CHAPTER 5.3

Progress of Cassava Mosaic Disease in Ugandan Cassava Varieties and in Varietal Mixtures

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A feature of the production of cassava (*Manihot esculenta* Crantz) in Uganda, as in many other countries of sub-Saharan Africa, is that many different varieties are grown and it is usual to find several varieties within individual plantings. Moreover, cassava is usually grown together with one or more intercrops, including legumes and cereals. The great diversity in the varieties grown and in the cropping systems adopted can be expected to influence the incidence and severity of cassava pests and diseases. However, this possibility has received only limited attention in relation to cassava mosaic disease (CMD), despite indications that the current pandemic in Uganda and in adjacent parts of north-west Tanzania and western Kenya is closely associated with the varieties adopted and is least damaging in areas where many varieties are grown.

The cassava component of the Natural Resources Institute (NRI) contribution to the Tropical Whitefly Integrated Pest Management (TWF-IPM) Project has considered the role of varietal diversity in relation to CMD under epidemic conditions in Uganda. It is proposed to consider further aspects of varietal diversity and the implications of intercropping in any additional phase of the project.

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Response of Local Varieties Aladu and Bao to Cassava Mosaic Disease

Ugandan farmers selected the varieties Aladu and Bao and originally grew them mainly in Apac District, where they appeared to have at least some degree of resistance to CMD. For this reason, and in the absence of more resistant varieties, they were introduced to Kumi, Soroti and other districts of Uganda in the early 1990s in attempts to rehabilitate cassava production following the devastating epidemic of CMD.

This approach was partially successful and farmers have retained both Bao and Aladu in some areas, although they are less resistant than some of the other improved varieties now available. Bao became heavily infected under the epidemic conditions encountered originally. However, as the epidemic abated and the symptoms became less severe, some farmers have attempted to return to Bao because of its attractive eating qualities and other desirable attributes.

Replicated plots of Bao and Aladu were established in May 1998 and recorded monthly to assess the incidence and severity of CMD. Comparable plots of the highly resistant SS4 also were established as a standard. All plants of Bao and Aladu were harvested individually in June 1999 and the data for individual plants (each of which had a full set of four neighbours) were used for analysis.

There was rapid spread of CMD to Bao and all plants were affected within 6 months after planting (MAP) (Figure 1). CMD spread less rapidly in Aladu and 15% of the plants were unaffected at the final observation 12 MAP. On average, symptoms developed in Aladu 5.1 MAP compared with 3.7 MAP for Bao. Few plants of SS4 were affected and the symptoms were less conspicuous than those of Bao and Aladu. Yields of tuberous roots were related to the stage of growth when symptoms were first expressed and Bao was more severely affected than Aladu (Figure 2). Little yield was obtained from plants of either variety that were grown from infected cuttings. Plants infected by whiteflies were affected less severely, especially those that developed symptoms at a late stage of growth.

The incidence and yield data were used to calculate the losses caused by CMD in relation to fully healthy stands and assuming that all plants were grown from healthy cuttings. The overall loss was 75% for Bao compared with 31% for Aladu. This confirms the vulnerability of Bao and the relative tolerance of Aladu, as farmers reported earlier. Moreover, sufficient symptomless plants of Aladu remained to provide cuttings for a further planting. This suggests that Aladu could be sustained even under epidemic conditions, provided that farmers select healthy cuttings at each cycle of propagation. Additional studies of this type are justified on the sustainability of a wider range of local varieties and under less extreme conditions of inoculum pressure than those encountered at Namulonge between 1998 and 1999.

