CHAPTER 1.6

Uganda

*Peter Sseruwagi**, *James Legg*** and *William Otim-Nape****

Introduction

Cassava mosaic disease (CMD) is the most important viral disease of cassava (*Manihot esculenta* Crantz) (Otim-Nape, 1993) in Uganda. It is caused by begomoviruses transmitted by the whitefly vector, *Bemisia tabaci* (Gennadius) and spread through virus-infected planting material (Harrison, 1987).

The first recording of CMD in Uganda was in 1928 (Martin, 1928). Severe epidemics from 1933 to 1944 were successfully controlled by planting resistant cassava varieties and through phytosanitation measures enforced by local government statute (Jameson, 1964). The disease then was considered a relatively minor problem until the late 1980s, when severe epidemics were again reported in northern Luwero District (Otim-Nape, 1988). By 1990, CMD had severely affected other cassava-growing districts of northern and eastern Uganda (Otim-Nape et al., 1997). In 1993 and 1994, the widespread crop losses associated with the CMD epidemic, coupled with drought, led to food shortages and localized famine (Otim-Nape et al., 1997). Between 1994 and 1998, the CMD epidemic continued to expand, affecting much of southern Uganda. Significant progress has been made in controlling the disease, particularly in north-eastern parts of the country, which were some of the first to be affected (Thresh et al., 1994) but the epidemic continues to spread in southern and western districts. The principal control method has been the deployment of resistant varieties.

Sweetpotato virus disease (SPVD) is correspondingly the most serious viral disease of sweetpotato (*Ipomoea batatas* [L.] Lam.) in Uganda (Bashaasha et al., 1995), although its distribution and impact on sweetpotato production have scarcely been studied until recently. Aritua et al. (1998) provide information on the disease for only two of the country's (at that time) 45 districts, Mpigi and Soroti (Figure 1). SPVD results from co-infection of *Sweetpotato chlorotic stunt virus*, transmitted by *B. tabaci* and *Sweetpotato feathery mottle virus*, transmitted by the aphid *Myzus persicae* (Sulzer) (Gibson et al., 1998).

In order to enhance understanding of whiteflies and whitefly-transmitted viruses on cassava and sweetpotato in Uganda, surveys were conducted

* International Institute of Tropical Agriculture-Eastern and Southern Africa Regional Center (IITA-ESARC), Kampala, Uganda.
** IITA-ESARC, Kampala, Uganda, and Natural Resources Institute, University of Greenwich, Chatham Maritime, Kent, UK.
*** Namulonge Agricultural and Animal Production Research Institute (NAARI), Kampala, Uganda.

between November 1997 and January 1998. It was anticipated that the data collected would be useful in helping researchers in Uganda monitor the development of the CMD epidemic, target control interventions more effectively and, in the longer term, develop sound integrated pest management (IPM) strategies for cassava and sweetpotato.

Figure 1. Cassava- and sweetpotato-growing areas surveyed for whitefly incidence in Uganda.

Surveys were carried out in 12 districts of Uganda (Figure 1) by multi-disciplinary teams from the National Agricultural Research Organisation and the International Institute of Tropical Agriculture (IITA). Districts were chosen to represent major cassava and sweetpotato producing areas. Farmers' fields of cassava 3-5 months after planting and of sweetpotato 3 months after planting were selected at regular intervals along main roads traversing each district. Data were collected according to the standardized survey methods, except that the number of fields varied between the districts because the survey areas were selected on the basis of agro-ecological differences rather than administrative boundaries (Table 1).

Increased Biological Understanding

Whitefly species and abundance

The survey identified two whitefly species, *B. tabaci* and *B. afer* (Priesner and Hosny). Of the 261 samples identified on cassava, 95.8% were *B. tabaci* and 4.2% *B. afer*. Only *B. tabaci* was recorded from sweetpotato.

