.a.s.l	Mosaic disease %	Mosaic disease severity (0 - 4)	Brown streak disease %	Brown streak disease range
Nicuadala	< 200	15	1.9	69	27 - 97
Murramballa	200 - 300	14	1.7	0	
Mocuba	300 - 400	17	1.3	70	17 - 100
Gerué	500 - 600	80	1.9	31	13 - 53
Maganja	< 200	< 1		83	10 - 100*
Namacurra	< 100	11	1.3	93	77 - 100

* Single site with only 10% CBSD (Cv. Gonia) otherwise 57 - 100%)

Table 13. Incidence of ACMD and CBSD on different cultivars recorded in six Districts of Zambesia Province.

District and cultivars	No of plants recorded	ACMD %	CBSD %
NICUADALA			
Mulaleia	220	5	73
Mucudo muevia	46	42	68
Bedu	21	41	50
Fernando Po	13	38	50
MURRAMBALLA			
Mocuba	131	12	0
Fernando Po	96	6	0
Maria	94	9	0
Circano	58	2	0
Mucudo muevia	30	0	0
Palavi	30	0	0
Casu	3	100	0
Samaravi	6	0	0

MOCUBA			
Mucudo muevia	97	9	59
Muripa	74	9	95
Mapota	43	5	95
Comparule	30	57	17
Macia	22	0	0
Mabele	2	100	2
GERUE			
Cancali	149	82	38
Namarocola	93	76	41
Shacuashacua	40	79	7
Mucudo muevia	11	82	18
Fernando Po	2	50	50
MAGANJA			
Passecole	60	0	100
Juliana	49	0	98
Gonia	38	0	37
Fernando Po	30	0	100
Mulaleia	30	0	93
Orela	24	0	25
Mucudo muevia	22	9	82
Manita	21	0	100
Carmita	13	0	100
Calele	7	0	86
NAMACURRA			
Mulaleia	253	6	94
Fernando Po	23	53	61
Circano	15	0	100
Marietta	9	33	78

Table 14. Whitefly populations and damage caused by mealy bug and green mite on cassava in six districts of Zambesia Province in Mozambique

District	B. tabaci	B. afer	CMB	CGM	
	No/plant*	total per 30 plants	%	%	severity
Nicuadala	3.8	3	8	7	1.1
Murrambala	1.5	8	4	33	1.1
Mocuba	14.0	1	2	32	1.2
Gerué	15.2	10	<1	74	1.7
Maganja	1.5	1	6	55	1.2
Namacurra	2.9	5	1	30	1.2

CONTRIBUTION OF OUTPUTS

Cassava is the staple crop for large areas of southern and coastal Tanzania and also in northern Mozambique. Although having poor storability once harvested, cassava has the advantage that it can be kept in the ground and harvested as required. It therefore has a major role as a food security crop, even in areas where there are alternative staples. The project has shown that CBSD is a major cause of crop loss in these areas. Our socio-economic surveys showed that farmers considered ‘root rot’ to be one of their main production constraints. The disease was present at very high incidences in Zambesia Province of Mozambique where there is almost complete reliance on cassava for food security. The contribution made by cassava to sustainable livelihoods in the coastal region of eastern Africa is two-fold: firstly it is the main subsistence crop and secondly, it provides a source of income through the sale of fresh cassava root and stem cuttings for planting material. CBSD impacts on livelihoods directly as the symptom of root necrosis decreases root yield, but also, the disease makes fresh roots unmarketable. Decreased incidences of CBSD would allow smallholders to increase the amount sold for cash or decrease the area of cassava grown which could then be used for other more valuable crops such as maize or groundnut. CBSD has its main impact on food security because the severity of root necrosis increases with the length of time the crop is in the ground.

The project has contributed to decreasing losses to CBSD in the following ways:

1. By raising awareness of the disease, dissemination of information on symptom recognition and technology transfer of screening methods. These have been adopted by the National Programme in Tanzania, SARRNET in eastern and southern Africa and by the DFID/ World Vision cassava improvement programme in Mozambique.

2. We have shown that CBSD can cause reductions in root yield of up to 68% with a further 7 - 20% loss in quality. The quality loss is due to those roots which are unmarketable or the necrotic tissue which the farmers' family have to cut from the roots before they can be dried for storage.

