Gatsby Occasional Paper

Mastering Mosaic:
The Fight for Cassava Production in Uganda

December 1997

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Cover photograph: *Dr. William Otim Nape displaying tuberous roots from a high yielding cassava variety "Migyera" at Bulisha in Masindi District. This is one of the varieties developed by his team at NARO which has helped to control the Cassava Mosaic Disease epidemic that has devasted Uganda in recent years.*

Above: *Devasted fields established with infected cuttings and later abandoned.*

Contents

Foreword

This booklet contains an account of the struggle to combat the devastating effect of cassava mosaic disease in Uganda from 1990 to 1997. We believe it is an important example of the ways in which agricultural scientists in Africa can make a real impact on the productivity and welfare of small scale farmers. In this case it is no exaggeration to say that conditions of extreme hunger were either reversed or narrowly avoided in a large area of Uganda where cassava is the key food crop.

The trustees of the Gatsby Charitable Foundation have for the last ten years maintained a commitment to funding the dissemination in Africa of varieties of key food crops with either high yield or disease resistant characteristics which are of value to small farmers. They are very pleased to have been asked in 1989 by Professor J Mukiibi, the Director General of Uganda's National Agricultural Research Organisation (NARO), to provide financial support to the work of the national cassava programme, at a time when there were great uncertainties as to the appropriate response to the outbreak of cassava mosaic disease. The fact that the programme has achieved the level of success described in these pages is a tribute to the competence and commitment to the team of NARO scientists who have designed and led the programme. Other donors (as listed on page 18) have also played a role in supporting this process and share in the credit for its achievements.

This paper is one of a series of 'Gatsby Occasional Papers' which are designed to present the experience of the Foundation in assisting with particular initiatives. They are published in the hope that the outcome of the initiatives will be of interest and value to a wider public.

Michael Pattison
The Gatsby Charitable Foundation

Origins

The Luwero Triangle,1988. In the course of five years of civil war between the guerilla forces of the National Resistance Army and the government forces of the then President Obote the villages of the District of Luwero, fifty miles from the capital city of Kampala, had lost at least 150,000 lives. Normal agricultural production, based on a mix of banana, cassava, sweet potato, beans and livestock had fallen dramatically. Cultivated land had been allowed to fall into fallow, cattle had been slaughtered to meet the needs of one or other of the warring factions and of the Baganda villagers who faced an unprecedented food shortage. From 1985 onwards yellow patches had begun to appear on the leaves of the cassava plants whose production accounted for about thirty per cent of food consumption. Soon most infected leaves were greatly reduced in size and fell prematurely. When farmers dug up the tuberous roots of the cassava plant they found little or nothing to eat. The spiral of hardship in Luwero had taken a dramatic turn for the worse.

During the preceding five years of civil strife most of the people of Luwero had supported the guerrillas of the National Resistance Army (NRA) in their fight against the discredited Obote regime. Their role in the war gave them easy access to President Yureveni Museveni following the victory of the NRA in 1986. In 1998 the Special District Administrator of Luwero District reported to the President's office that cassava mosaic disease (CMD) had reached overwhelming proportions causing an almost total collapse of output. The President's office then contacted the Minister of Agriculture, Victoria Ssekitoleko, who immediately mobilised those competent agricultural research staff - members of the national root crop programme - who remained 'on seat' after the de-stabilising years of the civil war. The key players, led by Dr. William Otim Nape, had in fact just been obliged to abandon their station at Serere, in eastern Uganda, where residual resistance to the new Government
had been manifested in raids on the research station. They had re-grouped at Namulonge Research Institute, fifteen miles north of Kampala.

Once mobilised to survey the cassava crop in northern Luwero, Otim Nape and his five colleagues found at least 2000 ha of the crop - enough to feed half the District for a year - completely devastated. Their report, handed to the Minister of Agriculture, diagnosed the virus known as African Cassava Mosaic (ACMV), carried by whiteflies, as the source of the devastation. However, this view contradicted an alternative current within the Ministry of Agriculture that the problem was in fact 'Green Spider Mite' - a microscopic insect which also destroys the leaves of the cassava. This analysis had led the Ministry of Agriculture to prepare a radio announcement, on the same day on which Otim Nape submitted his report, calling on all Luwero farmers to spray their cassava crop with pesticide. Fortunately, there was sufficient time for the announcement to be cancelled before it went on the air.

But if the problem was mosaic, what was the cure? Agricultural records from the 1930s showed that outbreaks of CMD at that time had been successfully combated by up-rooting all infected plants and re-planting with healthy, uninfected plants of varieties with some resistance. However this required consistent and rigorous adoption of the practice throughout the infected area. Although the 1930s epidemic had affected whole Districts population human densities at that time were much lower, and the numbers of farmers involved much smaller. Where feasible, the approach had been linked to the distribution of varieties of cassava with resistance to CMD. In the circumstances of 1988 there was no immediately available reservoir of varieties with resistance to mosaic - the Ugandan cassava breeding programme had been based at Serere and the breeding plots had now been ransacked by the local insurgents, and all genetic materials and records were lost. Although these limitations were recognised it was decided to proceed with a programme to remove and destroy all infected

Mother and children surrounded by a field devasted by Cassava Mosaic (Apac 1991).

Severely diseased plant grown from infected cutting produces no yield.

cassava plants, and to purchase healthy planting material in the form of a variety known as 'Ebwanateraka'. This was a variety developed as a result of breeding by a local farmer which was high yielding but with no resistance to mosaic : in the course of the 1950s and 60s it had come to be adopted very widely. In December 1988 the Minister of Agriculture launched a campaign based on this programme in Buruli County - chosen as one of the worst hit areas within Luwero. She called on farmers to destroy all infected material, and made a bonfire of a sample of such material which was covered by national television and radio. At the same time, using a grant of 6 million Uganda shillings (about $ 6,000) from USAID, about 4 million stems of Ebwanateraka were purchased by the Ministry of Agriculture in Iganga and Jinja Districts - which up to that time had been more or less unaffected by CMD. Within three months the newly planted stems were totally infected by mosaic and there was no hope of significant production of tubers.

It was not clear to the root crop team whether this devastating result was due to the inadequate eradication (or 'roguing') of previously infected plants, or to the non- resistance of the Ebwanateraka variety. Therefore the team responded by planting in May 1989 a 4 hectare block of Ebwanateraka which was managed under a very rigorous sanitation regime. By October 1989 it was clear that the problem went beyond efficient sanitation: almost all the 40,000 cuttings planted had succumbed to mosaic. This result confirmed that the resistance of the Ebwanateraka variety to CMD was inadequate in relation to the strength of the current threat, and that the problem needed deeper scientific understanding in order to develop a sustainable system for control.

It was clear that access to new varieties with much higher resistance to mosaic would have to be the central plank of any successful strategy. As early as 1979 Otim Nape, carefully shepherded by a security chief in President Amin's notorious State Research Bureau, had visited the International Institute for Tropical Agriculture (IITA) at Ibadan in Nigeria and solicited the collaboration of Dr. Sang-ki-Hahn, then leading IITA's Tropical Root Crop Improvement Programme. In the course of the 1970s Dr. Hahn had developed a number of varieties of cassava with high resistance - or tolerance to - mosaic and bacterial blight (another disease threatening cassava production). By the end of the 1980s these varieties were already having a major impact in southern Nigeria since in addition to their resistance to mosaic and bacterial blight they were very high yielding. Following this early visit to IITA, Otim Nape had acquired some of these varieties for experimental trials at Serere and they had appeared to perform well in Ugandan conditions - albeit with yields significantly lower than those achieved in Nigeria.