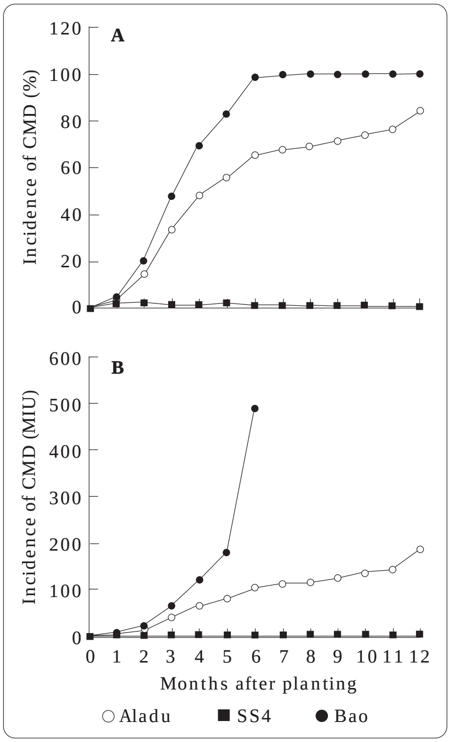

Figure 1. Mean monthly incidence of cassava mosaic disease (CMD) in local cassava varieties SS4, Aladu and Bao at Namulonge, 1998-99 experiment. Incidence data (A) as percentages and (B) transformed to multiple infection units (MIU).

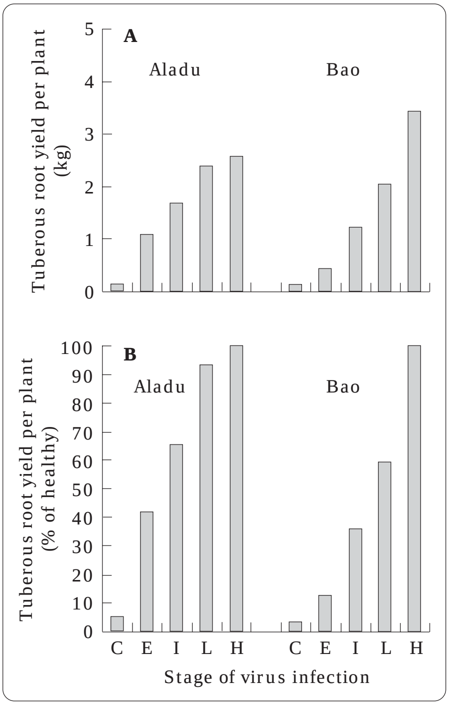

Figure 2. Relationship between time of first symptom expression of cassava mosaic disease and tuberous root yield per plant in local cassava varieties Aladu (left) and Bao (right). Data presented as (A) mean yield per plant and (B) yields expressed as percentage of healthy controls. Data for 10 plants each having a full set of four immediate neighbours. C = infected as cutting, E = early, I = intermediate, L = late infected and H = healthy (symptomless) plants. (The healthy Bao were nominal controls sampled in an adjacent plot in the absence of uninfected plants.)

Ability of Ugandan Varieties to Withstand Effects of Cassava Mosaic Disease

Experience over the last decade has shown that farmers in Uganda have overcome the effects of the CMD epidemic by adopting resistant varieties introduced from Nigeria or those selected by the National Agricultural Research Organisation (NARO) and by selecting from the local varieties already available within the country. Much information has been obtained on the performance of the resistant material that has been released to farmers through official rehabilitation schemes but little information is available on the features of the local varieties that have been adopted widely following the epidemic. Accordingly, a study has been made of the 18 local varieties listed in Table 1. They were collected from different parts of Uganda and selected for their apparent ability to withstand the most damaging effects of CMD.

Wherever possible, cuttings were collected from symptomless plants of each variety selected for study and from plants expressing mild and severe symptoms. The cuttings were planted at Namulonge in May 1998, together with the varieties Ebwanateraka, Bao, Migyera and SS4, which were included as standards. All plants were assessed monthly to record the incidence and severity of CMD. Vegetative growth and populations of the whitefly vector *Bemisia tabaci* (Gennadius) were also assessed and the plants were rated for overall vigour 12 MAP.