Whitefly populations on cassava (counted on the top five leaves for a single shoot of each of 30 plants per sampled field) were highest in the south-western districts of Masaka and Rakai and lowest in Masindi (the north-western limit of the survey area) and Tororo (on Uganda's eastern border with Kenya), with mean abundance ranging from 0.7 to 13.1 per top five leaves (Table 1) (see also Figure 2 in Chapter 1.14, this volume). The pattern of whitefly populations on sweetpotato (counted by disturbing leaves and making 10 serial counts of 1 min each of whitefly adults observed) was similar to that on cassava: abundance was greatest in the central districts of Mukono and Mpigi and lowest in Masindi and Apac. Mean adult whitefly abundance ranged from 0.9 to 14.8 per minute count. In similar studies, Aritua et al. (1998) found greater whitefly abundance on sweetpotato in the southern and central zones, which are characterized by more evenly distributed rainfall than the northern and eastern zones.

The data indicate a higher whitefly population on both crops in southern and south-western Uganda than in the northern and eastern districts of the country. Assessing the significance of these differences is difficult based on records collected on a single occasion, during what appears to be the continuing spread of an epidemic. Numerous factors such as physical

Table 1. Incidence (%) of cassava mosaic disease (CMD) and sweetpotato virus disease (SPVD), disease severity and whitefly abundance on cassava and sweetpotato in selected districts of Uganda, surveyed during November and December 1997.

District	No. fields	Cassava[a]					Sweetpotato[a]		
		Whitefly counts	CMD				Whitefly counts	SPVD	
			Whitefly infection	Cutting infection	Total incidence	Severity (1-5 scale)		Incidence	Severity (1-5 scale)
Masindi	7	0.7	11 (19)	34	45	3.0	0.9	3	2.0
Apac	6	1.4	22 (140)	71	93	3.0	1.9	9	2.3
Lira	7	1.4	11 (89)	81	92	3.0	1.4	3	2.3
Iganga	6	1.6	20 (80)	64	84	2.8	11.2	16	2.1
Tororo	7	0.9	16 (73)	69	85	3.6	1.5	15	2.8
Pallisa	7	3.0	21 (28)	15	36	3.0	3.4	6	2.6
Mukono	7	3.7	13 (47)	64	77	3.0	14.8	10	2.4
Mpigi	7	4.6	17 (59)	61	78	2.8	14.7	29	2.7
Luwero	6	3.0	12 (56)	71	83	2.6	7.8	7	2.2
Mubende	7	3.4	24 (29)	7	31	2.7	3.8	9	2.9
Masaka	6	13.1	50 (91)	17	67	3.0	3.2	14	2.7
Rakai	7	11.1	44 (60)	3	47	2.7	2.0	8	2.7
Average		3.9	22 (65)	46	68	2.9	5.5	11	2.5

a. Figures are means for each district. Whitefly counts, whitefly abundance on cassava (number of whiteflies per top five leaves) and on sweetpotato (per minute count); whitefly infection, figures in parentheses transformed to multiple infection units to allow for multiple infection (Gregory, P. H. 1948. The multiple infection transformation. Ann. Appl. Biol. 35:412-417); severity of disease is measured on an ascending 1-5 scale, from low to severe.

environment, host plant health condition and natural enemies have been shown to influence whitefly populations on cassava (Legg, 1995). Nonetheless, this general geographical trend in abundance does parallel the current trend in disease severity.

Disease incidence and symptom severity

CMD was present in all cassava fields sampled and overall incidence (the average proportion of affected plants) throughout the survey was 68% (see also Figure 2 in Chapter 1.14, this volume). Disease incidence was highest in the northern districts of Apac and Lira and lowest in Mubende. Symptoms were moderate (2.6 to 3.0 on an ascending scale of 1 to 5) with the exception of Tororo District, where the disease was severe (Table 1).

The pattern of CMD incidence in Uganda indicates a north-to-south progression. In areas of epidemic expansion in the south (Masaka and Rakai Districts) the main source of infection is whitefly transmission, whereas in post-epidemic areas to the north (Masindi, Lira and Apac Districts) whitefly transmission is less evident and diseased cuttings are the main source of infection (Table 1). The relatively low CMD incidence recorded in Pallisa District is because of the National Cassava Programme's recent introduction of CMD-resistant varieties, Nase 1 (TMS 60142), Nase 2 (TMS 30337) and Nase 3 (TMS 30572), originating from the IITA breeding programme. Similarly, disease incidence and infection were relatively low for the districts neighbouring Pallisa-Kumi, immediately to the north, and Soroti, to the south.