However, when the root crop team had been forced to abandon Serere Research Institute because of insecurity, they left behind all the improved cassava genotypes including a collection of 480 cassava germplasm lines, essential for cross-breeding with the exotic materials. It became clear that to control the new epidemic any surviving plants from the improved varieties at Serere had to be salvaged,brought over to Namulonge and used to develop more suitable varieties. At that time the Uganda People's Army (UPA), the rebel group active in the areas at the time, had decreed that to be caught carrying anything from the rebel controlled areas was a capital offence.

Could this material be retrieved in the conditions of continuing insecurity which prevailed at Serere in 1989? Luckily, the root crop team included Max Olupot, who was indigenous to the Serere area and could move relatively safely in the local environment.

In April 1988, Otim Nape instructed Olupot to sneak carefully to Serere, locate areas where advanced and uniform yield trials had been planted prior to insecurity and retrieve from the bush any remaining cassava plants he could see, irrespective of their miserable state. Olupot did exactly as instructed. He went quietly to Serere and fished from the dense mat of spear and buffalo grass one or two miserable stem cuttings of seven genotypes (including both the IITA types and types produced by the Institute's own selection programme). He cut two pieces of short stems of each genotype and hid them in his pockets. He returned incognito from Serere to Namulonge Research
Institute where the cuttings were rapidly multiplied. Soon the team had many plants of each genotype, enough for a preliminary yield trial.

Rumours also reached Namulonge that a Mr. A. Otwani (see picture below), a local farmer from Kidetok village in Serere county, had maintained some of these varieties. Again Olupot made a successful clandestine visit to Serere and packed a set of cuttings of the two varieties from this farm in his mukeka (made of palm

leaves) hand bag. These and earlier materials were to provide the basic material for a yield trial managed by the Namulonge team in 1989, followed by trials on 20 individual farms in northern Luwero.

The trials indicated that three of the varieties which originated with IITA and two of those developed in the previous ten years at Serere had either a partial or high degree of resistance to mosaic.

Mr. Otwani amid a field of his 'Migyera' cassava crop.

Was there justification for a strategy by which cuttings for planting from these varieties could be made available to farmers in large quantities in a short time frame? This could only be determined by answering a number of other subsidiary but nonetheless crucial questions including the fact that some of the varieties were 'bitter' in taste rather than 'sweet'. Bitter varieties of cassava have a potential to generate toxic hydrogen unless they are fermented in the course of processing for consumption. Fermentation is an integral part of processing in most of west Africa, but only in parts of Uganda. The development of varieties acceptable to farmers would therefore mean overcoming the problem of bitterness. Another underlying problem was that most farmers were quite ignorant about the nature and cause of mosaic, many believing that it was derived from a poison in the soil. The questions to be answered in formulating a strategy therefore included:

- would the mosaic problem be restricted to the areas where it was already present or would it expand and cover the rest of the country and if so how fast?
- would the resistance to mosaic last for longer than one season?
- would yields be sustained over a long period of time?
- would the varieties be safe to eat and therefore acceptable to farmers?
- how could farmers be persuaded that they needed to replant (and that the problem was not in the soil)?
- what was the most efficient way to scale up for multiplication of cuttings?
- how could material comprising millions of cuttings be distributed?
- how could agricultural advisory ('extension') staff be mobilised (in a context of minimal budgetary allocations?

As Otim Nape and his team began to review these questions in 1990 and 1991 they could see answers that might provide solutions. However, the big unanswered and underlying question was : what was the nature of the virus responsible for so much destruction, where would it extend next, and could it undermine whatever strategy was adopted?

A mobile 'front'

This question of the nature of the virus was becoming increasingly difficult to answer as evidence mounted that parts of northern Uganda were experiencing an attack of mosaic which was just as virulent, if not more so, than that in northern Luwero. The first reports of CMD in Kumi District had been received in 1988/90 - by 1991 it had reduced production by an average of 70 per cent across the District. Interviewed in 1991 by Adrienne Martin, a British economist working for the Natural Resources Institute, farmers' response was characterised as follows:

'Farmers say CMD was first noticed...in 1989/90, before the political upheavals. They associate its appearance with changes in their farm environment ; an increase in bush and grass growth with removal of grazing pressure, an overall reduction of the cropped area, an increase in cassava area in relation to finger millet, continuous cultivation of plots and less frequent weeding.'

A similar picture of devastation of the crop was reported from Palissa and Kitgum Districts in the far north, and from Soroti in the north east where crop loss in 1990/91 in the northern part of the District was described by the District Agricultural Officer as 'total'.

Commenting on this situation Dr. Teddy Brett, an economist from the Institute of Development Studies at the University of Sussex, with extensive experience of Uganda over a number of years, wrote in a report to the World Bank in 1991:

'Unless urgent steps are taken to deal with the situation, it is probable that the disease will wipe out virtually the whole of the existing crop. The immediate consequences for food security and cash incomes will be disastrous in all the areas which have come to rely on cassava so heavily. In the longer term this will require a shift into an alternative cropping pattern which, given the great popularity of cassava, must imply a significant welfare loss to the community. The case for urgent action to remedy the situation is therefore overwhelming.'

At the same time in the District of Lira there were widespread reports of an equivalent devastation of the crop; a serious negative impact was reported in Masindi and Apac, and evidence was surfacing of some damage from mosaic in all 32 Districts of Uganda. Otim Nape and his team realised that they needed to have better access to past and present international experience of the disease.

In January 1990 Dr. Michael Thresh, from the Natural Resources Institute of the University of Greenwich in the UK, attended a conference in Kampala on the virology of other tropical crops. In the course of that he renewed an acquaintance with Otim Nape who asked him to review the evidence on mosaic from Luwero and that coming in from other Districts. Mike Thresh is a virologist with forty years of experience of work on the epidemiology and control of viruses in both tropical and temperate agriculture. As a former Chairman of the British Society for Plant Pathology, he brought to the problem not only his own experience but those of an international network which included close ties to Dr. Dennis Fargette of the tropical research institute ORSTOM in France.

This expertise tried to build on the following picture. CMD is a form of mosaic which is indigenous to Africa and was first reported in 1894 by German scientists in the then Tanganyika. In the 1920s it was recorded in Uganda and elsewhere in eastern Africa, and in the 1930s in several countries of West Africa - its presence has now been recorded in every African country where cassava is grown. The virus is transmitted by a type of whitefly *('bemisia tabaci')* - which is a major pest of numerous crops in many parts of the world, particularly in the tropics and sub tropics. Such whiteflies feed on the underside of the leaves, lay their eggs there, and in the course of a life of some thirty days have the capacity to transmit the CMD virus to the leaf on which they are feeding. Since between 11 and 12 generations of whitefly per year are produced on the cassava the potential for multiplication in the impact of the virus is enormous.

However, there was only limited information on the factors affecting the rate of population growth of these whiteflies, or their effectiveness in transmitting the virus. These were particularly key issues in the Ugandan context since by 1992 there appeared to be three zones of infection pressure characterised by 'low', 'medium' and 'high' spread of the disease. Within the next two years it was clear that the demarcation between these zones was constantly shifting and that the 'front' of the 'high spread' zone where the disease was strongest was moving south at a rate of about 20 km per year. To the south of this front there were various 'hotspots' where the infestation was untypically strong - and it appeared that northern Luwero had been the most dramatic of these 'hotspots'. The movement of the front through Luwero and Mpigi Districts is shown in Figure 1. It was not clear in 1991 and 1992, but became clear later, that as the 'front' moved south the level of virulence of mosaic gradually receded returning to what might be regarded as an 'average' level (intermediate between the epidemic situation and that which had prevailed ten years earlier).