Populations of adult whitefly were unusually high throughout the period of the experiment and there was rapid spread of CMD both within the trial and in adjacent experiments. All the initially healthy plants of the local varieties became infected but there was relatively little spread to the resistant standards. There was wide variation in symptom severity depending on the variety and the initial health status of the planting material. Symptoms were generally highly conspicuous except in the local varieties Buhimba, Njule and Tongolo and in the resistant standards SS4 and Migyera. Nevertheless, many of the local varieties grew vigorously, especially when grown from cuttings collected from symptomless or mildly affected plants.

Table 1. Reaction of different local cassava varieties in Uganda to cassava mosaic disease (CMD) infection at Namulonge in the 1998-99 experiment. Data are for plants that were raised from cuttings collected from symptom-less (healthy) plants and from those with mild (category 2-3) and severe (category 4-5) symptoms.

Variety	Origin (District)	Incidence[a]		Category[b]	Initial CMD status[c]			Vigour index[d]		
		(%)	MIU		Healthy	Mild	Severe	Healthy	Mild	Severe
Buhimba	Hoima	34	41	MR	2.0	3.2	3.0	4.3	2.8	-
Katisa-Bakonjo	Mubende	85	190	HS	3.2	4.3	-	4.2	2.2	-
Kayumba	Mukono	68	114	S	2.7	4.5	5.0	-	2.7	1.1
Mpologoma	Mukono	-	-	-	-	4.8	4.9	-	1.9	1.3
Njule-sl	Mukono	35	43	MR	3.6	3.8	4.8	2.8	2.6	2.5
Unknown 2	Mukono	65	105	S	4.6	4.9	5.0	-	1.9	1.1
Kayinja	Mukono	65	104	S	3.7	4.1	4.9	2.8	2.6	1.7
Bao	Soroti	64	101	S	4.0	4.0	4.4	2.0	1.3	1.2
Rugogoma	Kibaale	60	92	S	4.0	4.8	4.8	3.2	1.4	2.0
SS4	Mpigi	0	-	HR	1.0	2.6	-	2.2	1.9	-
Luzira	Mpigi	72	129	-	4.0	4.9	4.5	1.8	1.2	1.0
Ebwanateraka	Mpigi	89	223	HS	4.8	5.0	5.0	1.0	1.0	1.0
Migyera	Mpigi	13	13	HR	2.6	3.6	3.2	3.8	3.4	2.6
Aladu-aladu	Soroti	55	79	I	3.8	4.6	5.0	2.1	1.2	1.1
Muwogo-omweru	Mukono	70	120	S	3.1	4.3	5.0	3.9	2.1	1.1
Matooke	Mukono	78	150	S	3.7	4.1	5.0	2.1	1.9	1.2
Tongolo	Masindi	51	72	I	3.0	3.7	5.0	2.0	1.7	1.0
Unknown 1	Mukono	68	112	S	3.7	4.8	4.9	2.7	2.0	1.3
Unknown 3	Mukono	48	64	I	3.4	4.4	4.8	2.7	2.6	2.4
Nyaraboke	Masindi	69	116	S	3.4	3.6	4.2	2.0	2.3	2.3

a. Incidence data 3 months after planting as % and as transformed to multiple infection units (MIU).
b. Variety categorization based on incidence 3 months after planting: 0%-20%, highly resistant (HR); 21%-40%, moderately resistant (MR); 41%-60%, intermediate (I); 61%-80%, susceptible (S); 80%-100%, highly susceptible (HS).
c. Symptoms rated on a 1 to 5 scale of increasing severity in relation to status of source plants from which cuttings were collected.
d. Vigour was rated on a scale of 1 (least vigorous) to 5 (most vigorous), 12 months after planting.