3. Screening techniques have been developed to assess the reaction of cultivars to CBSD, based on evaluation of both above ground and root symptoms. Cultivars have been identified with resistance or 'tolerance' to CBSD. The 'tolerant' cultivar Nachinyaya was identified by the project and has now largely replaced the CBSD-susceptible cultivars in Mtwara. There is strong demand for planting material of Nachinyaya.

4. Systems have been developed at Naliendele and Kibaha research stations for the production of virus-free stocks of cassava for the production of planting material. This is vital for cassava. For instance, much of the planting material in the WVI programme in Mozambique, was found to be infected with CBSD. Such material should not be distributed to farmers. Virus-free stocks have been produced by the project and are available for bulking-up.

5. Surveys in southern Tanzania have shown that CBSD is rarely found above 1000m and is present at low incidences above 600m. Between 300 and 600m it is present at moderate incidences and high incidences are found mostly below 300m. It is not possible to draw strict divisions between these zones based on altitude and occasionally high incidences may be found at altitudes above 300m, depending on the provenance of the planting material. Little spread of the disease seems to occur at higher altitudes. This has influenced the design of disease management systems. At low altitude where incidence is high and spread is rapid, phytosanitation must be used with resistant (or tolerant) cultivars. At mid altitude where disease incidence is moderate and there is less spread, virus-free planting material would be helpful, provided farmers continued to select their planting material from symptomless mother plants. At high altitude, where little spread occurs, selection of planting material and roguing should provide sufficient control.

6. The design of disease management systems is facilitated by some knowledge of the epidemiology and means of transmission of the virus. Although this has been investigated during the project, we have not been able to identify a vector. The most likely candidates remain the whiteflies (*Bemisia tabaci* and *B. afer*) and trials conducted in Tanzania have shown conclusively that CBSV spreads from plant to plant within a field and that the main period of spread coincides with the peak periods of whitefly infestation. However, it remains a priority to identify the vector.

7. Five villages have been identified for further work on disease management. Two of these are in the low altitude areas of high disease incidence, two in the mid altitude and one in the high altitude area. Farmer research groups have been set-up in each of these as a preliminary to adaptive research on CBSD management.

PROMOTION PATHWAYS

Because CBSD is recognised as a major problem by farmers in the coastal areas where disease incidence is high, this creates the opportunity for adoption of management systems. The cv. Nachinyaya has been adopted spontaneously by farmers. Unfortunately it does not represent a long-term solution because although tolerant of root necrosis it is susceptible to infection by CBSV.

Project outputs have been disseminated in three ways. Firstly, by direct contact with farmers and extension workers through the on-farm trials and farmer research groups. Secondly to the National and SARRNET cassava Programmes. The National Programme in Tanzania has adopted our screening methods and we worked closely with the SARRNET representative at Kibaha, until that phase of the SARRNET project came to an end in 1998. The project also has good links with the SARRNET representatives in Malawi and Mozambique. Dr Teri in Malawi has requested permission to produce a special issue of the SARRNET-sponsored journal 'Roots' in order to publish one of the project outputs on identification of CBSD and CMD. This will be published in English, Kiswahili and Portuguese and part-funded by CPP. The project has also worked with CARE in northern Mozambique and CONCERN in southern Tanzania in connection with cassava multiplication. Our main collaborator in Mozambique has been World Vision International and it is hoped that this collaboration will continue.

PUBLICATIONS

Papers in refereed journals

Hillocks, R. J. (1997) Cassava virus diseases and their control with special reference to southern Tanzania. *IPM Reviews* 2, 125 - 138. (A).

Hillocks, R. J., Raya, M. D. and Thresh, J. m. (1999) Distribution and symptom expression of cassava brown streak disease in southern Tanzania. *African Journal of Root and Tuber Crops* 3, 127 - 134. (A).