Whilst Michael Thresh and Otim Nape, in consultation with their international colleagues, had worked out this pattern of incidence by 1993, the factors which determined it and its probable future evolution were not all clear. It was not clear for instance:

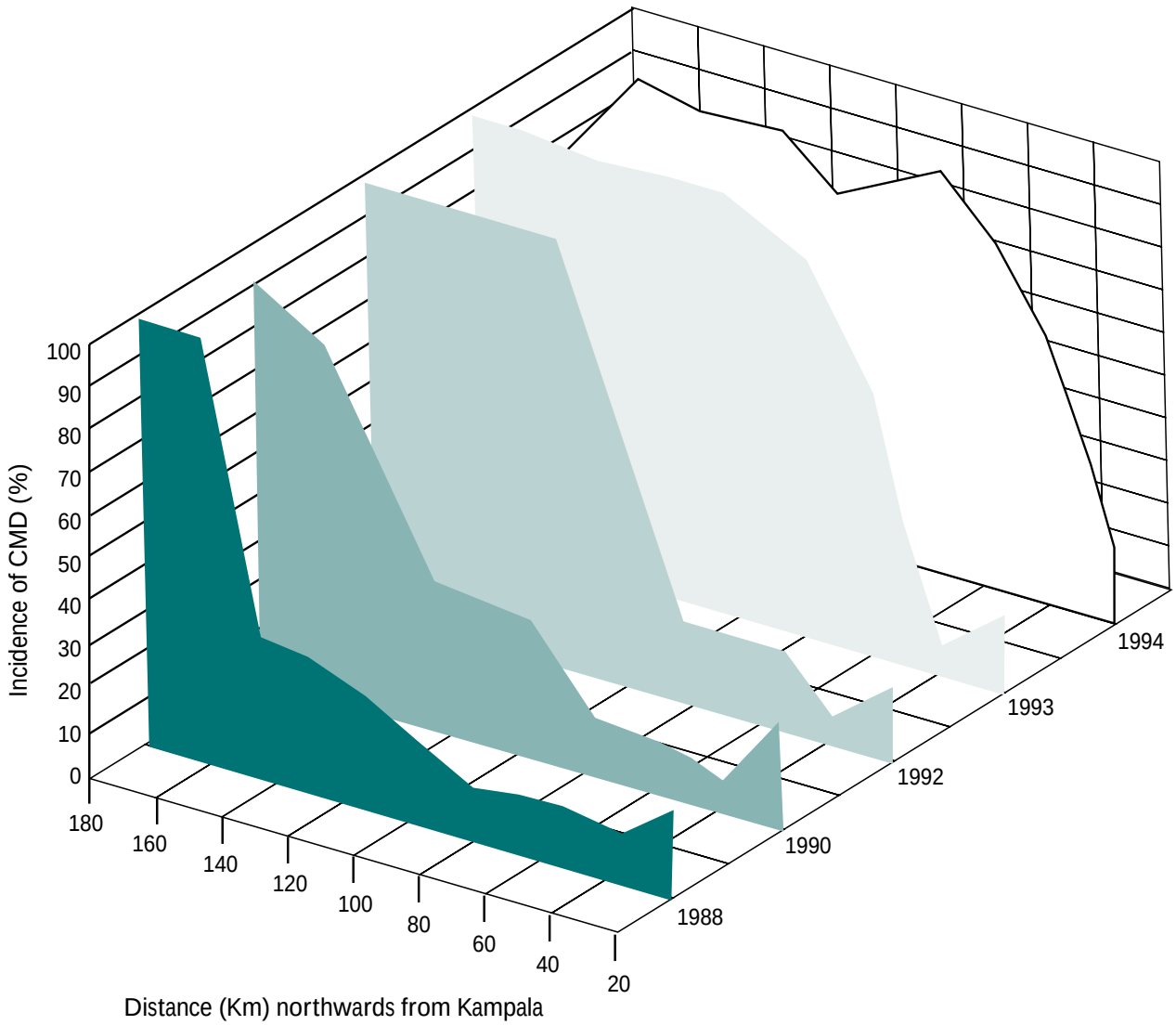
- whether the renewed expansion of the land area under cultivation in the Districts which had declined during the civil war would again increase the incidence of CMD

- whether the greater level of rainfall and humidity in the still largely unaffected areas of southern Uganda would favour or depress the growth of the whitefly population

- whether the exceptional strength of the virus itself was due to the increased and high whitefly population, or a new strain of the virus or an entirely new virus

In order to throw light on the third question - whether this was a novel virus - Thresh and Otim Nape solicited additional support from Professor Bryan Harrison, a senior virologist at the Scottish Crop Research Institute (SCRI) who had studied cassava mosaic over many years. He invited Otim Nape and a young Chinese molecular biologist, Xueping Zhou, to SCRI to work with him on the problem first hand. This team conducted a series of tests on the DNA of the virus in 1996 and eventually discovered that it was made up of parts of the DNA of the east African form of cassava mosaic virus, and of the ACMV which had long been established in Uganda and west Africa. The new virus now prevalent in Uganda had elements of common genetic information from the two viruses, arising from the exchange of genetic information between them. This finding is itself a breakthrough, and this is the first time such an effect has been observed in the family of ‘gemini viruses’ in which ACMV falls.

Figure 1: Changes in the incidence of CMD at different distances from Kampala from1988-1994.



Defining a strategy

By 1991 Otim Nape and his team were clear that in the zones of 'high' and 'medium' level infection pressure the planting of 'clean' (ie mosaic free) cuttings from local varieties would be inadequate to ensure that the virus would quickly re-infect the crop. The evidence was overwhelming that the increased whitefly population would continue to spread the virus, and that this infection would occur within months even if mosaic free material was planted in relative isolation at distances of a hundred metres or more from infected material. However, they also recognised that any strategy for addressing the question would require a massive effort at raising farmer awareness as well as an effective mechanism for testing and diffusing the resistant varieties.

The mechanism which was developed from 1991 was designed to integrate each of these considerations. Its key element was the fact that the root crop research team was able to mobilise selected extension staff and manage them to achieve a given set of objectives. The administration of agricultural (and other) services in Uganda is organised by the Ministry of Agriculture and there is a network of staff in every District. These are sub-divided into counties and sub-counties. Typically there are three or four counties per District and seven to eight sub-counties per county.

One tuberous root of variety 'Nase 1' (Namulonge Serere selection), on-farm trials in Luwero District (pictured is Anton Bua, socio-economist).

Masindi District on-farm trials. Foreground is Mosaic – susceptible local variety and in the background is 'Migyera' resistant variety.