Samples were collected from representative plants of all varieties for polymerase chain reaction (PCR) and enzyme-linked immunosorbent assay (ELISA) analysis to determine the cassava mosaic virus(es) present and their concentration and association with the symptoms expressed. Preliminary results showed that the epidemic-associated virus (now designated *East African cassava mosaic virus*-Uganda [EACMV-Ug]) and *African cassava mosaic virus* (ACMV) occurred alone or as a mixture. The few symptomless plants that reacted positively contained mixed infections and so provided evidence of virus latency.

These initial studies confirm the ability of some local varieties to partially withstand infection. They also indicate the scope for further studies on the behaviour of local varieties and on their sustainability, especially under the less extreme conditions of inoculum pressure encountered in post-epidemic situations.

Spread of Cassava Mosaic Disease and Whitefly Vector Populations on Varieties Grown Singly and as a Mixture

Detailed analyses have been done of field data collected during an earlier M.Sc. project funded by the Rockefeller Foundation. This project assessed the spread of CMD and whitefly vector populations in four contrasting varieties grown singly and as a mixture under epidemic conditions at Namulonge in 1995-96 and 1996-97. There was much spread of CMD to the susceptible variety Ebwanateraka, little to the resistant SS4 and intermediate levels in TMS 30337 (Nase 2) and TMS 30572 (Nase 3, also known as Migyera) (Figure 3). The amount of spread to the resistant and partially resistant varieties was similar in the sole plots and in the mixture. In contrast, there was less spread to the susceptible Ebwanateraka in the mixture than when it was grown alone. The effect was significant and is likely to have been even greater under lower levels of inoculum pressure than those experienced in the two experiments. This suggests that resistant varieties may be used to provide at least some degree of protection to susceptible ones. Indeed, the effect could be of considerable practical importance because farmers may be reluctant to discard susceptible varieties that are valued because of quality or other favourable attributes.

A new varietal mixtures experiment was planted at Namulonge in September in 1998. There were four treatments each replicated four times in a complete randomized block design:

(1) Variety Bao (susceptible): alone.
(2) Variety SS4 (resistant): alone.
(3) Bao and SS4 planted alternately in 50:50 mixture.
(4) SS4 (50%) grown as an outside barrier around Bao (50%).

Monthly assessments were made of adult whitefly populations, CMD incidence and CMD severity. The assessment of whiteflies was done so that any edge or barrier effects would be detected.

The health status of the Bao planting material was unsatisfactory and there was substantial infection arising from the cuttings used. This reflects the difficulty now being experienced in Uganda in obtaining healthy material of susceptible varieties. Nevertheless, preliminary analyses show big differences between SS4 and Bao in the incidence and severity of CMD (Figure 4). There was also evidence that the incidence of CMD in Bao was less in the mixture than in the pure stand. However, there was no evidence of a barrier or edge effect using SS4 and the comparison may have been vitiated by the extent of cutting infection with Bao. A further difficulty is that Bao is a tall erect variety that outgrows SS4, which is a relatively low spreading type. This suggests that varieties of similar habit and conformation should be selected for any further evaluation of mixtures.