SPVD occurred in 60 of the 80 sweetpotato fields sampled. Generally, SPVD incidence was greater in southern areas along the shoreline of Lake Victoria, with the highest incidence in Mpigi District on the northern shore of the lake, and the lowest in Masindi and Lira, further to the north. Overall, SPVD symptom severity was moderate in all the districts surveyed.

Natural enemy species and distribution

Whitefly natural enemies collected in the survey included predators and parasitoids. Few predators were collected. This was probably due to the limited time available during the survey for collecting samples, the relatively low populations of whiteflies on cassava and sweetpotato, and the difficulty of observing arthropods actually feeding on whitefly immature or adult stages.

The predator *Conwentzia africana* Meinander was recorded from 16 locations in three of the four target areas. Three species of whitefly parasitoids were identified: *Encarsia sophia* (Girault and Dodd), *Encarsia* sp. (*luteola* group) and *Eretmocerus* sp. *E. sophia* was the most widespread and numerous, occurring through most of the surveyed area (Table 2). *Eretmocerus* sp. occurred principally in south-western Uganda. *Encarsia* sp. (*luteola* group) was only identified from eastern Uganda. The absence of records of parasitoids from some of the districts surveyed, particularly those in the north, is thought to be largely because of the relatively low abundance of whiteflies recorded in these locations. Seasonal and environmental factors clearly play an important role in the abundance of whiteflies and their parasitoids, and in order to collect more comprehensive data, the surveys would have to be repeated, perhaps at 3-monthly intervals throughout the year. Little is known about the role of natural enemies in the population dynamics of *B. tabaci* on cassava and sweetpotato.

Table 2. Occurrence of parasitoids reared from mummies collected from cassava at each of the sampling sites in Uganda.

District	Parasitoid occurrence per sampling site[a]		
	Encarsia sophia	*Eretmocerus* sp.	*Encarsia* sp. (*luteola* group)
Masindi	-	-	-
Apac	-	-	-
Lira	-	-	-
Iganga	3/6	1/6	1/6
Tororo	2/7	-	-
Pallisa	2/7	-	-
Mukono	6/7	1/7	-
Mpigi	4/7	3/7	-
Luwero	-	-	-
Mubende	2/7	-	-
Masaka	1/6	3/6	-
Rakai	3/7	2/7	-

a. Dashes indicate the absence of any reared parasitoids.

Increased Socio-Economic Understanding

Farmers' assessment of whitefly-related problems

Only a small proportion of cassava and sweetpotato farmers (22%) recognized whiteflies. In contrast, the diseases CMD and SPVD were more widely recognized (CMD by 100% of cassava farmers and SPVD by 48% of sweetpotato farmers) and had specific local names in most of the locations where they were prevalent. Both diseases were commonly referred to with words describing the mottling or deformation of the leaves induced by the disease, and a number of names were common for both crops. Virtually all cassava farmers recognized CMD as a production constraint, whereas for SPVD only 35% of producers considered it a problem. Most cassava farmers (74%) considered that CMD was becoming more severe. Sweetpotato producers were similarly pessimistic about the outlook for SPVD, with 65% of the producers who recognized SPVD as a problem considering that it was becoming more severe. Farmers expressed no clear opinion as to the time of year at which whitefly/disease problems are especially severe. The picture of the spread of the CMD epidemic provided by farmers' first record of severe CMD in their fields, indicating a north-to-south progression, is in close agreement with scientific records of the expansion of the severe CMD epidemic (Otim-Nape et al., 1997; Legg and Ogwal, 1998).