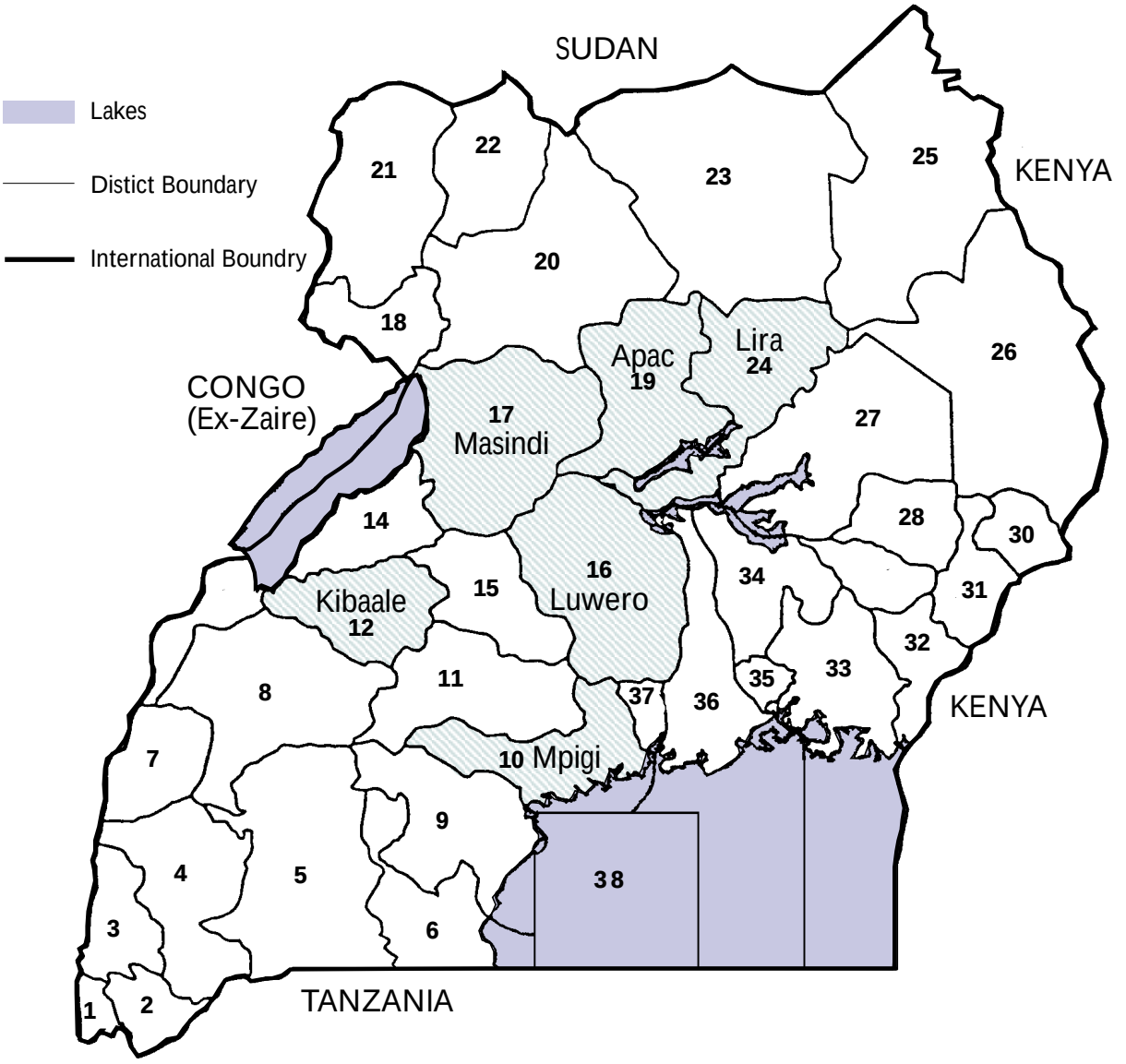
The strategy adopted for the purpose of this programme was based on the selection, from 1991 onwards, of three Districts representing the different zones of infection pressure: these were Mpigi (low spread), Luwero (high spread) and Masindi (intermediate spread). In that year the Gatsby Charitable Foundation responded to an invitation from the Director General of the National Agricultural Research Organisation, Professor J. Mukiibi, to fund the programme. In a second phase of the project from 1983, Apac, Lira and Kibaale Districts were added to this list - all at the 'intermediate' phase. The assumption underlying this approach lay in the need to establish a critical mass of mosaic-resistant planting material which could not be 'swamped' by a mass of infected material. The location of these Districts is shown in Map 1.

The components of the programme within each of the selected sub-counties were as follows:

- extension staff training
- training for farmer awareness
- on-farm field trials of target varieties
- farmer appraisal of field trials
- multiplication of selected varieties by individuals, groups and at institutions
- distribution of planting material to groups and individuals
- raising awareness of farmers on the need for fermentation of 'bitter' varieties (principally 'Migyera')

Map 1: Sketch map of Uganda showing the six Gatsby and 32 other Districts.

(Note: District boundaries were modified in 1997)



1	Kisoro	11	Mubende	21	Arua	31	Mbale
2	Kabale	**12**	**Kibaale**	22	Moyo	32	Tororo
3	Rukungiri	13	Bundibugyo	23	Kitgum	33	Iganga
4	Bushenyi	14	Hoima	**24**	**Lira**	34	Kamuli
5	Mbarara	15	Kiboga	25	Kotido	35	Jinja
6	Rakai	**16**	**Luwero**	26	Moroto	36	Mukono
7	Kasese	**17**	**Masindi**	27	Soroti	37	Kampala
8	Kabarole	18	Nebbi	28	Kumi	38	Kalangala
9	Masaka	**19**	**Apac**	29	Pallisa		
10	**Mpigi**	20	Gulu	30	Kapchorwa		

The effective functioning of this system depended upon the close involvement of the District Agricultural Officer (DAO) - the senior agricultural officer within the District - who in each case appointed a subordinate cassava co-ordinator to work exclusively on the cassava programme in the target sub-counties. In addition, at the level of each sub-county, a member of the extension staff was appointed to act as full time co-ordinator for that sub-county. The teams ultimately reported back to Otim Nape as the leader of the national root crop programme. This came to be known as the National Network of Cassava Extension Workers, or NANEC. These arrangements are shown schematically in Chart 1 opposite.

In 1991 all District agricultural and plant protection officers in the country received training on the epidemiology and control of CMD. By 1992 all agricultural and field extension staff in the project Districts had also been trained on the disease, in improved cassava production methods and on rapid multiplication of planting material of improved varieties. A total of more than a hundred DAO's and plant protection specialists were trained from 1991-93 ; over the same period - but following the DAO's training - within the target Districts a total of nearly 400 extension staff were trained in practical 5-day workshops held at the District level. Finally, within the target sub-counties a total of 4,600 farmers (or nearly 200 per sub-county) attended one day 'awareness' campaigns which alerted them to the potential of the new varieties and to the recommended rapid planting system. In the subsequent years this programme has been re-inforced to the extent that the training and 'farmer awareness' programme had by the end of 1995/6 embraced a total of 1350 extension staff, 2000 'opinion leaders' and 16,300 farmers.