Thresh, J.M. and Mbwana, M.W.(1998) Cassava mosaic and cassava brown streak virus diseases in Zanzibar. *Roots* [PART 1] 5, 6 - 9.(A)

Mtunda, K., Mahungu, N.M., Thresh, J.M., Kilima, M.S. and Kiozya, H.C. (1999) Cassava planting material sanitation for the control of cassava brown streak disease. In: M.O. Akoroda and J. M. Teri (eds) *Food security and crop diversification in SADC countries: the role of cassava and sweet potato*. Proceedings of the SARNNET Scientific Workshop, Lusaka, Zambia 16 - 20 Aug 1998. pp 300 - 304.(A)

Unpublished conference presentations

Thresh, J.M. (in press) Virus diseases of cassava in eastern and southern Africa. SARNNET Scientific Workshop, Lusaka, 16 - 20 Aug 1998. paper (B)

Project Reports (a copy of each is included with the FTR)

Hillocks, R. J. and Raya, M. D. (1997) Survey of cassava virus diseases in southern Tanzania. Project R6767 Report No.1 Chatham, NRI, pp.9. (C).

Katanila, N.A. and Raya, M.D. (1998) Farmers' perceptions and practices in relation to cassava virus diseases in southern Tanzania. Project R6765 Report No. 2. Chatham, NRI/Ministry of Agriculture, Tanzania, pp. 20.(C)

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Hillocks, R.J. and Thresh, J.M. (1998) Cassava brown streak disease: virus-free planting material as a means of control. Project R6765 Report No. 4. Chatham, NRI. pp. 7.

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Thresh, J. M., Tomas, J (1999) Survey of cassava virus diseases in Nampula Province of Mozambique. Project 6765 Report No. 7. Chatham, NRI, pp. (C).

Visit Reports

Hillocks, R. J. 91996) Report of a visit to Tanzania to initiate RNRRS-CPP Project on cassava virus diseases, September 1996. Project 6765 Report pp. 4. (C)

Hillocks, R. J. (1997) Report of a visit to Tanzania in connection with collaborative research on cassava brown streak disease, 9 - 20 February 1997. Project R6765 Report pp.4. (C)

Hillocks, R. J. (1997) Report of a visit to Tanzania to carry out field activities associated with collaborative research on cassava virus diseases, 9 - 21 June 1997. Project R6765 Report pp.4. (C)

Thresh, J.M. (1997) Visit to Tanzania, 10 - 20 June 1997. Project R6765 Report pp.4. (C)

Hillocks, R. J. (1998) Report of a project management visit to Tanzania, 14 - 22 March 1998. Project 6765 Report pp. 4. (C)

Thresh, J. M (1998) Report of a visit to Zanzibar and Tanzania to assess incidence of cassava virus diseases, 18 - 31 January 1998. Project R6765 Report pp.4. (C)

Hillocks, R. J (1998) Report of a visit to Tanzania to review field trials in southern Tanzania and to conduct a survey in Coast Region, Jan 19 - Feb 2 1998. Project R6765 Report pp.4. (C)

Hillocks, R. J.(1998) Report of a project management visit to Naliendele Research Institute in Tanzania, 30 June - 3 July 1998. Project R6765 Report pp. 4 (C)

Hillocks, R. J. (1998) Report of a project support visit to Naliendele Research Station, 10 - 27 November 1998. Project R6765 Report pp. 7. (C)

Hillocks, R. J (1999) Report of a project management visit to Tanzania, 9 - 21 August 1999. Project 6765 Report pp 4. (C)

Other dissemination

Hillocks, R.J. and Thresh J.M. (1998) Cassava mosaic and cassava brown streak virus diseases in Africa: A comparative guide to symptoms and aetiologies: Fact sheet. English. 30 copies [Field](D)

Further dissemination expected

1. The fact sheet above is to be published in 'Roots' as a special edition with translations in Kiswahili and Portuguese. Expected publication - first half of 2000.

2. Results from the Mozambique survey will be sent to 'Plant Disease' as this is a first record of the disease in that country. Submission date - December 1999.

3. Results from the field trials on effect of CBSD on yield will be submitted to 'Annals of Applied Biology'. Submission date - November 1999.

4. Results from work on rate of spread of CBSD will be submitted for publication to 'J of Phytopathology'. Submission date - February 2000.

REFERENCES

HILLOCKS R. J., RAYA, M. & THRESH, J. M. (1996) The association between root necrosis and above-ground symptoms of brown streak virus infection of cassava in southern Tanzania. *International Journal of Pest Management* 42, 285 - 289.

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Appendix 5. Inventory control form

NRIL contract No. ZA0058
DFID Contract No. 6765
Project Title: Management of cassava virus diseases in southern Tanzania
Project Leader: Rory Hillocks

No equipment with a value greater than £500 has been purchased for this project.