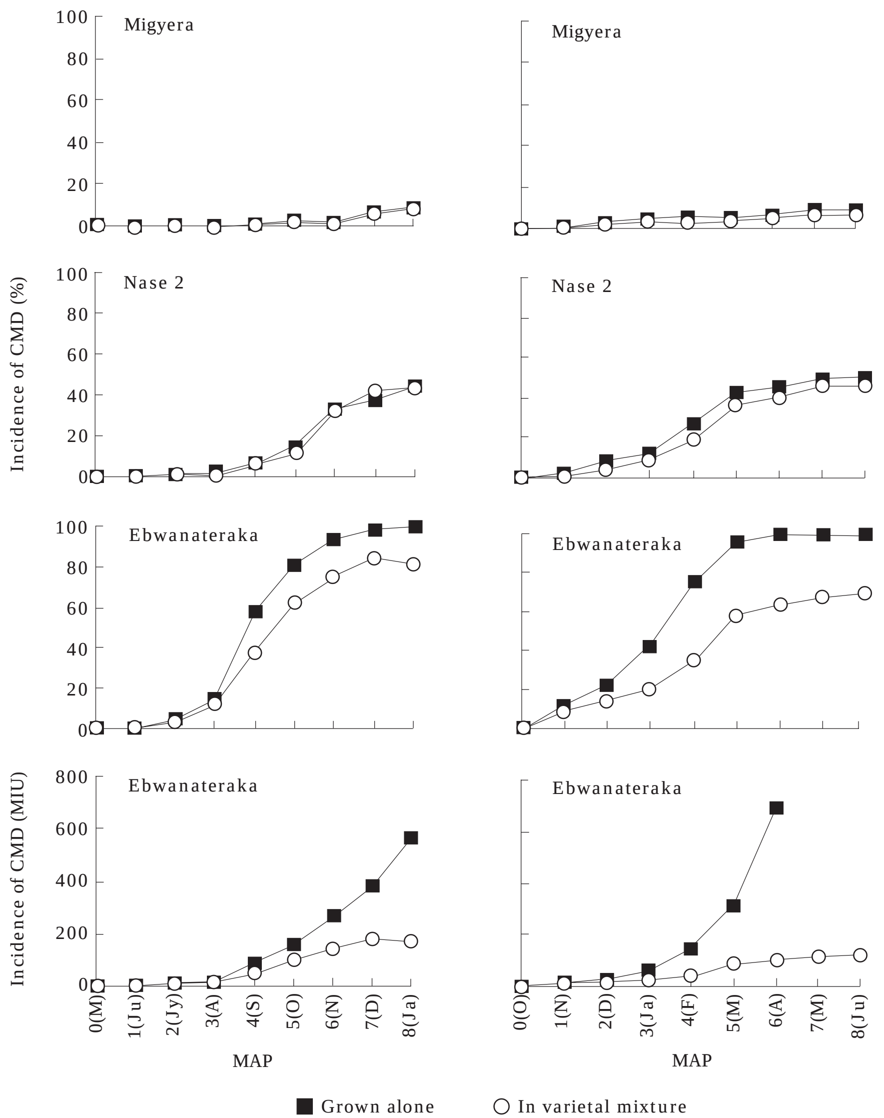

Figure 3. Mean monthly incidence of cassava mosaic disease (CMD, %) in successive months after planting in varieties Migyera, Nase 2 and Ebwanateraka when grown alone and as a mixture at Namulonge in (left) the 1995-96 and (right) the 1996-97 experiments. Incidence data for Ebwanateraka were transformed to multiple infection units (MIU) in the bottom two figures.