Yield Trials

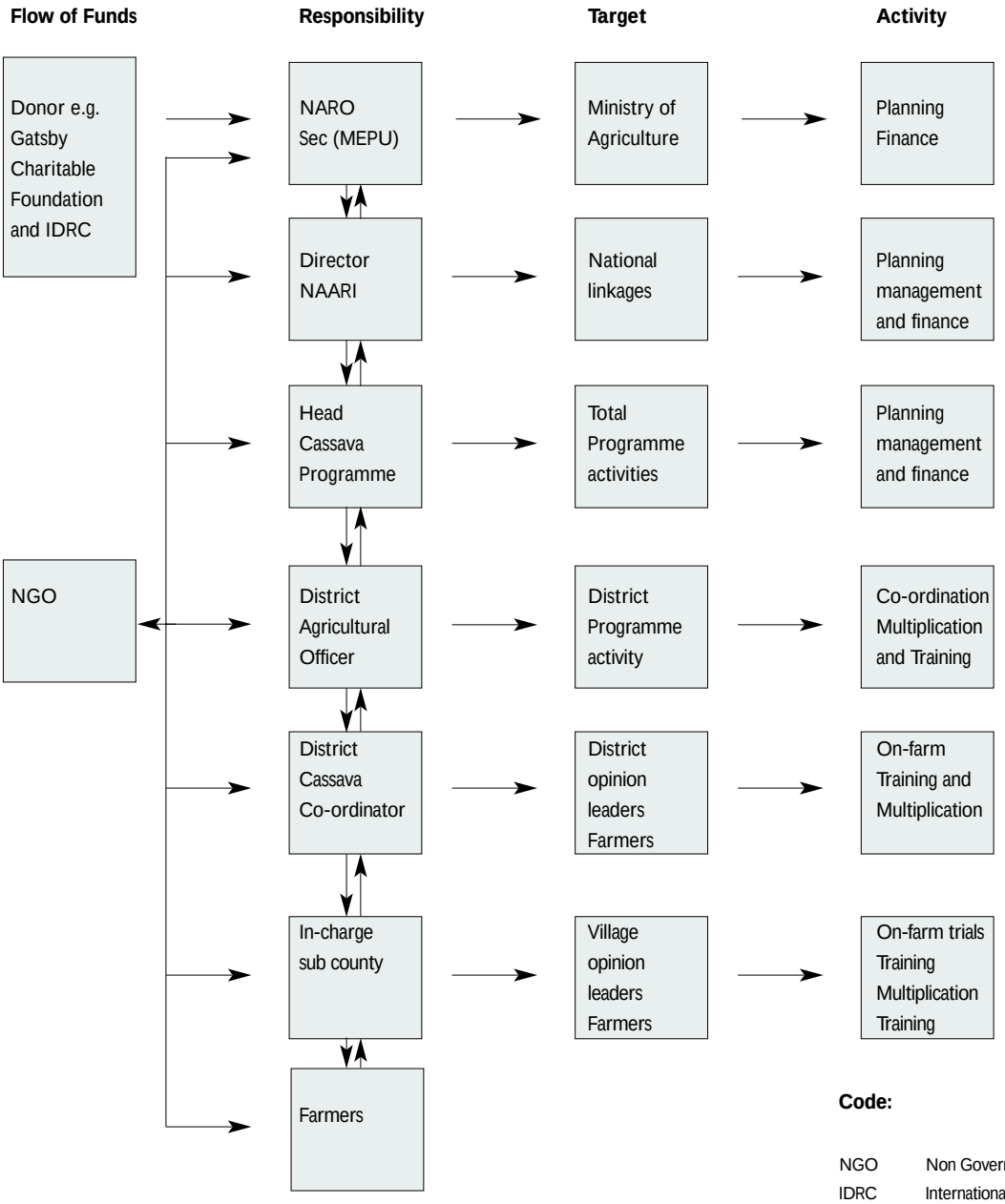
It was obviously critical that farmers would be prepared to accept all the characteristics of the new varieties, in addition to their resistance to mosaic. The NANEC team therefore embarked on multi-locational trials aimed at testing adaptability, CMD resistance and yield of improved cassava genotypes starting from the 1989-1990 and 1990-91 seasons.

At different stages of growth of the crops and at the harvest, farmers near each trial were called to the site and briefed, and then asked to make their own assessment and form opinions on each genotype. At harvest, the farmers were particularly asked to assess the relative yield of each genotype after which tubers of each genotype were selected, peeled and cooked. A panel of testers comprised of farmers and their wives only were allowed to test both cooked and raw tubers of each genotype.

The information provided by the farmers, and the records collected

Women preparing cassava tuberous roots from on-farm trials for palatability tests.

Chart 1: NANEC Organisation Chart



Code:

NGO	Non Governmental Organisation
IDRC	International Development Research Centre
NARO	National Agricultural Research Organisation
NAARI	Namulonge Agricultural and Animal Research Institute
MEPU	Monitoring, Evaluation and Planning Unit

Mrs Genevieve Einam of NARO demonstrates improved processing techniques to a women's group in Masindi District, 1994. Here she is sieving cassava flour.

on the performance of the genotypes were considered in the selection process. By 1994, three of the Tropical Manihot Selection varieties (best suited to the tropics) were officially recommended to farmers and released by NARO's Variety Release Committee as Nase 1, Nase 2 and Migyera. The average performance in 1995 of these varieties in on-farm trials measured against that of 'local' varieties is shown in Figure 2.

Multiplication block of 'Nase 2' in Luwero District.

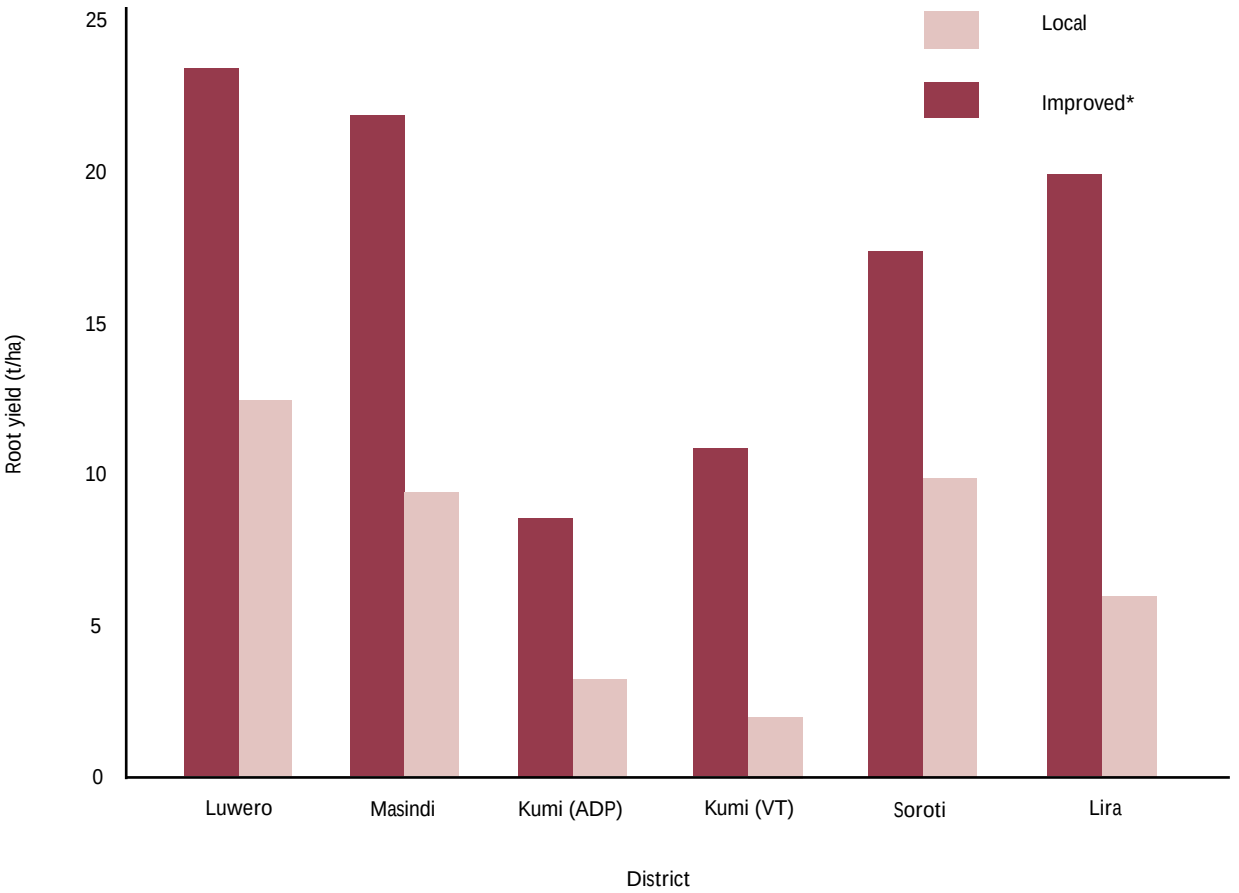
Multiplication

In order to supply the multiplication blocks at the sub-county level it was necessary to have a central multiplication block. Cassava is planted at a rate of roughly 10,000 cuttings per hectare ; each plant will produce up to 6 cuttings for re-planting. Consequently 10,000 cuttings produce 60,000 or enough to plant 6 ha. Established plants can be cut back to yield cuttings for up to three years, although they will become less productive over this period of time. A multiplication block for this purpose was established at Namulonge, and a total of 35 ha planted to the target resistant varieties in each of the years 1991,1992 and 1993. This material was sufficient to plant a total of 350 ha for multiplication purposes in the target six Districts by 1992 / 3, and an additional 125 ha in other Districts. The multiplication programme in these additional Districts was managed under projects financed by a number of donors including the World Bank, the EU and several NGOs.