Managing whiteflies and whitefly-transmitted viruses

A common response amongst farmers to the CMD problem has been to abandon production of the crop altogether. Whilst cassava farmers assessed losses to CMD at more than 75% of production, sweetpotato farmers estimated losses to SPVD to be less than 25%. Farmers attempting to control CMD and SPVD mainly used roguing, while some applied wood ash on the infected plants. Only 6.5% of farmers reported having received information on control practices through extension and/or research channels. Selection of planting material free of disease symptoms was the most widely used disease control practice for both cassava and sweetpotato, and the second most widely reported was roguing of plants that developed symptoms. However, most farmers reported the two methods to be only partially effective in controlling the diseases.

Thirteen out of 19 farmers growing resistant varieties of cassava and zero out of 11 farmers growing resistant sweetpotato varieties cited resistance as a control method. However, only about 24% of cassava farmers growing resistant varieties found their performance to be superior to that of local varieties. Assessments of the benefits of disease-resistant sweetpotato varieties were more mixed, with some farmers reporting no difference in performance between resistant and local varieties. About 20% of both cassava and sweetpotato farmers attributed differences in the disease response of the different varieties to some kind of resistance to infection, inherent in the variety. On the other hand, 28% of cassava producers and 18% of sweetpotato producers had no idea why such differences should occur. Very few farmers reported using chemical pesticides to control either CMD or SPVD. Of these farmers, almost all used dimethoate, an organophosphate insecticide, so their intention was presumably to control the whitefly vector. Most of these farmers used pesticides on the recommendation of neighbours or relatives, sprayed when symptoms were seen, and did so on one to three occasions during the production cycle. However, many reported that the approach was ineffective.

Whitefly-related crop production costs in affected areas

Since farming families produce most cassava and sweetpotato for home consumption rather than sale, it was difficult to assess the value of lost production attributable to CMD and SPVD and costs incurred in trying to manage these diseases. As mentioned above, the most widely practiced management tactics were selection of disease-free planting material and roguing, both of which involve investment of additional labour. Because labour is usually provided by members of farming households, rather than hired, this represents a time-related opportunity cost rather than a direct financial one. More focused follow-up studies are required to provide an understanding of the economic costs and benefits of managing these diseases.

Conclusions

The results of the survey indicate that farmers' approaches to managing the whitefly-borne virus diseases, CMD and SPVD, are generally ad hoc and based on only a partial understanding of the problem. Since researchers already have a considerable body of knowledge relating to these problems that is not being applied at farm level, this suggests that information flow between farmers and researchers is weak. However, the absence of a clearly defined and well-articulated IPM approach to managing CMD and SPVD could be a contributory factor. Researchers believe that such an approach would combine the use of both local and improved resistant varieties with the selection of clean planting material and subsequent roguing of diseased plants—plant health methods that are already widely practiced.

The development and enhancement of channels of information flow from research to farm level is clearly critical to the successful adoption of IPM of whiteflies and whitefly-transmitted viruses. A number of initiatives have recently been implemented in Uganda to strengthen both the extension system and linkages between research and extension and to foster a participatory approach to working with farmers to develop appropriate and sustainable IPM strategies. It is hoped that these will improve the efficiency of the two-way flow of information between researchers and farmers in the years ahead, facilitating the more widespread adoption of IPM strategies as they become available.

Future work should focus mainly on managing CMD and SPVD, through multiplication and distribution of the existing disease-resistant varieties, and on developing, evaluating, multiplying and distributing new disease-resistant materials. Since most farmers reported the planting of clean cuttings and roguing of diseased plants to be ineffective, there is a need to find out under what conditions these measures could be both effective and adoptable by farmers. Future work should also consider the possibility of community-based phytosanitation, which offers the prospect of widespread reductions in CMD or SPVD inoculum pressure and thereby reduced rates of spread. Too little is currently known about the activity of parasitoids or other natural enemies of *B. tabaci* on either cassava or sweetpotato to offer the prospect of their immediate use within an IPM strategy. However, both introductions of exotic parasitoids and augmentation through habitat management have been used successfully in the United States to improve management of *B. tabaci* (Goolsby et al., 2000). It may be appropriate therefore to explore similar approaches to using parasitoids such as *E. sophia* for the management of *B. tabaci* as vector of CMD and SPVD, although this is always likely to be a measure of secondary importance to the major control approaches of resistant varieties and phytosanitation.

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