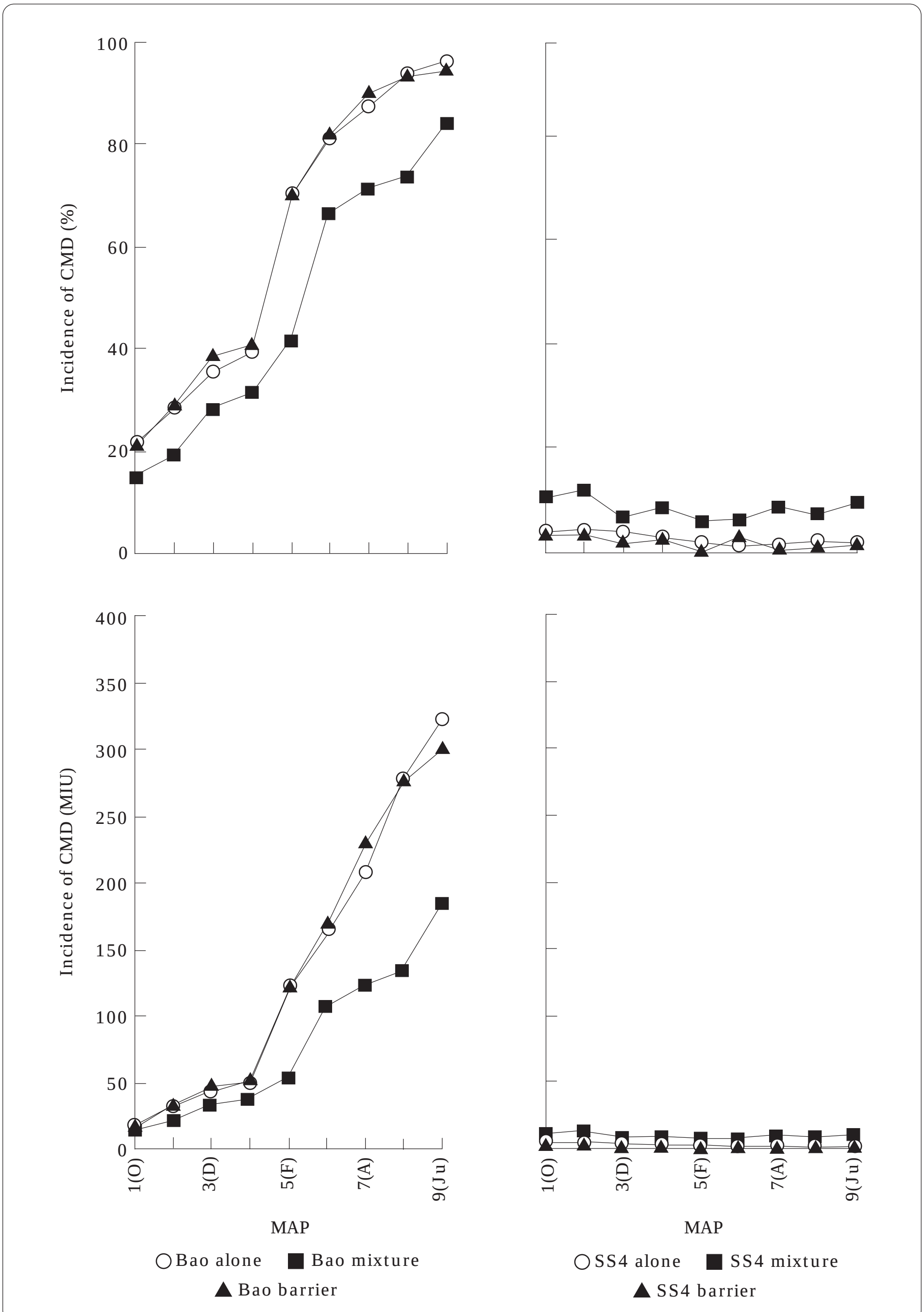

Figure 4. Mean monthly incidence of cassava mosaic disease (CMD, %) in successive months after planting (MAP) in varieties SS4 and Bao when grown alone, as a mixture and with SS4 as a barrier around Bao at Namulonge in the 1998-99 experiment. Incidence expressed as % (top) and as transformed to multiple infection units (MIU) (bottom).

The experiment was harvested 12 MAP to consider the yields of healthy and infected plants of each variety in relation to the type and healthy status of their immediate neighbours. It is particularly important to assess the ability of SS4 to compensate for the impaired growth of Bao in the mixture of the two varieties.

Conclusions

The results obtained are consistent with previous observations on the behaviour of local varieties and on the scope for adopting somewhat tolerant varieties and varietal mixtures as a means of alleviating the effects of CMD (Sserubombwe et al., 2001). Further studies on the behaviour and sustainability of local varieties, especially under the less extreme conditions of inoculum pressure encountered in post-epidemic situations, need to be made.

Acknowledgments

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Reference

Sserubombwe, W. S.; Thresh, J. M.; Otim-Nape, G. W.; Osiru, D. O. S. 2001. Progress of cassava mosaic virus disease and whitefly vector populations in single and mixed stands of four cassava varieties grown under epidemic conditions in Uganda. Ann. Appl. Biol. 138: 161-170.