The multiplication function was carried out by individual farmers, farming groups and on government farms (ranging from prison farms to disused research stations to schools). Several methods of distributing planting material from these blocks to farmers were tried and evaluated in each District. From this it became clear that a balance between types of multiplication systems, and types of distribution systems was necessary. In the case of institutions, it was relatively easy for the research team to retain a high degree of control over the management of the block (in areas such as weed control and the timing of taking cuttings). On the other hand management was expensive, the blocks were relatively inaccessible to farmers, the distribution system was prone to 'political' interference.

In the case of multiplication by individuals the advantage was that if the individual proved competent he or she maintained a well managed block at low cost to the programme, and could be relied on to maximise production of cuttings. On the other hand there was a danger that only a few individuals (probably close to the farmer concerned) would have access to the material, that expansion of the area in use would be restricted (by the production of other crops) and that there might be disorganised 'theft' of the material. This has the effect of distributing the material but makes it more difficult to follow its impact. The effectiveness of

Figure 2: Yield of the improved and local varieties in various Districts 1995



* Yield of improved variety is mean average of eight improved varieties

Farmers carrying stems of improved varieties from multiplication block. Cycles have proved effective for the transport of cassava and also the spread of CMD.

multiplication by groups depends on the extent to which the group is functioning well, and has an accepted system for apportioning both work and the cuttings once they are harvested. If these systems are in place multiplication is probably optimal; if not, then cultivation may not be sustained, it may be difficult to expand the land area under cultivation, and there may be major disputes about the basis on which cuttings are distributed.

Over the whole period of operation of the programme from 1991/2 to 1995/6 this system has led to the distribution to farmers of a more than 100 million stems ready for planting, of which 70 million were distributed to the target priority Districts and 30 million to the remainder. In the photograph above one farmer is shown carrying cuttings home from a multiplication block by bicycle; each stem will be divided into ten cuttings for planting. The impact of the cuttings generated by this multiplication system has been decisive, particularly in the target districts, in enabling cassava production to recover from mosaic. A sample survey of the

Impact

impact of the cuttings was conducted by district extension staff in early 1996. It assessed the impact of the project into 'target' sub-counties and by others within the 'target' Districts. Its conclusions are summarised in the table on the next page.

The figures indicate that 57 per cent of the total area grown to cassava in the target sub-counties is now planted to the improved varieties, and about 20 per cent is planted to them even in those sub-counties which were not 'targeted'.

Experiences in other Districts

Whilst this activity was being undertaken by NANEC in its target Districts, largely funded by the GCF, other agencies were actively engaged in the fight against CMD elsewhere. The key initiatives were: two programmes funded by the World Bank (the Agricultural Development Project [ADP] and the Northern Uganda Reconstruction Project [NURP] in Soroti and Kumi Districts, the NGO 'Vision Terudo' (also in part of Kumi District), Oxfam (also in Kumi) and the NGO 'CARE' in Arua and Moyo Districts. Thus Kumi received support from at least four different initiatives.

The first of these in time was that of Oxfam which in 1991 initiated a programme based on the importation from other Districts of 'local' varieties which were apparently free of mosaic. These were initially planted in a multiplication block, and the material was distributed to women farmers in very small packages of eight stems per farmer. This proved to be unsuccessful primarily because when planted on farms the spread from existing plantings nearby proved to be too severe, and nearly all of the planted cuttings soon succumbed to mosaic.

In contrast the programme managed by 'Vision Terudi' was quite effective. It worked with the mosaic resistant varieties recommended by NARO and organised communities to plant multiplication blocks. These groups were closely related to church congregations and the distribution system was also related to church membership. The church link provided a means of organising an effective distribution system with a minimum of theft and loss. It was, however, only active in those counties of Kumi District (principally Ngora and Kumi counties) where the most active evangelistic church was strong.

The two initiatives supported by the World Bank in Kumi were based on different principles. In 1992 the ADP organised a programme based on highly susceptible local varieties, multiplied in blocks managed by groups, but dependant upon the principle of weeding out (or 'roguing') any infected plants to prevent the spread of mosaic. In practice it proved difficult to ensure that these sanitation measures were really effective and much of the material which had been distributed succumbed to CMD. In 1995 the NURP adopted the different strategy of relying only on the improved virus resistant varieties, but the management system was not as effectively co-ordinated as in the Districts where the NANEC structures were in place. Consequently the impact to date has been very limited, and in early 1997 Ministry of Agriculture staff were reporting that CMD had again devastated the cassava crop in Kumi with serious implications for food availability.

The experience of Kumi District was reflected in Soroti where both the ADP and NURP programmes were supported by the World Bank, but where several church denominations were also active in fighting mosaic and where there was also modest involvement by the Namulonge team (in a separately funded programme). As in Kumi the overall impact of these initiatives has been very modest, with CMD continuing to severely depress food production. On the other hand the initiative taken by CARE in Arua District, which was based on material supplied from Namulonge, has had considerable success in generating improved material, multiplying it through community groups, and enabling farmers to combat mosaic. In this case there has been an effective extension programme to raise the awareness of farmers in relation to the use of the improved material.

The different specific characteristics of the initiatives in Kumi and Soroti Districts are summarised in the Tables A1-A3 in Annexe 1. Table A3 shows the structure of the initiatives in the six Districts where the NANEC system has been in place.

Table 1: Impact of the improved varieties in the target Districts

		Cassava area as % total farmed area	Improved varieties as % cassava area
Apac	Target sub-counties	43	63
	Others	48	16
Luwero	Target sub-counties	51	69
	Others	34	34
Masindi	Target sub-counties	66	52
	Others	34	24
Lira	Target sub-counties	40	36
	Others	44	10
Kibaali	Target sub-counties	48	49
	Others	21	20
Mpigi	Target sub-counties	46	42
	Others	36	0
TOTAL	Target sub counties (mean)	49	57
	Others (mean)	36	20

Source: Sample survey conducted in mid-1996 by Cassava Improvement Programme staff. See the section 'The Uptake of Improved Varieties in the Six Gatsby Project Districts' in the report 'Progress in Cassava Technology Transfer in Uganda': NARO and NRI/University of Greenwich January 1997.

Broader lessons

The relative success of the campaign to control and overcome the impact of CMD in the six Districts which were targeted by the NANEC programme may have considerable implications for the diffusion and adoption of improved crop varieties in a wider African context. These relate particularly to root crops (to yams, sweet potatoes and to perhaps other crops which are vegetatively propagated), and to a context in which plant disease is ravaging a crop but where varieties of the crop are available which are resistant to, or tolerant of, the disease in question. More broadly there may also be some lessons for the creation of an effective programme structure linking research scientists, extension staff and farmers for the first phase of the dissemination of a new variety or technology.

The essence of the NANEC system is one in which the research scientists are empowered to work with extension staff and farmers to alert them to the potential for adoption of a new variety, to carry out trials of these varieties at farm level and to establish the first stages of a multiplication system which can ensure the diffusion of the material. The multiplication aspect of the system relates only to vegetatively propagated crops, since in the case of crops propagated by seed, multiplication is much easier and this function is carried out largely by seed production companies. However, in the case of root crops the diffusion needs to be carried out to the stage where there is sufficient critical mass of the material to facilitate continuing farmer to farmer transfer.

The practical application of this system, in a context of very tight financial constraints, depends on research scientists having control of a fund which can be used to finance each of the components of a NANEC-like arrangement. This ensures that in the early phase of the launch of a new variety with high potential the initiative will not fall between the responsibilities of two organisations (one charged with research and the other with extension), at least one of which may be torn between multiple objectives. Specifically, the fact that control of the fund enables research scientists to activate extension personnel, or to initiate multiplication at local institutions (such as schools or prison farms) or by groups of farmers, is critical to the success of the process. At a later stage management can be handed to the wing of the Ministry of Agriculture which focuses on the transfer of new technologies on a broader front.

The development of a cost effective system of multiplication has been intrinsic to the success of the NANEC system. This has turned on, first, the generation of a sufficient quantity of foundation planting material at the centre to provide the volume of cuttings required for the second stage of multiplication at District level. Second, it has depended on the co-option into the multiplication process of a group of institutions at the local level, the composition of which will vary from District to District. The strategy should be flexible enough to work with schools or prison farms in one case and groups of farmers in another - or a combination of both. Groups are likely to prove effective multipliers when their members have been working together for some time and when they have not come together specifically for the purpose of the project. A further advantage of groups of this kind is that they will be more efficient and equitable distributors of the cuttings once they are available - a process which otherwise can be very controversial. The key to the cost effectiveness of this approach is that nearly all the costs are marginal which facilitates the active use of an under used asset which already exists (eg a prison or school farm).

A stage can be reached in the multiplication process where there is a critical mass of material on-farm, which is sufficient to ensure that it continues to be in circulation, assuming that the qualities of the varieties, including their disease resistance are maintained. The fact that NANEC has achieved an adoption level of 60 per cent in its target sub-counties, and a twenty per cent adoption rate in other sub-counties of the target Districts, suggests that this critical mass may have been achieved by 1996. If no gains in yield, resistance or improved plant characteristic were expected from the breeding programme it would be reasonable to cease formal multiplication in these Districts, on the grounds that all farmers who needed to access the material could do so. There is in any case a need to ensure that the many local varieties retain a place in the production system so that their genetic characteristics continue to be accessible both to farmers and to research scientists.

However, in practice and in the context of NANEC a continuing breeding programme is in place, both within NARO and within IITA at Ibadan and in Uganda. This has already led to the identification of varieties with characteristics which are superior to those already released. If on-farm trials provide sufficient justification, and if they are to reach farmers, there will be a need for a continuing multiplication system with the above

characteristics to ensure their availability. The same principles will apply to the multiplication of other vegetatively propagated crops.

The NANEC experience has been an unusually powerful case of agricultural research being brought to bear on a problem which was creating conditions of severe hunger, identifying a solution, and implementing the solution. The ingredients were expertise, organisational ability and a modest quantum of finance. They are capable of replication in other contexts.

Healthy cassava plant developed by the programme.

[This text was written by Laurence Cockcroft, Adviser to the Gatsby Charitable Foundation working in close consultation with Dr. William Otim Nape and Anton Bua, of the Uganda National Root Crops Programme, and Dr. Michael Thresh consultant to the Natural Resources Institute of the University of Greenwich, UK. From 1992 to 1997 the Gatsby Charitable Foundation has disbursed a total of £580,000 [US$ 0.9 million] to this project. Other funding which directly or indirectly supported elements of the national programme has been provided by IDRC, USAID, DfID (formerly ODA), World Bank, World Vision, ACORD, CARE, VEDCO and the Church of Uganda].

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Annexe 1

Table A1: Approaches adopted by government organisations and various NGOs in the distribution and multiplicaton of planting material in Kumi District 1991-1995.

Project	Year Initiated	Varieties	Source of material	Method of propagation	Involvement of research	Involvement of extension	Remarks
Oxfam	1991	Bao Aladu	Apac	Individual women	Identified source of planting material	Minimal	Inadequate supervision by extension workers. Varieties susceptible.
Vision Terudo	1991	Migyera Nase 1 Nase 2 TMS 4(2)1425	NAARI SAARI Serere farmers	Selected communities Groups Institutions	Provided planting material Technical support	None	Limited coverage but rate of uptake of improved varieties has been very high in project areas.
ADP/WB	1992	5 local varieties	Iganga	Blocks (farmer groups)	None	Site selection Farmer training on phyto-sanitary measures	Most of these varieties are highly susceptible but incidence remained low in areas where control measures were followed.
NURP	1995	Migyera Nase 1	NAARI SAARI	Farmer groups	None	Site selection Monitoring Supervision	No linkage between research-extension farmers.
Cassava Action Research and Development	1995	Nase 1 Nase 2	SAARI	Farmer groups	Site selection Supervision Training Provided planting material	Farmer selection Farmer training Supervision	Single allocation of funds Subsequent distribution of stems left to farmers and extensionists

Annexe 1

Table A2: Approaches adopted by government organisations and various NGOs in the distribution and multiplication of planting material in Soroti district 1990 -1995.

Project	Year Initiated	Varieties	Source of material	Method of propagation	Involvement of research	Involvement of extension	Successful Yes/No	Remarks
Baptist Mission	1990	Bao Aladu	Apac	Groups Individuals	None	Minimal	Partially	Material has diffused to other farmers but much disease
Agricultural Development Project/ World Bank	1992	Bao Aladu TMS	Apac	Women's groups Demonstration plots	Supplied stems	Farmer awareness campaigns	Yes	Bao high susceptible Farmer awareness successful in Kapelegyong
Soroti Catholic Diocese Development Association	1992	Bao Aladu	Soroti	Groups	None	Minimal	No	Poor linkage between research extension farmers
Church of Uganda Cassava Programme	1994	Migyera	Serere farmers	Groups	None	None	No	Poor monitoring. Lack of funds led to discontinuation of project
Northern Uganda Reconstruction Programme: Cassava Multiplication	1994	Migyera Nase 1 Nase 2	NAARI SAARI	Demonstration plots Farmers groups Institutional	None	Farmer selection Supervision		No linkage between research-extension-farmers
Presidential Commission for Teso	1994	Migyera	Serere farmers	Individuals	none	none		Supervision by non technical staff was too weak to have tangible results
Cassava Action Research and Development programme	1995	Nase 1 Nase 2	SAARI	Groups	Site selection Monitoring Supply of stems Training of extensionists	Farmer selection Farmer training Monitoring	Yes	High CMD resistance of improved varieties has boosted farmers' morale. Single allocation of funds. Subsequent distribution of stems by farmers and extensionists.

Annexe 1

Table A3: Approaches adopted by Gatsby and other NGOs in the distribution and multiplication of planting material elsewhere in Uganda 1991-1995.

Project	Location/ district	Year Initiated	Varieties	Source of Material	Method of propagation	Involvement of research	Involvement of extension	Remarks
Gatsby	Masindi	1991	Migyera Nase 1 Nase 2	NAARI	Individual Institutional	Supplied stems Trained extensionists Monitoring	Farmer selection Farmer training Phytosanitary activities	Increased volume of improved varieties Management of fields significantly improved
Gatsby	Luwero Mpigi Lira	1991	Nase 1 Nase 2	NAARI	Individual Institutional Group (Lira)	Supplies stems Training Routine supervision	Farmer selection Training Phytosanitary activities	Extension staff supported - allowances, transport and training
Gatsby	Kibaale Apac	1992	Nase 1 Nase 2	NAARI	Individual Institutional	Supplied stems		
ACCORD	Moyo	1992	Nase 2 Migyera	NAARI	Individual	Supplied Stems		
CARE	Arua Nebbi	1993	Migyera	NAARI	Communities Institutional	Supplied stems	None	Rate of diffusion of new varieties slow, since ratooning was not practised
World Vision	Luwero	1994	Nase 1 Nase 2 Migyera	NAARI	Individual Institutional	Minimal	Farmer awareness	Inadequate support
VEDCO	Luwero	1995	Nase 1 Nase 2	NAARI	Institutional	Supplied stems	Routine phytosanitary activities	
Cassava Action Research and Development Programme	Pallisa Kapchorwa Mbale	1995	Nase 1 Nase 2	NAARI	Institutional	Supplied stems Planting supervision	Full collaboration	Single allocation of funds. Subsequent distribution of stems left to farmers and extensionists

Annexe 2

Report in New Vision, April newspaper (April 28th 1989)

Cassava in West Nile Hit by Disease

Cassava, the second staple food crop in West Nile after millet, is becoming extinct in the region following a cassava mosaic virus epidemic which has befallen the region for nearly two years now.

The virus which was first noticed in the area in mid-1987 attacks the terminal buds of cassava and crumples the shooting leaves. The plant eventually starts to dry up from the bud downwards until the whole plant dries out completely.

The most hit areas are the counties of Virra, Ativa, Terego and Maracha. One can hardly see mature cassava plantations in these counties. Cassava plants seen in the fields are rare and are at their early stages of growth: between two to four months. However, there may be little hope of them surviving to maturity.

Unfortunately, the species which farmers claim are yet safe from the virus are very scarce indeed. It is not unusual to see men and women carrying loads of cassava stalks on bicycles and heads, respectively, for long distances, some up to 25 miles from areas where they were lucky to have got it. People have now gone crazy to the extent of selling the cassava stalks they think are free of the virus to fellow farmers, something I had never seen since I was born.

In the markets there is a serious shortage of cassava. The little which is there sells like hot cakes. A tin full of it now costs 100 shillings while a full sack costs between 5,000 and 6,000. It originally cost 2,500.

People trek all the way from Maracha and Aringa counties to Nebbi district in the south, a distance of about 50 miles, in search of cassava. The district is the main source of cassava flour for food and its stalks for planting.

Some people cannot see themselves starve to death but go on food stealing melees. This is mostly done at night from granaries. Others have gone to the extent of helping themselves to people's goats and chickens, probably to barter for cassava. There are already many reported cases of thefts. These include cases of disappearance of cassava from rock outcrops where women normally spread it for drying after it has undergone the fungal growth process.

The food shortage in the region is further aggravated by the massive return home of Ugandans from refugee camps in southern Sudan which was finally completed at the end of March 1989.

Annexe 3

Extract from report on crisis situation by District Agricultural Officers (July 1994)

African Cassava Mosaic Disease in Uganda

Extracts from the reports of some of the District Agricultural Officers who were summoned to attend a crisis meeting convened at Mukono Agricultural Institute, July 1994.

Kamuli. "All the four counties of the district are infected but infection declines north to south. In the whole two counties of Budiope and Bulamogi to the north there is no cassava plant worth the name: infection is 100% and all plants are stunted. Southwards in Bugabula county infection is 60% and spreading very fast. It is only Basaya county to the south bordering with Jinja district which is somewhat free of mosaic: infection is about 40% but also spreading fast. For a number of years now the district has been depending on cassava from Iganga and Mukono districts to make up its requirements.

"The recent famine in many parts of the district came as a natural consequence of a number of factors. The majority of people quite rightly attribute it to the failure of the 1993 second rains resulting in a dry period which merged with the normal dry season of early 1994, culminating in the now historic drought. Many people also, but incorrectly, accuse the armyworm which broke out in April that year. What few people realise, however, is that the outbreak of the famine is strongly linked to African cassava mosaic disease which has been devastating the cassava crop in the district for some years now.

"By virtue of being a drought resistance crop cassava is a major influence against famine. That is why it was inevitable to experience the ongoing famine. It was an offspring of the unholy marriage between the recent drought and the current CMD epidemic. If this continues unabated at its present rate the cassava crop will be completely wiped out of the district in the next two years and will result in perennial food insecurity and poverty among the rural people. An arrangement to reverse the current epidemic trend in the district should justifiably be put in place. Hence the earnestness in praying for the project."

Pallisa. "Pallisa is one of the districts recently hit by the famine where death due to starvation was recorded. This was mainly due of the lack of cassava which mainly contributed up to 80% of the household food requirement. It is also a cash crop. At present there is almost no cassava in the district as it has been wiped out by mosaic virus disease. A few existing crops are totally infected and are stunted and not more than 60cm in height."

Masindi. "The relaxation of the agricultural by-laws, introduction of some local high-yielding varieties (but not resistance to disease), the economic and environmental disruption, immobilisation of extension agents and farmers, wars and famine aggravated the matter as people started harvesting the good looking plants thus leaving behind the miserable infected plants with hardly any tubers."

Kigoba. "With the spread of cassava mosaic most of the local varieties were wiped out, hence the onset of famine in many homes. As a result there was a change from growing cassava to finger millet and sweet potato and many families are easily affected by famine due to the lack of good planting material except for one tolerant variety called Bugangaizi which was imported from Kibaale. The only source of cassava in Kasanda is Mubende district."

Mubende. "With the introduction of improved planting material there is a high probability of curtailing the famine. There is already a high demand for planting material due to the introductions received during the on-farm trials carried out in the district during 1993."

Kitgum. "As a result of mosaic disease and the decline in production of cassava which is a famine reserve crop, the district suffered a serious famine last year in which a number of people lost their lives and Government had to spend a lot of money to provide relief food items to the affected areas."

Mukono. "Cassava in Mukono district is grown as a food and cash crop. It is almost replacing banana in the cropping system of the district. As such the area put under cassava would be expected to be increasing. However, production is decreasing because it has been severely affected by the dreadful cassava mosaic virus. It is widely observed that the local varieties have succumbed to infection with time and yields have decreased tremendously.

Hence the need to replace the local varieties with high-yielding ones which are also resistant to mosaic."

Annexe 4

Other relevant publications describing the epidemic and the control programme.

Accelerating the transfer of improved production technologies: controlling cassava mosaic virus disease epidemics in Uganda by Otim Nape G W, Bua A and Baguma Y 1994b. African Crop Science Journal 2: 479-495

Bemisia tabici and cassava mosaic virus disease in Africa by G W Otim Nape, J M Thresh and D Fargette, Bemisia 1995: Taxonomy, Biology, Damage, Control & Management. Intercept Ltd, Andover, UK.

Cassava mosaic virus disease in Uganda: the current pandemic & approaches to control G W Otim Nape, A. Bua, J M Thresh et al 1997 Natural Resources Institute of University of Greenwich, London.

Proceedings of a Workshop to evaluate progress of the programme described above held in Masindi (Uganda) January 1996. (National Agricultural Research Organisation [Uganda], Natural Resources Institute of the University of Greenwich, London and Gatsby Charitable Foundation).

Cassava multiplication and distribution to needy farmers in Uganda by C Simkins and B Blasto. Volunteers in Overseas Co-operative Assistance (USAID / NARO) Kampala 1997.

Progress in Cassava Technology Transfer in Uganda. January 1997 by NARO and NRI / University of Greenwich.

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